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PROCEDURES FOR DETERMINING THE SURFACE ZONE PARAMETERS AND THE BOUNDARY IN THE SUBSURFACE USED IN SEISMIC PROSPECTING

VIOREL VOIN *

Abstract: In the papers we present the methodology of establishing the boundary parameters in the boundary parameters in the subsurface as it is used in seismic prospecting.

Key words: Procedures, the surface, parameters, boundary, the subsurface, seismic survey

One of the main operations in the process of processing the observed data used in reflexion or refraction seismic prospecting is to leave out the influence of the surface area by applying static corrections.

The operation of diminishing the observed data actually lies in leaving out the effect of the topographical relief, present in the upper part of the geological cross-section, as they introduce a series of anomalies into the observation periods.

In order to do this, the use of some methods for determining the parameters of the surface zone is required with a view to bringing all the observed data to a sole reference plane.

1. Procedure for determining the surface zone parameters

The terrain relief whose elevation is furnished by the topographical works, the propagation velocity of elastic waves in the rock determined by seismologging, or the times of the first arrivals, constitutes the necessary parameters on whose basis the static corrections used in seismic prospecting can be calculated.

In order to do this, a series of special workings are carried out in the field, such as seismologging, short refraction profiles or the methods based on the data of seismic recordings are resorted to.

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1.1. Determining the parameters of the boundary in the subsurface by the seismologging methods

The seismologging works are carried out in bore holes where elastic waves are being generated.

Seismologging can be either direct or inverse according to heather the blast takes place at the surface (bore hole mouth) and the reception is done in the bore hole, or the wave generation is done in the bore hole and the reception takes place at the surface (fig.1).

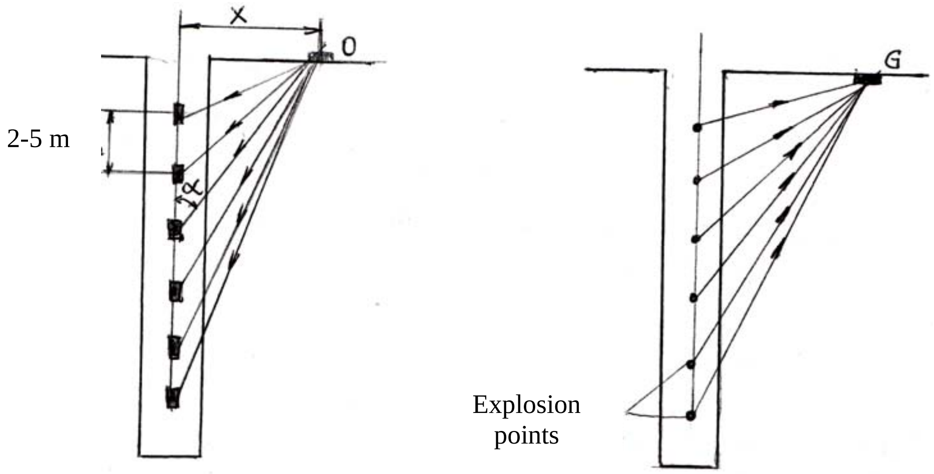

Fig.1. Direct and inverse seismologging in bore holes

Direct seismologging uses a set of geophones which are introduced into the bore hole, performing a sole recording as a result of the generation of elastic waves at the surface.

Either an explosive source or surface sources such as the Dynoseis method or the fall of weights on the ground can be used in order to produce elastic waves.

The inverse seismologging is more rarely used because of its lower productivity. With this method, the elastic wave reception is done with a single geophone, and the generation is done in-sequence from the bare hole bottom to the surface. In this case, the elastic wavers are produced only by means of explosive sources.

As a no longitudinal vertical graph (hodograph) can be obtained with the observed data recorded in the field the first processing operation lies in turning this hodograph into a vertical longitudinal one. In order to do this, the observation periods are multiplied with the cosine of the angle formed between the bore whole axis and the seismic source direction, according to the relation:

$$tg\alpha = t_{obs} \cdot \cos\alpha ; \tag{1}$$

the α angle is determined for each geophone position with the relation:

$$tg\alpha = \frac{x}{h}; \tag{2}$$

in which: x is the distance between the bore hole axis and the first geophone;

h – the depth at which the explosive source is placed in the bore hole.

With the values t and h we draw up the longitudinal vertical hodograph which is made up of two line segments in keeping with the number of strata marking up the surface area.

1.2. Determining the boundary parameters by the refraction profiles method

Determining the parameters of the boundary in the subsurface on the basing of the refraction hodographs (fig.2) can be done on the basis of the relation which defines the equation of the refraction wave's path-time lines and which can be written:

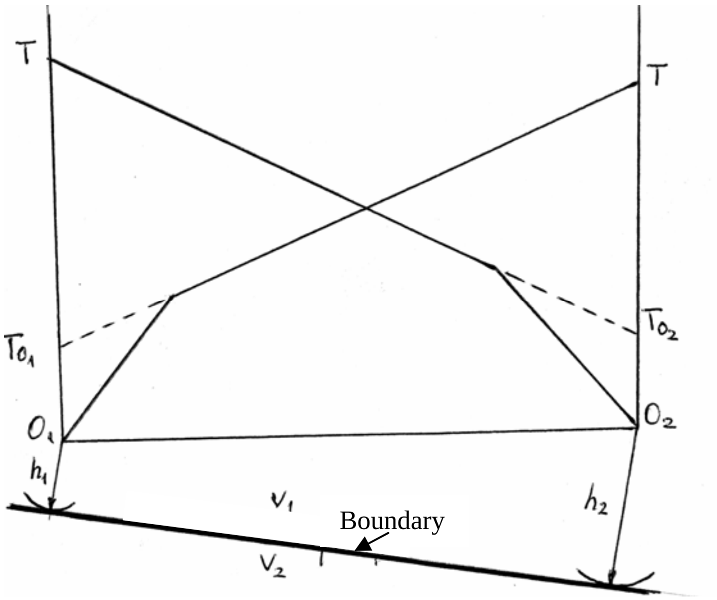

Fig.2. Seismic hodographs of refraction

$$T = \frac{x\sin(i_c + \varphi)}{v_1} + \frac{2h\cos i_c}{v_1}; \tag{3}$$

where: x is the distance from the explosive source to the first geophone;

i_c – the critical incidence angle;

φ - the dip angle of the boundary in the subsurface;

h – the boundary depth;

v_1 – the elastic waves propagation velocity.

If in relation (3) we consider x = 0, the intersection times of the refraction line with the *y* – coordinate are obtained:

$$T_{O_1} = \frac{2h_1 \cos i_c}{v_1}; \qquad T_{O_2} = \frac{2h_2 \cos i_c}{v_1}; \qquad (4)$$

The depths at which the boundary in the subsurface lie can be found with these relations:

$$h_1 = \frac{T_{O_1} \cdot v_1}{2\sqrt{1-(\frac{v_2}{v_1})^2}}; \qquad h_2 = \frac{T_{O_2} \cdot v_1}{2\sqrt{1-(\frac{v_2}{v_1})^2}}; \qquad (5)$$

Other important parameter is the critical refraction distance that is the distance reached at the same time both by the direct (surface) wave and the longitudinal wave. For the analytic calculus of this distance, the condition is laid that the arrival time of the two waves should be the same and the value of x_c is obtained:

$$x_c = 2z\sqrt{\frac{v_2 + v_1}{v_2 - v_1}}; \qquad (6)$$

2. Conclusions

The two important parameters in seismometry, that is the critical refraction x_c and the distances h_1 and h_2 at which the boundary lies in the subsurface, can be obtained by means of the equations of the refraction hodograph.

In order to obtain a selection at the recording of the impulses on the seismographic record it is necessary that the geophones should be placed at a greater distance than the critical refraction distance, that is $x>x_c$. In this way, the first waves that will reach the geophone will be longitudinal waves which are the object of study in seismic prospecting.

Bibliography

[1] Voin V. , *Prospectarea si explorarea zacamintelor*, Editura Corvin Deva, 1998

[2] Tanev, T., Koehler. F., *Estimation and correction of nearsurface time anomalies. Geophysical prospecting*, vol. 39, no. 4, 1978

FROM RHEOLOGY TO PLASTICITY AND VISCOPLASTICITY

MIHAELA TODERAS*

Abstract: Obtaining some models of non-linear behaviour of the materials have 2 directions: the study of rheological properties and define of the form of the equations for a three-dimensional solicitation. The rheology, the science that study the matter in time, from the point of view of the flow, of the deformations, allows obtaining some correlations between stress, deformations and their derivates, and characterize the nature of the components. We will introduce in this paper the most complex behaviours, starting from elementary notions and the description of the different criteria's which allow the generalization of the obtained equations in three-dimensional cases.

Keywords: elasticity, plasticity, viscoplasticity, rheological model, behaviour, criterion, hardening.

1. Fundamental elementary notions

The qualitative form of the materials behaviour result after realizing some simple tests, allow them to be framed in well – defined classes. The fundamental behaviour that could be represented through elementary mechanical systems are: the elasticity, the plasticity and the viscoplasticity. The most well-known elements are, fig1:

- the resort, which symbolizes the linear elasticity for which the deformation is reversible and it exists a relation between the charging parameters and the deformation ones (fig.1.a);
- the damper, which schematize the linear viscosity (fig.1.b) or non-linear (fig.1.c). The viscosity is pure if there is a relation between loading and the speed of this; if this relation is linear the model is related to Newton's law;
- the patina, which describe the appearance of the permanent deformation if the loading is big enough (fig.1.d). If the first step of the permanent deformation does not evaluate with the loading, the behaviour is perfect plastic and moreover, if the

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deformation between the flows is neglected, the model is rigid – perfect plastic.These elements could be combined, making rheological models, which represent mechanical systems, used as a support in defining the models.

The response of these systems could be thought in 3 different plans, which allow showing the obtained behaviour by a certain type of experiments:

- hardening or monotone increase of the strain (strain – stress plan, ε - σ);
- creep or constant loading (time – stress plan, t - σ);
- relaxation or constant strain (time – strain plan, t - ε).

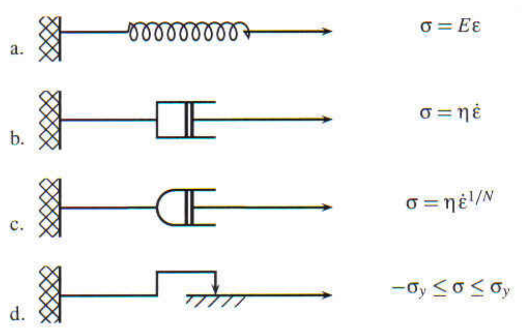

Fig.1- Fundamental notions in the representation of behaviour.

2. Uniaxial plasticity

The association between a resort and a patina in series produces a elastic perfect plastic behaviour (fig.2.a) the system not being able to support a stress which's absolute value is bigger then σ_y.

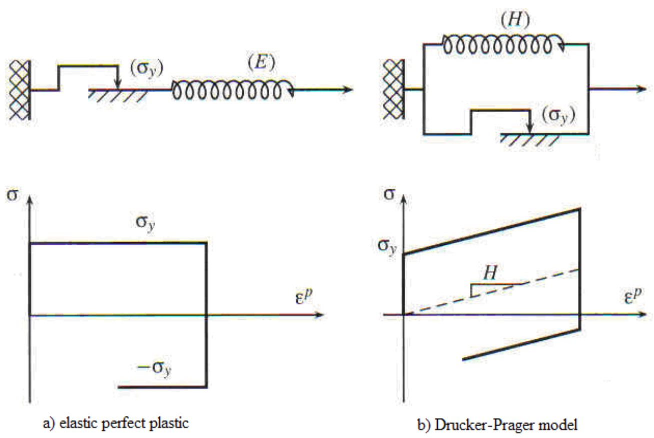

Fig.2- Association in series and parallel of the patina and resort.

The characterization of this model is made by considering the loading function f, dependent of the only variable σ, defined by:

$$f(\sigma)=|\sigma|-\sigma_y \quad (1)$$

The elasticity field belongs the f's negative values and the system' behaviour resume itself to the following equations:

- the elasticity field, if $f<0$ $(\overset{\circ}{\varepsilon}=\overset{\circ}{\varepsilon}{}^{e}=\overset{\circ}{\sigma}/E)$
- the elastic unloading, if $f=0$ and $\overset{\circ}{f}<0$ $(\overset{\circ}{\varepsilon}=\overset{\circ}{\varepsilon}{}^{e}=\overset{\circ}{\sigma}/E)$
- plastic flow if $f=0$ and $\overset{\circ}{f}=0$ $(\overset{\circ}{\varepsilon}=\overset{\circ}{\varepsilon}{}^{p})$

In elastic domain, the plastic strain rate $\overset{\circ}{\varepsilon}{}^{p}=0$, the elastic strain rate becoming zero, during the plastic flow. The model is without hardening, because the stress's level varies at the end of the elastic field. The model is susceptible to reach infinite deformations under a constant loading, leading to the damage of the system by excessive deformation. The association in parallel, fig.2.b - Prager's model, of these 2 elements is related with a behaviour in which the hardening is present; it is a linear hardening and is named kinematical, because it depends of the actual value of the plastic strain. In this case, the loading function depends of the actual value of the plastic strain. So, this function depends of the applied stress and the intern stress, X, that characterize the new neutral state of the material:

$$f(\sigma)=|\sigma-X|-\sigma_y \quad (2)$$

The stresses evaluate during the plastic flow, being useful as control variables. It always exists the possibility of expressing the plastic strain rate according to the rate of the total strain:

$$\overset{\circ}{\varepsilon}{}^{p}=\frac{E}{E+H}\cdot\overset{\circ}{\varepsilon} \quad (3)$$

It is remarkable to notice that the calculus of the dissipated energy during a cycle, produces the same result as the first scheme, which indicates the fact that for his type of behaviour a part of the energy is temporarily stocked in the material (here is the resort) and wholly restituted at downloading. This gives a physical illustration of the reversible hardening notion, when other rules of cinematic non-linear hardening are accompanied by a dissipation of this energy.

In uniaxial elastoplasticity, the loading – unloading conditions are expressed in general case through:

- the elasticity field if $f(\sigma,A_i)<0$ $(\overset{\circ}{\varepsilon}=\overset{\circ}{\sigma}/E)$
- elastic unloading if $f(\sigma,A_i)=0$ and $\overset{\circ}{f}(\sigma,A_i)=0$ $(\overset{\circ}{\varepsilon}=\overset{\circ}{\sigma}/E)$

- plastic flow if $f(\sigma, A_i) = 0$ and $\overset{\circ}{f}(\sigma, A_i) = 0$ $(\overset{\circ}{\varepsilon} = \overset{\circ}{\sigma}/E + \overset{\circ}{\varepsilon}{}^p)$

In the general case, the H model depends on the strain and / or the hardening variables; the value of the plastic model in the point (σ, A_i) is obtained by writing that the representative point at the loading during the flow remains on the limit of the elasticity field, and the resulted equation is named “the coherence equation”:

$$\overset{\circ}{f}(\sigma, A_i) = 0 \tag{4}$$

In these examples, the elasticity field is either fix or mobile, its length being conserved. The first case does not need any hardening variable, in the second, the X variable occurs and it’s depend on the actual value of the plastic strain which on the general case will become a tensorial variable. The type of hardening which is related to it is the cinematic hardening (fig.3.b). In the particular case illustrated by the rheological model, the evolution of the X variable is linear according to the plastic strain, this being the model of linear kinematic hardening (Prager, 1958).

Another elementary evolution of which the elasticity field could support is the expansion (fig.3.a), related to a material of which’s elasticity field records a growth in length, but it remains centrated in the origin; it is about an isotropic hardening (Taylor and Quinney, 1931), in the f function, the variable R which occurs, is the dimension of the elasticity field:

$$f(\sigma, X, R) = |\sigma| - R - \sigma_y \tag{5}$$

The evolution of this variable is the same, no mather of the sign of the cumulated variation of plastic strain, p, a variable which’s derivate is equal with the absolute value of the plastic strain rate, $\overset{\circ}{p} = \left|\overset{\circ}{\varepsilon}{}^p\right|$. So, it does not existing a difference between p and ε^p while the loading is monotone increase. In this case, the verification of the condition means expressing the fact that the actual value of the stress on the bound of the elasticity field:

- for kinematic hardening: $\sigma = X + \sigma_y$
- for izotropical hardening: $\sigma = R + \sigma_y$

which means the fact that the evolution law of the hardening variable is the one that determines directly the form of the extension’s curve.

The izotropical hardening is mostly used for important deformations (over 10 %). The kinematic hardening continuous to play an important role after the unload, even for big deformations and it is prevalent for small deformations and the cycle loadings, allowing the correct simulation of Bauschinger effect, meaning the fact that the elasticity stress in compression unloads related to the initial stress as a following of a pre-hardening in extension.

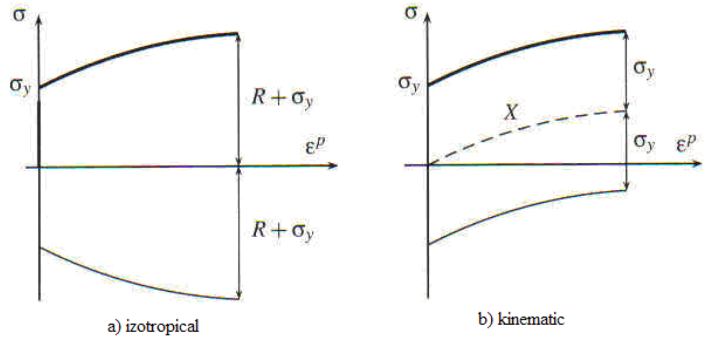

Fig.3- Representation of the two types of hardening.

3. Viscoelasticity and viscoplasticity

Viscoelasticity could be well defined through simple models Maxwell and Voigt which group a damper in series and in parallel (fig.4) or through the utilization of some composed models, such as Kelvin – Voigt or Zener (fig.5). The particularity of Voigt model is that it does not present instant elasticity, its function of relaxation not being continuous and derivable on pieces.

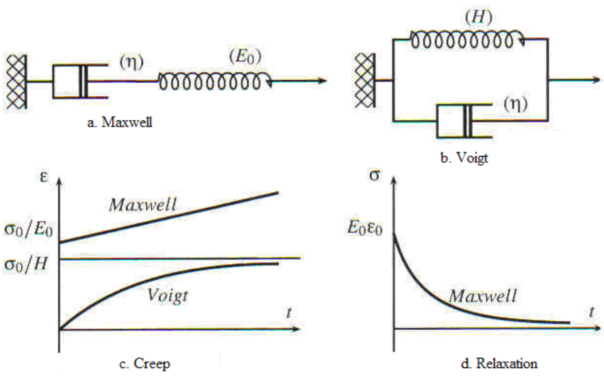

Fig.4- Representation of the simple models Maxwell and Voigt.

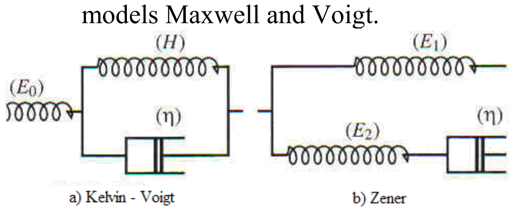

Fig.5- Examples of composed models.

The Voigt model is not used for relaxation, unless putting it under deformation is progressive and because of that, in order to effectuate the calculus of structure, it was associated with a series resort – the Kelvin – Voigt model. Under the effect of a stress σ_0 = const. in time, the deformation goes asymptotic to σ_0 / H, meaning that the creep is limitated. In the case of Maxwell model the creep's rate is constant and the disappearance of the stress during an experiment is total. By adding a simple damper to a simple model, there is the possibility to pass easily from a model which has a plastic behaviour, independent from time, to a viscoplastic model (fig.6), the resulted model being the generalized Bingham model. By eliminating the resort in series the viscoplastic rigid model is obtained, and by suppressing the resort in parallel, there will be no hardening.

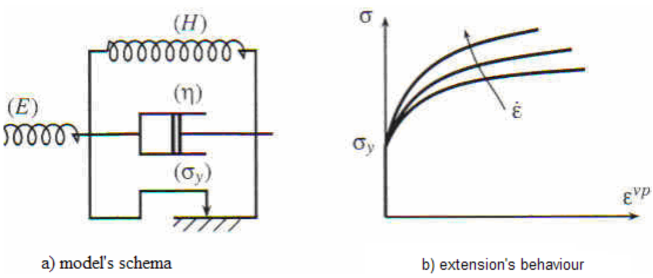

Fig.6- Bingham generalized model.

In the case of a viscoplastic model, there are 2 possibilities to introduce the hardening, by conserving the possibilities to action either upon the plastic variables – the case of the models with additive hardening, or upon the viscous stresses, when we talk about the models with a multiple hardening, a representative law describing this type of hardening being Lemaitre's law:

$$\overset{\circ}{\varepsilon}^{vp} = \left(\frac{|\sigma| K}{\ }\right)^{n} \mathrm{sign}(\sigma) \qquad \text{- Norton's law} \qquad (6)$$

$$\overset{\circ}{\varepsilon}^{vp} = \left(\frac{|\sigma| K}{\ }\right)^{n} p^{-n/m} \mathrm{sign}(\sigma) \quad , \quad \text{with} \quad \overset{\circ}{p} = \left|\overset{\circ}{\varepsilon}^{vp}\right| \qquad \text{- Lemaitre's law} \qquad (7)$$

where K, n, m – the material's coefficients.

4. Criterias

The used models, offer a uniaxial loading, shown an elasticity field, in the stresses domain and the hardening variables, for which it does not exist plastic flow or viscoplastic. The trace of this field on the stress axe is limited at a segment which can support a translation or an extension, sometimes even limited to a point. On the other side, certain models are capable to represent a maximum stress, supported by the material. The main classes of criterias in writing the model are:

a-criterias in which the hydrostatic pressure does not appear (the new criterion von Mises and Tresca);

b- criterias which take into account the hydrostatic pressure (the criterion Drucker – Prager, Mohr – Coulomb, the "closed" criterias);

c-anizotropical criterias.

4.1. Criterias in which the hydrostatic pressure does not appear

While the trace on the stress' tensor does not appear, the most simple criterion is the one that used only the second invariant of the stress' tensor of J, which is related to an ellipse in the space of the symmetric tensors, meaning the von Mises criterion:

$$f(\underset{\sim}{\sigma}) = J - \sigma_y \tag{8}$$

σ_y – the elasticity limit in extension.

This makes the maximum shears to appear in every main plan, represented through the quantities (σ_i - σ_j). Specific to Tresca criterion is not to keep from these quantities, only the highest values. Adding a pressure to each term of the diagonal does not modify the criterion's value. The expression, contrary to the von Mises criterion, does not define a regular surface (the discontinuity of the normal, angular points):

$$f(\underset{\sim}{\sigma}) = \max_{i,j}\left|\sigma_i - \sigma_j\right| - \sigma_y \tag{9}$$

It is interesting to compare these two criterias. Because being situated in the space of 6 (or 9) components of the stress' tensor is not an issue, we must see the boundaries of the elasticity field in the subspaces with 2 and 3 dimensions. The representations are being made:

a) in extension – shear plan (fig.7.a) the only components $\sigma = \sigma_{11}$ and $\tau = \sigma_{12}$ not being zero. The expressions of the criterias are reduced to:

- von Mises: $$f(\sigma,\tau) = \sqrt{\sigma^2 + 3\tau^2} - \sigma_y \tag{10}$$

- Tresca: $$f(\sigma,\tau) = \sqrt{\sigma^2 + 4\tau^2} - \sigma_y \tag{11}$$

b) in the main stresses' plan (σ_1, σ_2) (fig.7.b) when the stress $\sigma_3 = 0$:

- von Mises: $$f(\sigma_1,\sigma_2) = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2} - \sigma_y \tag{12}$$

- Tresca: $$f(\sigma_1,\sigma_2) = \begin{cases} \sigma_2 - \sigma_y & \text{if} \quad 0 \le \sigma_1 \le \sigma_2 \\ \sigma_1 - \sigma_y & \text{if} \quad 0 \le \sigma_2 \le \sigma_1 \\ \sigma_1 - \sigma_2 - \sigma_y & \text{if} \quad \sigma_2 \le 0 \le \sigma_1 \end{cases} \tag{13}$$

In a deviatoric plan, the criterion von Mises is represented through a circle, which is related to its interpretation, through octaedrical shear, the Tresca criterion is represented through a hexagon.

c) in the space of the main stresses each of these criterias of the main stresses each of these criterias is represented through a generating set cylinder (1, 1, 1) in the base of the defined curves in a deviatoric plan.

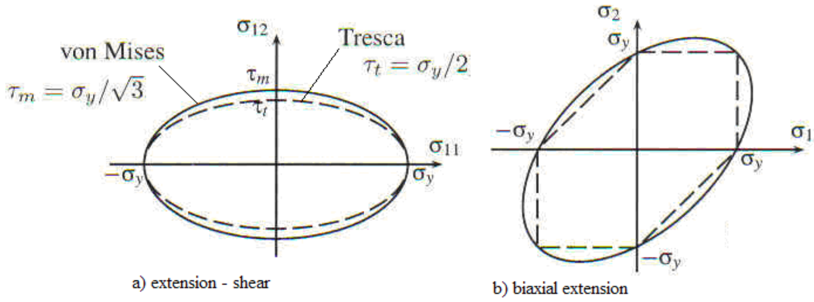

Fig.7- Comparison of the Tresca and von Mises models.

4.2. Criterias in which hydrostatic pressure is take into account

These criterias are necessary to represent the plastic deformation of the materials, lands or of the presence of fissures, the discontinuities of the materials, expressing the fact that a hydrostatic stress of compression it opposes to the plastic deformation. One of the consequences of their formulation is that they introduce a non-symmetry extension – compression.

The criterion Drucker – Prager is an expansion of the von Mises criterion, a linear combination between the second invariant and the trace of the stresses' in a deviatoric plan, being a circle:

$$f(\underset{\sim}{\sigma}) = (1-\alpha)\,J + \alpha\,I - \sigma_y \tag{14}$$

The limit of elasticity in extension remains σ_y and in compression is - σ_y / (1 – 2 α), α being a coefficient related to the material, α = 0 – 0.5 (α = 0 $\Rightarrow$ von Mises criterion (fig.8).

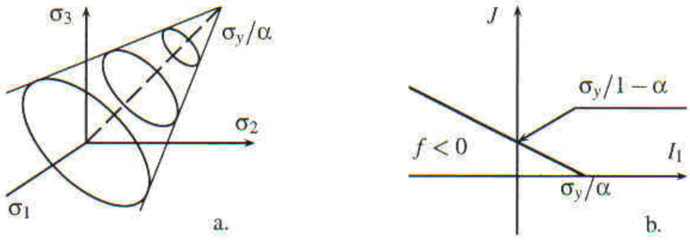

Fig.8- The representation of Drucker – Prager criterion: a) in the main stress space; b) in the I_1 – J plan.

The Mohr – Coulomb criterion has a certain resemblance with Tresca criterion, making the maximum shear to appear, but in the meantime the average shear, represented through the Mohr's center circle correspondent to the maximum shear:

$$f(\underset{\sim}{\sigma}) = \sigma_1 - \sigma_3 + (\sigma_1 + \sigma_3)\sin\varphi - 2\,C\cos\varphi \quad \text{with} \quad \sigma_3 \le \sigma_2 \le \sigma_1 \tag{14}$$

This criterion assumes that the maximum shear that the material can support (T_t, fig.9.a) is as bigger as the normal stress compression is higher. The admitted limit is an intrinsic curve in the Mohr plan:

$$|T_t| < -\tan(\varphi)\,T_n + C \tag{15}$$

where: C – cohesion; φ - the internal friction angle of the material; φ = 0, C ≠ 0 – pulverulent material; φ ≠ 0, C = 0 – pure cohesive material.

In a deviatoric plan (fig.9.b) is obtained a non-regular characterized through the values:

$$\sigma_t = \frac{2\sqrt{6}\,(C\cos\varphi - p\sin\varphi)}{3+\sin\varphi}$$
$$\sigma_c = \frac{2\sqrt{6}\,(-C\cos\varphi + p\sin\varphi)}{3-\sin\varphi} \quad , \quad p = -\frac{1}{3} I_1 \tag{16}$$

These two criterias show the fact that the material becomes infinite resistant in triaxial compression, behaviour who's not generally verified for the real material sensible to hydrostatic pressure. In order to simulate on, for example the compaction, is reduced to "closed models" in which the limit curve is defined through two pieces. As an example is the Cam-Clay model used for clays which's limit curve is defined by two ellipses in the plan (I_1 – J) or the "cap mode" model, which closes with an ellipse the criterion Drucker – Prager.

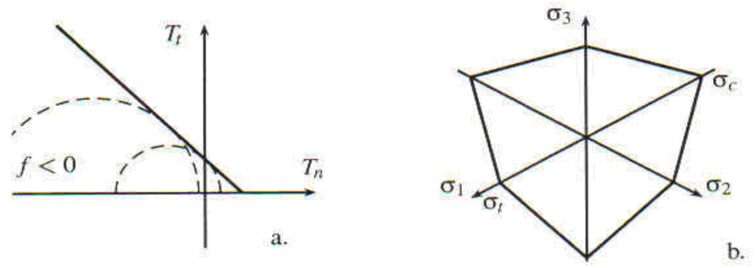

Fig.9- Mohr – Coulomb criterion: a) in the Mohr plan; b) in deviatoric plan.

4.3. Anizotropical criterias

If the loaded surface of a metallic material is measured experimental, it is seen that in the presence of unelastic deformations it records an extension, a translation and a distortion, the first two modifications being represented by the izotropical and kinematic hardenings, the last one not being considered by the current models.

There are anizotropical materials, such as composites materials. There are lots of possibilities of expansion of the izotropical criterias, in order to describe the anizotropical materials. The most general way is the fact that a criterion is a function of the components of the stresses tensor in a given base. The chosen form must be intrinsic.

The most general solution generalizes the von Mises criterion, using instead of J(σ) the expression:

$$J_B(\underset{\sim}{\sigma}) = \sqrt{\underset{\sim}{\sigma} : \underset{\approx}{B} : \underset{\sim}{\sigma}} \tag{17}$$

which introduces the tensor of 4th order $\underset{\approx}{B}$. Choosing for $\underset{\approx}{B}$ the tensor J so that $\underset{\approx}{s} = \underset{\approx}{J} : \underset{\approx}{\sigma}$ ($\underset{\approx}{s}$ - the associate deviator for $\underset{\approx}{\sigma}$) is obtain von Mises criterion.

Through considerations of symmetry, as for the elasticity case, the number of free components of the $\underset{\approx}{B}$ tensor could be reduced. Moreover, from the usual conditions, the assurance of the plastic incompressibility must be taken into account. If the material has 3 symmetric perpendicular plans, the terms are zero and there will only remain 6 components.

5. Conclusions

The general equations which describe one of the materials behaviour show the nature of the viscoelasticity, plasticity and viscoplasticity models, and the last two having in common the existence of an elasticity field.

It must be mentioned the fact that the deformation or the plastic flow is momentary, while the flow is being delayed. This thing has important consequences in writing the elastic – viscous – plastic behaviour. The effects should not be neglected, because they are will determined.

The majority of these effects (the oldening, the interactions with the environment, etc.) is well established and represents the object of simulations, specific to each studied case. The criteria's used for describing the behaviour, as well as the flow laws, must be chosen according to the studied material, its type, the presence of irregularities, fissures, discontinuities, structural defects and what is important especially for rocks, is their anisotropy. A nowadays case in geotechnic is the one of the izotropical materials, which's criterion must be written according to the main normal stresses, which are normal stresses and tangential on a perpendicular face on the axe of schistosity, meaning a parallel face with the izotropical plan of schistosity.

REFERENCES

[1] Hoek, E. – *Practical Rock Engineering*. Edition complete, 2000.

[2] Toderas, M. - *Modele de comportament vâscoplastic utilizate în mecanica pământurilor*. Buletin ştiinţific al Universităţii de Nord Baia Mare. Seria D. Volumul XIX, ISSN 1582–0548, 2005, pg. 715 – 722.

[3] Toderas, M. - *Les lois incrémentales pour les sols*. Annals of the University of Petroşani, Mining engineering. Vol. 6 (XXXIII). Petroşani, ISSN 1454–9174, 2005, pg. 46 – 55.

[4] Todorescu, A. – *Reologia rocilor cu aplicatii in minerit*. Editura Tehnica, Bucuresti, 1986.

MODERN TECHNOLOGIES FOR THE REALIZATION OF A GEOGRAPHIC INFORMATIONA SYSTEM (GIS) IN ORDER TO A SUSTAINABLE DEVELOPMENT OF THE AREAS AFFECTED BY THE MINING EXPLOITATION

NICOLAE DIMA*
OCTAVIAN HERBEI*
ROXANA ULAR**
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Abstract: Known as GIS (Geographical Information Systems), the instruments of visualizing and analyzing the geographical information ``constitutes today a field with a spectaculars evolution. The special GIS operations over the spatial information make from these instruments not only some efficacy instruments for making maps, but especially, irreplaceable instruments for analyzing the information that refer to the terrestrial surfaces. Also, the existent information can be reused, due to the fact that one of the main purposes of introducing the GIS technology consists in creating – by conversion in digital form – some efficient possibilities of maintaining and updating the information. During the last quarter of century, the GIS applications have been extended quickly into the following fields: natural resources, energy, transports, business, and public safety.

Key words: system, geographic information system (GIS), programs, methods, procedures, application.

1. Introduction

An information geographic system (GIS) is an assemble of persons, equipments, programs, methods and norms (rules) having as purpose to collect, stock, analyze and visualize the geographic data.

A GIS is an informatics system able to have and to use date that describes different places on the earth. It is a very powerful set of instruments for collecting, saving, transforming and visualizing the spatial data of real world.

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The main purpose for introducing the GIS technology consists in increasing the efficient possibilities for maintaining and updating the data.

A GIS is a system that allows the introduction, stocking, manipulating, analyzing and visualizing the data that have the spatial reference. A schedule of this definition can be put under the following shape:

1. geographical data (with spatial distribution);
2. systems of programs (software + that contains the procedures for analyze and special management);
3. calculation systems (hardware);

Being an informatics system, the GIS have all features specific to this category of systems as follows into the fig. 1.

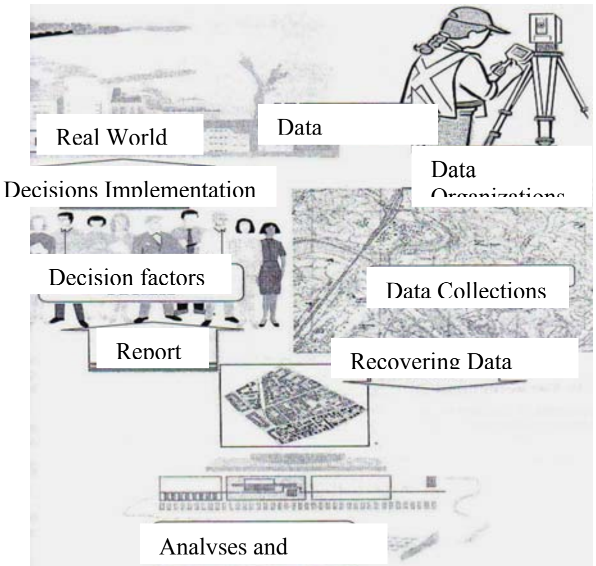

Fig. 1

Fields of using a GIS are as follows: environment, agriculture, landscape gardening, natural resources, transport, demography, and cadastre.

The GIS is an interdisciplinary field that involves many sciences as follows: geography, cartography, digital cartography, tele-detection, geodesy, statistics, and mathematics.

In case of exploiting the useful mineral substances at the open cast and underground casts lead to modifications of the terrestrial area that must be monitorized along whole exploitation in order to follow in time the evolution the phenomena of displacement and deformation of the terrestrial area, for protecting the existent constructions and for using in future of the area affected by the underground exploitation and the open casts making a GIS in order to make a decision for suitable development of these areas.

The main objectives of a GIS project are as follows:

- assuring the logistic support for development and plying the „Extended system for Local Implementation - EDIS ”
- developing the advanced techniques and instruments for spatial planning of the are at national, regional, rural, urban level according to the requirements of the suitable development at EU level.

2. Stages for implementation and using of a GIS

Mainly, the implementation and exploiting a GIS is developed in the following stages:

- *Defining the requests.* It involves a detailed study of the user's requirements. After this study there are established the quantitative and qualitative features of the final products (precision, structure, representing scale) and it is estimated the data volume;
- *Establishing the system functions*. Being known the requirements, it is necessary to be specified the functions which must be accomplished by the system for fulfilling its objectives.
- *Projecting the data base*. Into the GIS the data are stocked in thematic layers. It is necessary to be defined these layers and features (attributes) of the data stocked in each of them.
- *Choosing and procuring the equipments and programs*. Among different possibilities for implementing a GIS must be chosen the variant that assures the totality or majority of the functions established as being necessary in conditions of maximum efficiency.
- *The personalization of the programs at the application requirements*.
- *Loading the data base. It consists in making the digital map by completing the layer data.*
- *Exploiting the GIS*. This is developed in three main directions: **updating, analyze, reports**:

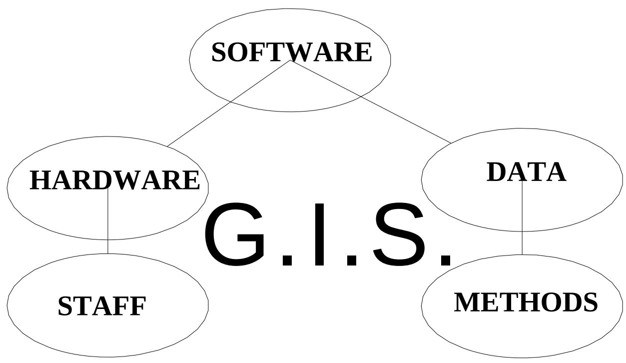

Fig. 2 Structure of information systems

3. Data models in digital map

In a digital map, all four components of a geographic data are expressed digital through values organized in a specific structure, forming a geo-database. This contains data that define the position and shape of the represented entities (graphical data) and also data that are expressed the features of these entities (attributive or textual data).

There are used two main models for organizing the digital maps:

- Into ***raster model*** the represented territory is divided in many cells, which are especially squares, having all the same dimension.
- Into the ***vector model*** it is considered that any geographic entity can be represented as a *point*, or a *line* (or arch), or as a *area* (or polygon). With a point it is represented punctual phenomena (for example altitudes). The lines are formed from many points linked between them and they represent for example administrative limits or any other limits. An area is delimited by lines and it is used to be represented entities or phenomena for which the area is semnificative (administrative territories, lakes, types of vegetation, etc.)

For the digital map of the information system for administrating the towns it will be used the vector model.

In both models the geographic data of a certain territory are organized on many *layer*s or thematic *coverage*.

The digital map of the territory is represented by the amount of all defined layers. It could be build a derived map elaborated from a layer or a certain combination of existent layers.

4. Accomplishing the digital map

The digital map must be made by valorizing all the existent resources based on a good analyze of these content and the involved costs, following to assure the necessary quality, in conditions of maxim efficiency. Into the fig. 3 it is presented a general scheme of principle of sources that can be taken into consideration for making the digital map.

Acquisitioning the data is the process of conversion of the data for the shape in which it is exists in one that can be used by a GIS.

In order that the spatial data can be obtained from a great variety of sources, it must be done the difference between acquisitioning new data and of the existent one.

5. Structure of a G.I.S. application

The GIS technology is used in all fields for which the spatial information is relevant, so the fields that use the geographic map for stocking, analyze and representing.

No matter what is the field, any GIS application includes a spatial data base (digital map) and a program (soft) that exploit these data base.

The digital map must contain the spatial data specific to the field of the application. In order to furnish the useful information, the data base must be actual, that means to represent correctly the terrain (geographic space) which is continuously in changing.

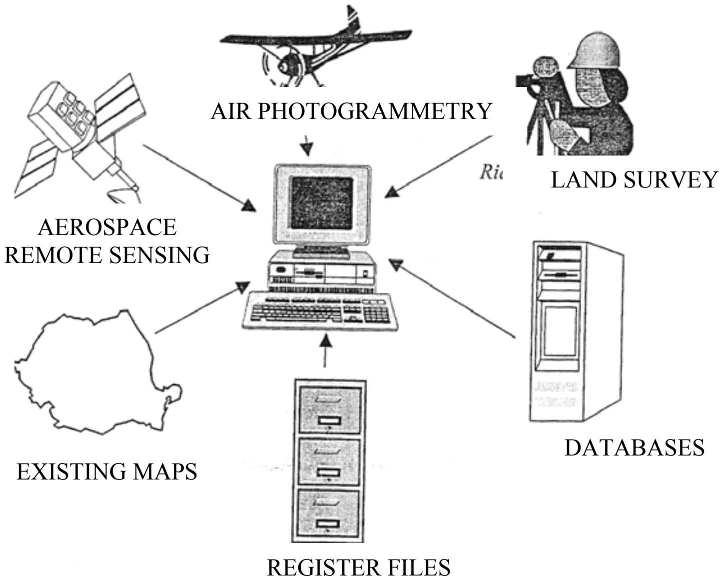

Fig. 3

The soft contains many analyze functions of spatial data contained into the digital map and of visualizing the resulted information, specific to the application field.

6.Monitorising the deformations and displacements of the terrestrial area under the influence the underground exploitations

After the exploitation of the underground and opens casts substances there are formed holes called exploitive areas. If the exploitation of the substances is made underground and through open casts are limited by the closed areas or there are created free area (stages). By creating the exploitive areas, the equilibration of the surrounding rocks is deranged. The tendencies of reestablishing the equilibrium produce a displacement of the rocks through appearing some compass force or compression force, which produce some cracks deforming the explicated space and the terrestrial surface.

The displacement and deforming phenomenon of the rocks from the surface under the influence of underground exploitation and open casts show specific features of each substance. The main factors, which determine the displacement features, are as follows:

- the physical and mechanical properties of the rocks;
- the geology and hydrology;
- the dimension and position of exploited space;
- the exploitation methods and speed before of mining works;
- the relief and area of the terrain.

After the exploitation of the mineral substances at the ground there appear some areas as follows:

- breakdown;
- cracks;
- transition.

The movements of the terrestrial areas after sections those are well determined in study mining activities reference systems with topographical and geodesic measurements.

The cracks can be represented and studied through maximum deformations or along the direction or declination of the direct and transversal substances.

The determination of the parameters that define the displacements and deformations of the terrestrial areas and prognosis of these phenomena it can be done classical measurements in alignments and surveying stations.

The deformations of the terrain surfaces after the underground exploitations make necessary to be observed intensively the deformations through different procedures of great precision, one of which being the GPS technique. This great precision technique can be used where the existent geodesic network is not enough developed, is not homogeny or not offer the requested precision for studying the deformations of the terrain.

Creating the network for determining the deformations based on GIS

For studying the modifications of the morphology of terrestrial area after underground exploitations by using GPS technique it was designed and made a network a network of geodesic points of references, composed in tow rings: and exterior one or interior one. The points from the exterior ring have been placed at over 10 km distance from the limit of the mining field. The interior ring consists the points situated at few km from the mining field limits, to which it belongs the state geodesic network of order 1 and 2, the points situated near the mining works, points of alignments of observation, and other basic points for leveling and gyroscopically observations.

The selection of the points was made by taking into account the possibility for observing the GPS signals and the position into the network, in order to obtain optimal results. A sketch of the network is shown into the fig. 4.

Determining the coordinates of the network points with the GPS technique was made four times in two years. Using the differential method, referring to the coordinates of the geodesic network, in session of 1.5 hours, made the measurements. For determining the coordinates of the reference points it was introduces the

Gauss-Krüger system on the ellipsoid WGS-84. The analyze of the precision of the network showed that the medium error was of ±1,52mm, while the maximum errors weren't more than ±3mm.

The medium errors of determining the heights weren't more than ±3mm (in medium, ±1÷3mm).

Determining the deformations of the terrain by reaccepting directly the GPS signals

It is known that the deformation of the terrain area can be evaluated by using some parameters correspondent as follows: the sinking (vertical displacement), the horizontal deformations, the declination and the curve. Among them the sinking can be determined the easiest and more precisely (precision leveling). Similarly, the horizontal deformation can be determined by comparing the distances between the points.

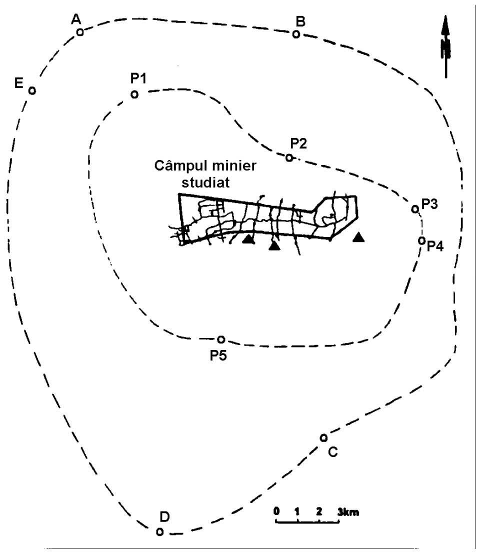

Fig.4 Sketch of the network of GPS reference points

By using the GPS system for determining precisely the coordinates of the linking points allows to be resolved these difficulties. The calculations showed that the unclosing between the real horizontal displacement and the one deduced from the GPS observations wasn't more than ±2mm (after eliminating the unclosing errors was ±1mm on each axe of plane coordinates). The height deviation wasn't more than ±2mm. So it was proved a real precision for determining the network points and possibility of using the GPS technique for determining the terrain deformations.

The result of connecting the deformations measurements at the GPS points network

Determining the sinking of the area and the undulation function of the cvasi- geoid

As it is known by processing the GPS signals it is possible to be obtained the geodesic coordinates B, L and h (latitude, longitude and altitude) of a point into the geocentric reference system, the altitude being obtained to the surface of the reference ellipsoid WGS-84. Crossing to the national reference system needs to be determined the ondulation function of cvsi- geoid, the determination of the distance between the cvasi-geoid and ellipsoid. This function allows the determination of the normal altitude based on the values obtained through GPS measurements.

This function was appreciated based on GPS measurements from all reference networks and the precision leveling made over some points from the network that was connected to a control point. This function allowed to be determined the heights of the points of connection of the alignments of observations based on GPS measurements.

Determining the horizontal displacements

For determining the precision of horizontal displacements obtained through GPS it was accomplished the connection of an observation alignment through a poligonation (angular and linear measurements) at the network of reference points. The measurements were made by using an electronic precision theodolite (the medium error for measuring an angle $\pm 5^{cc}$, the medium error of measuring for the length ±1mm). After connecting the reference ends, the calculations were made into the Gauss-Krüger system. The measured lengths were reduced to the ellipsoid; having assured the stability of the end points of the alignment, it was obtained a medium error of the coordinates of ±1mm, and taking into consideration also the error of the coordinates of the connection points was obtained the value of ±3,2mm.

7. Conclusions

1. The diversity of the processes that produce modifications into the morphology of the surfaces of mining fields need a frequency monitoring the deformations. If the state of the network requests it will be the GPS technique.

2. The measurements and experiments had as results a very high precision for determining the spatial coordinates of the GPS points of the GPS points of the network; the medium error of determination is not more than ±3mm. So there are assured better conditions for connecting the geodesic observations necessary for obtain the deformations that by using the classical methods.

3. Of great importance for assuring a high precision is a precise network of reference points. These points must be situated in an opened area at a distance of few km but not more than 10 km from the mining field limits. A reference network should be composed in no more than 10 points.

4. The reception of the GPS signals will be made with 5 or 6 receivers.

5. The reference network with spatial coordinates determined by the GPS observations allow a fast and economic connection of the measurements made for obtaining the deformations of the surface and monitoring the movements of landfall.

6. The connection of the angular or linear measurements of precision to a network of GPS points has as result an improvement of to times of the precision, in comparison with classical poligonation.

7. From the point of view of the precision, the determination of the altitude for the points through GPS is equivalent to the connecting to a leveling detail having a length of few km and allows the determination of the vertical displacements with a medium error of ±2mm.

8. The results of the monitoring the horizontal and vertical displacements of the points led to obtaining some precisions of the 3 mm, if it is used the GPS system.

Bibliography

[1]. Dima, N. , *Geodesy,* Universitas Publishing, 2006.
[2]. Dima, N., Herbei O, etc, *General Topography and elements of mining topography*, Universitas Publishing, 2005.
[3]. Dumitriu, G. , *Information Geographic System*, Blue Publishing, 2001.
[4]. Neuner, J. , *Global Positioning Systems,* MatrixROM Publishing, Bucharest, 2000.
[5]. Herbei, O., *Mathematics cartography, elaborating and laying down the maps*, Eurobit Publishing, Timişoara. 2002.

THE TIME'S INFLUENCE IN THE MONITOR PROCESS OF THE MOVEMENT AND DEFORMATION PHENOMENON OF THE TERRESTRIAL SURFACE IN THE CASE OF THE UNDERGROUND MINING EXPLOITATION

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Abstract: The time influence on the pursuing of the deformation and movement phenomenon of the terrestrial surface has a special importance, being one of the main factors which define the studied phenomenon.

Key words: time, deformation, movement, surface, underground.

1. Introduction

The exploitation of the underground deposits is one of the most complex technologies.

Because of the opening, preparation and underground exploitation of the solid mineral deposits, in the terrestrial crust remain a series of voids, which cause the gravitational tensions' redistribution and which determine exceeding of the rock's resistance in their concentration points, followed often by the deformation and collapse of the formations in the respective mining works' ceiling and walls.

The stadium of the underground exploitation on the surface is necessary for pointing out the movement and establishing the protection measures of the surfaces executed objectives and even of the surface itself.

The parameters that characterize the phenomenon must be well determined from the topographical measurements, their evolution and prognosis will lead to some mining damages avoid, which could affect the surface as well as the constructions situated on the surface.

The massif movements produced by the deposits' underground exploitation depend on time, as the geodesic observations and measurements show.

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After the layer's exploitation these modify gradually, from zero to a certain final value, which they reach asymptotically that is after an infinite period of time.

The time factor depends on the rock's type and behavior, on the exploitation depth, on the exploitation method and speed.

We presume that on the distance r (the influence ray in the depth z) of given point M, which means in point A (fig. 1) starts the exploitation of the horizontal layer, after the time t, the frontal line will be in B position, then:

$$AB = a = v \cdot t \tag{1}$$

In which *v* is abates' advancing speed.

As a consequence of the layer's exploitation, a point M from the massif suffers a certain movement, which vertical component is w_1 and the horizontal one is *u*. We will discuss mainly the horizontal component. Generally it depends on the coordinate *z*, the influence ray *r*, abates' advancing speed *v*, the time *t*, the exploitation depth H and the rock's properties.

In order to find a dependence function we use a basic principle, the one that the

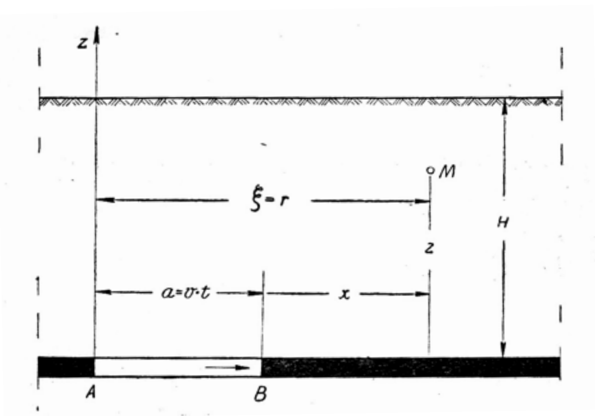

Fig. 1

movement speed of a certain point in the massif is proportional with the difference between the movement's final value, when the work front has stopped in point B, and the movement's size which takes place at a certain moment, *t*.

$$\frac{du}{dt} = c(u_k - u) \tag{2}$$

where: *c* – quotient that depends on the rock's properties situated above the exploited layer and on depth H.

The final value of the movement u_k depends on the size of the exploited space a and on time, because $a = v \cdot t$.

The equation's general integral (2) is the following function:

$$u = A \cdot e^{-ct} + c \cdot e^{-ct} \int u_k \cdot e^{-ct} dt \tag{3}$$

The constant A must be determined in initial conditions.

2. The movements' calculations

Three stages for the massif's movement are distinguished:

Stage I – when the front approaches the given point.

$$0 \le t \le \frac{r}{t}$$

The movement's final value is:

$$u_k = -\frac{n \cdot w_{\max}}{r \cdot z}\left[\frac{r^2}{6} - \frac{\xi^2}{2} + \frac{\xi^3}{3r} + a \cdot \xi - \frac{a \cdot \xi^2}{r} + \frac{a \cdot^2 \xi}{r} - \frac{a^2}{2} - \frac{a^3}{3r}\right]$$

where: n is a constant, which characterize the massif,

$w_{\max}$ the massif's final submersion, after the total extraction of the layer.

In this formula we replace: $\xi = r$, $a = v \cdot t$

And we get:

$$u_k = -\frac{n \cdot w_{\max}}{r \cdot z}\left(\frac{v^2 \cdot t^2}{2} - \frac{v^3 \cdot t^3}{3r}\right) \tag{4}$$

s value is replaced in equation (3), and after the integration and the initial conditions *l*=0, *u*=0, we get the following formula for the horizontal movement:

$$u = -\frac{n \cdot w_{\max}}{r \cdot z}\left[\begin{array}{l}\frac{v^2 \cdot t^2}{2} - \frac{v^2 \cdot t}{c} - \frac{v^3 \cdot t^3}{3r} + \frac{v^3 \cdot t^2}{r \cdot c} - \frac{2v^3 \cdot t}{r \cdot c^2} + \\ + \frac{v^2}{c^2}\left(1 + \frac{2v}{r \cdot c}\right)\left(1 - e^{-ct}\right)\end{array}\right] \tag{5}$$

The absolute value of the movements increases in this period from $u_0 = 0$ to a certain value u_1 which can be calculated replacing $t = \frac{r}{v}$ in the relation (5).

After the ordination of the terms we will have:

$$u_1 = -\frac{n \cdot w_{\max}}{r \cdot z}\left\{\frac{r^2}{6} - \frac{v^2}{c^2}\left[1 + e^{-\frac{cr}{v}} - \frac{2v}{r \cdot c}\left(1 - e^{-\frac{cr}{v}}\right)\right]\right\} \tag{6}$$

Stage II – when the front moves away from the given point on a distance that equals its influence ray (fig. 2). This corresponds to time:

$$\frac{r}{v} \leq t \leq \frac{2r}{v}$$

The movement's final value in this interval is:

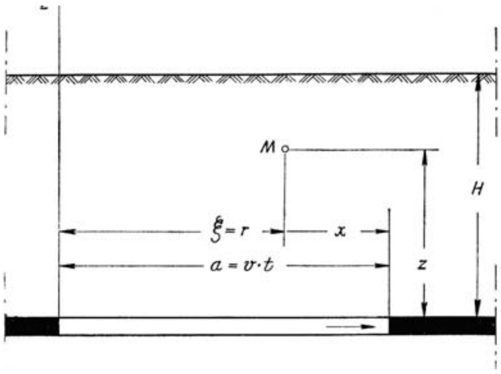

Fig. 2

$$u_k = -\frac{n \cdot w_{\max}}{r \cdot z}\left[-\frac{2}{3}r^2 + 2r \cdot v \cdot t - \frac{3v^2 \cdot t^2}{2} + \frac{v^3 \cdot t^3}{3r}\right] \tag{7}$$

By using the above equation in equation (3) we get the formula for the momentary movement value.

$$u = -\frac{n \cdot w_{\max}}{r \cdot z}\left\{\begin{array}{l} -\frac{2}{3}r^2 + 2r \cdot v \cdot t - \frac{2r \cdot v}{c} - \frac{3}{2}v^2 \cdot t^2 + 3\frac{v^2 \cdot t}{c} - 3\frac{v^2}{c^2} + \frac{v^3 \cdot t^3}{3r} - \\ -\frac{v^3 \cdot t^2}{r \cdot c} + 2\frac{v^3 \cdot t}{r \cdot c^2} - -2\frac{v^3}{r \cdot c^3} - \frac{v^2}{c^2}\left[1 - \frac{2v}{r \cdot c}\left(2e^{\frac{rc}{v}} - 1\right) \cdot e^{-ct}\right] \end{array}\right\} \tag{8}$$

Stage 2 is characterized by the fact that the movement's absolute value reaches the maximum, which takes place after the passing of the exploitation line below the given point.

The values u_k and u become equal in this time, and the speed *du/dt* equals zero. From this moment on the speed modifies its direction, the point begins the inverse movement, the values of u decrease and they reach at the end on this stage (*t=dr/v*) the following value:

$$u_2 = -\frac{n \cdot w_{\max}}{r \cdot z} \cdot \frac{v^2}{c^2}\left[1 - e^{-\frac{2rc}{v}} - \frac{2v}{r \cdot c}\left(1 - 2e^{-\frac{cr}{v}} + e^{-\frac{2cr}{v}}\right)\right] \tag{9}$$

In the formulas (8) and (9) the exponential function can be solved in series, taking its first six terms.

Stage III – when the layer's line has distanced itself from the point on a distance higher than the influence ray *r*. This has the following correspondent time:

$$\frac{2r}{v} \le t \le \infty$$

The movement's final value in this stadium equals zero. As a consequence:

$$u = u_2 e^{-ct}$$

$$u = -\frac{n \cdot w_{\max}}{r \cdot z} \cdot \frac{v^2}{c^2}\left[1 - e^{-\frac{2cr}{v}} - \frac{2v}{r \cdot c}\left(1 - 2e^{-\frac{cr}{v}} + e^{-\frac{2cr}{v}}\right)\right] \cdot e^{-ct} \tag{10}$$

As time passes, u tends gradually to zero. So, we can see that by approaching the exploitation front below a certain determined point of the massif, this point suffers a decrease of the horizontal movement u in the direction of the approaching front than, after its passing, it stops and begins the inverse movement, while the movement disappears gradually.

The horizontal maximal movement u_{max} can be determined by the curves u_k and *u* (fig. 3). This takes place in the curves' insertion point. Its value depends on the influence ray r, at the level of the given point and on the rock's properties (parameter *c*) and on the exploitation speed *v*.

3. The deformations

In order to determine the deformations we consider a mobile coordinate system, which origin is in the front. From figures 1 and 2:

$$v \cdot t + x = r$$

From where: $t = \dfrac{r - x}{v}$ (11)

Replacing in relation (5) for the interval I and deriving the above expression in report with the variable *x* we get the specific horizontal – longitudinal deformation:

$$\varepsilon_x = \frac{\partial u}{\partial x} = -\frac{n \cdot w_{\max}}{z}\begin{bmatrix} -\left(\frac{r-x}{r}\right) + \left(\frac{r-x}{r}\right)^2 + \frac{v}{c \cdot r} - \frac{2v}{c \cdot r}\left(\frac{r-x}{r}\right) + \\ + \frac{2v^2}{c^2 \cdot r^2} - \frac{v}{c \cdot r}\left(1 + \frac{2v}{c \cdot r}\right) \cdot e^{-c\frac{r-x}{v}} \end{bmatrix} \tag{12}$$

In period II , for *x*=-*r* we will have:

$$\frac{\partial u}{\partial x} = -\frac{n \cdot w_{\max}}{z} \cdot \frac{v}{c \cdot r}\left[1 - e^{-\frac{2cr}{v}} - \frac{2v}{c \cdot r}\left(1 - 2e^{-\frac{cr}{v}} + e^{-\frac{2cr}{v}}\right)\right] \quad (13)$$

The exponential functions are serially solved.

Besides the longitudinal deformations $\frac{\partial u}{\partial x}$ in certain cases an important role have the transversal deformations $\frac{\partial u}{\partial z}$, for example, in wells' case, these lead to the vertical axe of the well deformation, which can limit the possibility of the well's use during the massif's movement.

4. Conclusions

The time is a parameter that has an influence in the surface's movement and deformation phenomenon and which, together with the geological and mining factors (the exploitation method, the mining works' dimensions on inclination and direction, the conduct way for the mining pressure, the advancing speed of the work fronts and the deposits' exploitation degree) which define this phenomenon, accomplishes a wide view on the terrestrial surface's changes under the influence of the underground exploitation.

The use of the topographical methods in checking this phenomenon which determines the size of the areas affected by the underground exploitation can realize, after successive determinations, future prognosis of the phenomenon and measures that are mandatory for the protection of the surface constructions.

References

[1.] Herbei O., "*Determinarea parametrilor de deformare a suprafeţelor terenului şi cercetarea stabilităţii construcţiilor amplasate la suprafaţă sub influenţa exploatării subterane în cazul zăcămintelor de minereuri",* PhD Thesis, 1995

[2.] Litwiniszyn j., "*W plyw czasu na stan odksztalcenia I naprezenia gorotworu",* Archiwum Gornictwa I Hutnictwa, t. III, zesz. 4, 1955

[3.] Budryk W., "*W plyw wyeksploatowania poktadu na stan naprezen I odksztalcen w gorotworze"*, Archiwum Gornictwa I Hutnictwa, t. III, zesz. 4, 1955

THE ACTUAL SITUATION OF NATIONAL HARD COAL COMPANY'S SETTLES PONDS AND FUTURE PREVISIONS

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Abstract: The paper presents the actual situation of National Coal Company's settles ponds and future previsions

Key words: settle pond, waste dump material, dump, micro cyclone, flotation

National Coal Company (C.N.H. S.A. Petrosani) is the main economic agent from Jiu Valley. The main activity object of the company is coal extraction and preparation.

The exploitation was made in underground (1000 m under surface). The coal bedding has a high content of methane, and because of that the exploitation must be done with special protection measurements.

Because of the mining restructuring, many mines were closed in this moment National Coal Company has 7 open mines.

For this reason all production is actually concentrated in one preparation plant (Coroiesti) (Photo 1) and there were closed Petrila and Lupeni preparation plants. Also Coroiesti preparation plant was modernized.

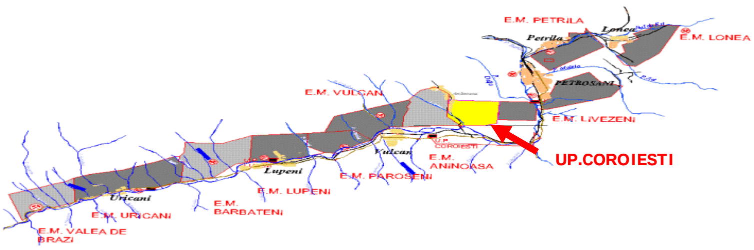

Photo 1. UP Coroiesti locating

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Modernizing Coroiesti preparation plant (photo 2) is an investment in Paroseni project and contains also the modernize of thermal power station Paroseni (4 - th block).

Photo 2. Coroiesti before and after modernizing

Coroiesti processing plant is situated in the western area of Valea Jiului mining basin, in Vulcan city. The raw coal processed at Coroiesti comes from Vulcan, Paroşeni, Lupeni, Uricani, Livezeni, Petrila and Lonea mines.

From the technological process results as a waste a coal sludge which is transported and stocked in two settle pond.

The settle pounds are situated downstream processing plant, at 500 m and have 1.5 km length next to West Jiu River, until to the eastern Aninoasa city's limit. At west it is the main processing plant building, at south Mohora stream and at North, West Jiu River

The access in the area is made on rail train and 66 A Petroşani - Uricani county road. The access in the settle pond's perimeter it is made through the main processing plant yard.

Both settle pond are "field" type and are realized by closing some areas with dams made from mining waste from mine working.

No 1 settle pond has 2 compartments (A and B) (photo 3) that functioned alternative in time, with a 14 ha surface and a 3.000.000 m³ volume.

Photo 3. No 1 settle pond with 2 compartments (A and B)

Natural field altitude under 1 settle pond is between 579 m and 589 m over the see and dam's altitude between 600,5 m and 608.9 m over the see. From the last measurement B compartment's dam was height increased with approximately 2 m. The initial designed dam had 587.10 m over the see, the maximum height.

Number 2 settle pond (photo 4) it is situated in the continuation of the first settle pond, has 1 compartment, 11 ha surface and 2 000 000 m³ volume.

Natural field altitude varies between 576 m and 584 m over the see and dam's altitude between 594.5 and 599.3 m over the see toward 587.10 m the initial designed altitude.

Photo 4. No 2 settle pond

Both settle pond are bordering in B importance evaluation group.

The settle ponds have no evacuation system for cleaning water because of their oldness and because were exceeded the initial designed altitudes. Along time they were used alternatively.

Contour dams and compartment dams were initials executed in a project. The seeding dam was executed with an interior clay screen with 4.30 the maximum altitude.

Contour dams and compartment dams were height increased during exploitation, using waste dump material. The total length of dams is 1600 m for no.1 settle pond and 1300 m for no. 2 settle pond.

Because of their emplacement and their constructing solution, the settle ponds can put in danger the adjacent area only if one of the dams is giving up. This thing will due to the discharge of the coal sludge from the settle pond in Jiu River and adjacent area.

For preventing the accidents were made arrangement works (foto 5) for the West Jiu riverside between no. 1 settle pond and processing plant's yard. The arrangements works were made on 614 m length and protect no. 1 settle pond (A and B compartment) dams all over the Jiu River.

Photo 5. Arrangement works for the West Jiu riverside

The coal sludge resulting from the washing – classification technological process it is transported in two radial sediment traps for thickening and then if it is not take over by the Cleaning Station it will be pumped into the settle ponds.

Over the time the coal sludge was stored unequal in all tree settle ponds compartments, term the concrete condition for that moment.

The stored coal sludge has in its composition mainly clay and coal dust with the following characteristics:

- Density - 1,25 ÷1,4 kg/dm³
- Concentration -200÷500 g/l
- Ash content - 60÷70 %
- Granulometry - 0÷1 mm
- Fuel value -2300-2500 kcal/kg

The maximum slime pulp volume pumped in the settle ponds is 900 m³/ day (in the winter period) and 120 m³/ day (in the rest of the year).

Whereas the settle ponds are now to the full storage capacity, are necessary aggradations works for dams. But these works will put in danger the settle ponds security. Because of that were searched other solutions for solving the environmental and security problems.

Were analyzed 3 technical alternatives:

1. No. 2 settle pond reclamation with evacuation systems for clean water and conserving no 1 settle pond (compartment A)
2. Empting the settle ponds and storing the material in a different area

3. Empting and valorize the existent coal sludge and temporary storage of resulted wastes (clay) until they are also valorize

The first alternative *No. 2 settle pond reclamation with evacuation systems for clean water and conserving no 1 settle pond (compartment A)* has like advantage increasing the storage capacity for 8.3 years but with high investment costs, high time span for works, the impossibility for reusing no 1 (A compartment) settle pond.

Regarding the second alternative *Empting the settle ponds and storing the material in a different area,* has like advantage assuring the re arrangement and endowment conforming with legislation but with high investment for equipment acquisition, high time span for material processing, the space absence for storing drained coal sludge, increasing water consume and increasing the unsecured grade for the settle ponds.

In these conditions the perspective for Coroiesti settle ponds will be the third alternative *Empting and valorize the existent coal sludge and temporary storage of resulted wastes (clay) until they are also valorize*

The alternative will have the following phases:

a) Empting works – will be done starting no. 1 (A compartment) settle pond's southern dam, the most approached to the processed plant yard. The empting will be dome with a hydraulic crane with long arm which permits the settle pond excavation in a longitudinal sense from suffices distance; in this way the surrounding dams will not be affected. The extracted coal sludge is deposited in a silo which aliments a rotate screen for retaining suspension material. A centrifugal pump will send the diluted coal sludge through a treatment unity for fine particles (situated next to the settle pond) to an appropriate field.

b) Coal sludge processing and treatment - Will be made in a special treatment unity constructed for coal sludge from Coroiesti, which permits revaluation of energetic and mineral content. The treatment has the following processing methods and parts:

- Coal sludge conditioning and dilution control
- Granulometric separation by cyclone method with the separation purpose of the immediate valorizing fraction from the ones who need preparation.
- Gravimetric separation technology with the improving purpose of energetic fraction quality.
- Depending of marketing price (quantity and quality) and depending of energetic potential of material will be approach special techniques for ultra fine particles treatment through different methods (micro cyclone, flotation, fine particles agglutination of coal with the obtaining purpose of superior combustible)

Washing water system and clay's treatment - The ultra fine fraction (which contains clay) will pass through a cleaning and dehydrating unity equipped with press filters. After that the water in introduced again in the process and the dehydrated and agglomerated clays will be valorize for extern use (construction material industry) or like tight material for the new basins or waste deposits. The whole process will be lead by a supervising central unity which permits a permanent vision on the functioning parameters.

The alternative has like advantages:

- The processing of coal sludge resulted from technological process without transporting and putting it in the settle ponds
- It will no make auto transport on dams (so they are no vibrations)
- Longitudinal excavation permits progressive release of fragile dams
- It isn't necessary water contribution in basins
- The re utilize possibility and the arrangement possibility of the settle ponds conforming with the standards
- The re arrangement of the dams
- The waterproof possibility with clay from the process

The alternative's disadvantage is that because the initial investment is very high and it can not be supported by National Coal Company, it is necessary to find a company which wants to invest in processing and valorizing the coal sludge.

Bibliography

[1]. IPROMIN, *Safety stage evaluation for no 1 and 2 settles ponds from Coroiesti –* Bucharest, June 2005.
[2]. CNH SA Petroşani *Project for following no 1 and 2 settles ponds from Coroiesti.*
[3]. IPROMIN & S.C.CAZAN IMPEX SRL *Pre feasibility and feasibility studies regarding „No 2 settle pond re arrangement conforming to legislation and rearrangement of no 1 settle pond (compartment B) as a functioning reserve"* Bucharest 2005 - 2006.
[4]. CNH SA Petroşani *Attribution documentation for empting the settle ponds from Coroieşti* –2007.

ANALYSIS OF THE STRESS AND STRAIN STATE AROUND THE TOP COAL CAVING FACES, IN THE CASE OF COAL SEAM NO.3, FROM JIU VALLEY COAL BASIN, USING THE FINITE ELEMENT METHOD

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Abstract: The top coal caving mining of the coal seam no.3, from the Jiu Valley basin, because of the large masses of rocks, which are put in motion, determines the stress and strain state developed around the mining faces to be very complex. Beside of the stability problems of the underground mining workings that arise, these contribute, also, to the appearance of certain phenomenon that produces accidents, sometimes, even very grave. This paper presents the stress and strain state analysis for some situations, encountered more frequently in practice, modelled with the aid of the finite element method.

1. General considerations

The stress state developed in the surrounding rocks is fundamentally modified by the consequence of coal seam mining and is accompanied by deformations, failures and displacements of rocks, with various intensities.

The development of the stress and strain state in certain coal faces in Jiu Valley basin lead to the behaviour of some dangerous geomechanical phenomenon for the personnel's and equipments' security. Thus, during the years 1999-2004, in the influence zones of the top coal faces of Lupeni, Uricani and Vulcan mines, 4 cases of grave accidents were produced, involving human life loses injuries, material damages and important coal reserves immobilisation [5].

The main factors that determine the stress and strain state around the top coal caving faces are the followings: the natural state of stress; the excavation sizes; the

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overburden strata of the coal mining face; the geomechanical characteristics of coal and surroundings rocks; the face support characteristics; the spatial position of other excavations in the vicinity of the coal face [1].

The description of the stress-strain state of the top coal, in the case of the top coal longwall mining faces, can be synthesised thus: the top coal motion begins from a zone located in front of the face line, at the level of the first traction plane (the beginning plane of motion, for the coal with less hardness, is between 15m and 20m, before the face and at 6-10m, for the medium hardness); the main displacement of the top coal before the face is horizontal, and behind the face, it is vertical, resulting a top coal tipping toward the gob area; the induced fractures' density in the top coal increases, determining a progressive crush of the coal toward the drawing door [3].

The influence domain of the goaf is divided in the following zones (fig.1): a) the roof face zone, where the roof rocks load the support under the mining pressure influence, producing the coal face convergence; b) the zone ahead of the coal face, where the abutment stress acts and which decreases continuously, exponentially, toward the natural stress of the massive; c) the zone behind the face (the gob area), where the stresses are greatly reduced because of the rocks' distressing by the failure phenomenon and increase progressively, tending to stabilise toward a maximum value. After the width of the gob area, the previously presented zones are divided into the following influence areas, where the stresses take different values: 1-the middle zone of the coal face; 2-the side zones of the panel; 3-the boundary zone of the adjacent panels [1].

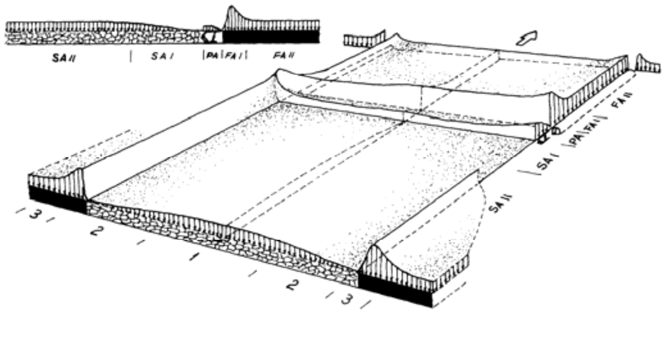


Fig.1. Block diagram with the main influence zone around a longwall mining face, in the case of thick coal seams, with middle and gentle dip (Onica, 1995 [1])

Some authors delimit the abutment zone in front of the coal face, in three behaviour zones, thus: 1-fractured zone, of flowing; 2-the non-elastic deformation zone; 3-elastic zone (where the stresses decrease continuously toward the initial stresses), and other authors, similarly, define the following four zones: 1-the plastic zone; 2-the residual stresses zone; 3-the elastic stresses zone; 4-the natural stresses zones. Also, according to its behaviour, the top coal situated above the coal face support is formed from two parts: the front part, where the top coal is traversed by the shear induced fissures and the gob area, where the top coal is destructed and transformed into a plastic behaviour zone [1,3].

The size of the fractured coal zone, immediately after the cutting operation of the coal face, is about 3-5m and the abutment stresses can surpass $2.5-3\cdot\gamma\cdot H$. This zone is progressively extended inside the coal massive, during the time, and in the same time with the phenomenon development the maximum abutment stresses are displaced.

Also, in the case of the top coal caving, a roof caving periodicity arises, but with a reduced intensity (having as result a periodical variation of the pressure acting on the coal face support), with the difference that, in this case, because the face advancement velocity is much reduced, the time factor determines a natural destruction of the rocks and the detachment of the rocks cantilevers in the goaf.

The repeated tension – distension actions of the coal face support, during the technological process, have an important crushing effect on the top coal massive (on the 2-3m profoundness), respectively an oscillation of the top coal stresses.

In the case of the top coal caving mining of a thick coal seam, simultaneously in several slices, it is very important to establish the minimum decalage between two coal faces, taking into account the stress state superposition, respectively the reciprocal influence of these faces. From this point of view, for the Jiu Valley basin coal faces, a minimum decalage was calculated between 37m and 54m (fig.2) [3,4].

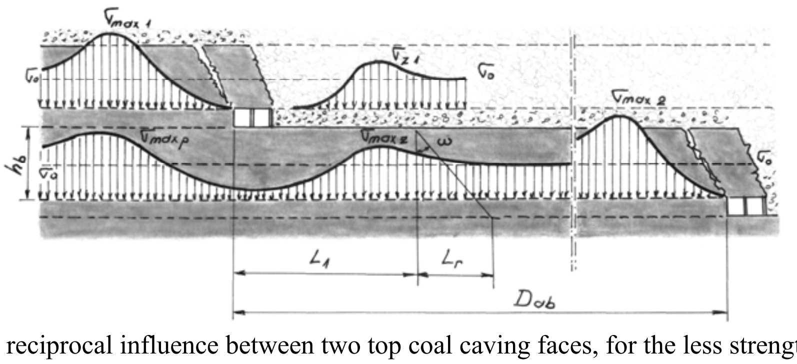


Fig. 2. The reciprocal influence between two top coal caving faces, for the less strength coal [4]

The stress state developed around the coal face affects the top coal integrity, which degradation depends both on the geomechanical characteristics of the coal and on the loading intensity and its duration. The face advancement velocity being very reduced, the top coal in front of the face is fissured under the abutment stresses, having a granular massive behaviour, non-cohesive or with reduced cohesion and with internal friction.

In the case of top coal caving mining, the caving height of immediate roof is big and significantly correlated with the mining thick of the coal seam and with the filling rate of the gob (rocks capacity of loosening).

Between the coal face zone and the gob, a complex structure of blocks or compressed rocks pieces is formed, being in equilibrium and disposed in a bridge shape. Taking into consideration the sublevel caving conditions, the equilibrium structure is predisposed to a two failure modes, thus: by sliding and by rotation. When the main roof thickness is more reduced, the cyclical destruction of the equilibrium structures can arise, resulting another important modality of failure of the main roof. In certain conditions, the destabilisation of the articulated blocks structures can determine the coal face loading, by surcharging of the immediate roof. Therefore, the structures in the equilibrium arc of these, formed by the articulated big blocks, will be reciprocally influenced. The soft rock seams existence, between these two equilibrium structures, will diminish much from the reciprocally interaction of them [3].

2. The stresses and deformations state analysis with the aid of the finite element method

For the first time, in the Jiu Valley top coal longwall mining conditions, the finite element method was used, implemented in the CESAR-LCPC code, version 4 (made by the Central Laboratory of Bridges and Roads of Paris) [7], for the study of the stress-strain developed around the top coal caving longwall mining. Thus, the study was focused by results obtained from the calculus made on the followings models [6]:

1) the top coal caving longwall faces (h_b=5m), in the starting stage (fig.3);
2) the top coal caving longwall faces, with h_b=5m (fig.5.a);
3) the top coal caving longwall faces, with h_b=10m (fig.4 and 5.b);
4) two successive top coal caving longwall faces, with h_b=5m and 20m decalage (fig.6);

The 2D modelling achievement, in the plan deformation hypothesis, for every model previously defined, necessitated the performing of the following stages: I) the establishment of the boundaries, the interest zones and the meshing of the model; II) the determination of the zones (regions) and the computational hypothesis and the geomechanical characteristics input; III) the boundaries conditions establishment; IV) the initial conditions and the loading conditions establishment; V) the achievement of calculus and the stoking of results [2].

For a better precision of the calculus, the models were performed until the surface, resulting the models with the sizes Y=410m / X = 350m, establishing the sizes of the interest zone around the coal faces where the stress and strain variation are maximum. The model meshing was made by the triangle finite elements with quadratic interpolation. There were taken into consideration 3 regions with various geomechanical characteristics which, in the elastic, linear and isotropic behaviour hypothesis, was defined thus: 1) for the roof and floor rocks: ρ_r=0,026MN/m^3, E_r=5000MPa şi μ_r=0,2; 2) for the coal seam no.3: ρ_c=0,014MN/m^3, E_c=1000MPa, μ_c=0,15; 3) for the caved rocks: ρ_s=0,008MN/m^3, E_s=50MPa, μ_s=0,4. Regarding the limit conditions: the superior side of the model is considered free and the lateral sides, blocked. Initial loading conditions of the model were considered as geostatic, for a depth of H=260m. The induced stresses by the excavation presence were represented by the horizontal stress of 1.7MPa and vertical of 6.5MPa, considered as tractions on the interior surface of the excavation. The face support presence was made by the support loading capacity of 0.5MPa, which is the loading of the model achieved in the total stresses. The calculus results were stocked in the graphical form on the model surface (isovalue, vector and tensor representation) and in the predefined sections.

The stresses study has in view the assessment of the coal and the surrounding rocks' stability and the geomechanical phenomenon behaviour. In this way, the stresses rate of concentration σ_y / σ_x (fig.4) and of principal stresses σ_1 / σ_2 (fig.3 and 6) can describe the stresses disequilibrium and, implicitly, the arising possibility of a failure phenomenon. A bigger rate leads to the fact that the principal stress circle intersects the rocks characteristic curve, thus developing the failure phenomenon and the opening of certain fissures and cracks inside of the coal and of the rocks mass. Also, from the point of view of stability, the tensile and shear stress study is very significant because the rocks and the coal have very reduced limits of tensile and shear and, frequently, the failure arises when these strength limits are surpassed.

In the starting stage of the top coal caving face, it is observed that the vertical deformations *v* are bigger than the ones of the coal faces situated into the mining stage, because the very big voids created above the face support, that determine a progressive convergence of the support toward the goaf, respectively a top coal tilting in this direction.

The most important concentration rate of the principal stresses σ_1 / σ_2 is in front of the coal face and ahead of the top coal void (fig.3), where the biggest arising probability of the dislocation phenomenon of the coal exists (table no.1). The coal failure has the chance to be produced by traction in the top coal above the face support and by shear in the same zone and in the superior corner of face. The shear failure of the coal face, beginning with the superior corner, can lead to the coal face sliding and in the case of long face stagnation, even to an important rocks' falling-down, inside the face.

Table no.1. **The stresses value for the model "the top coal caving longwall faces, in the starting stage"[6]**

The stress, **[KN/m^2]**							
σ_x	σ_y	σ_{xy}	σ_1	σ_2	τ_{max}	σ_t	σ_c
+6200 ÷ -15500	+9 400 ÷ -19 600	+2 540 ÷ -9 760	+17 300 ÷ -5 500	-200 ÷ -22 300	+9 800 ÷ -10	17 300 ÷ ±0	±0 ÷ -22 300

Observation: *In the previous table, there are presented: the horizontal stress* σ_{xx} *and* σ_{zz} *and vertical* σ_{yy}*; the shear stress* τ_{xy}*; the maximum principal stress* σ_1 *and minimum* σ_2*; the maximum shear stress* τ_{max}*; the compressive stress* σ_c*; the tensile stress* σ_t*.*

The stresses' distribution in the massive, in the case of the mining starting, leads to a certain advancement of the top coal degradation above the face support which, after the quasi-total drawing of the top crushed coal, the support rests unprotected against the rock falling from the goaf and the coal face is predisposed at major accident by rocks' falling-downs.

For to analyse the manner how the increasing of top coal height contributes to the stresses distribution in the massive we took into consideration two different models: one, with a top coal height of 5m and second, with 10m height. The brief presentation of the stresses, obtained after the calculus, is made in the table no.2.

Table no.2. **The stresses value for the model "the top coal caving longwall faces, in the mining stage"[6]**

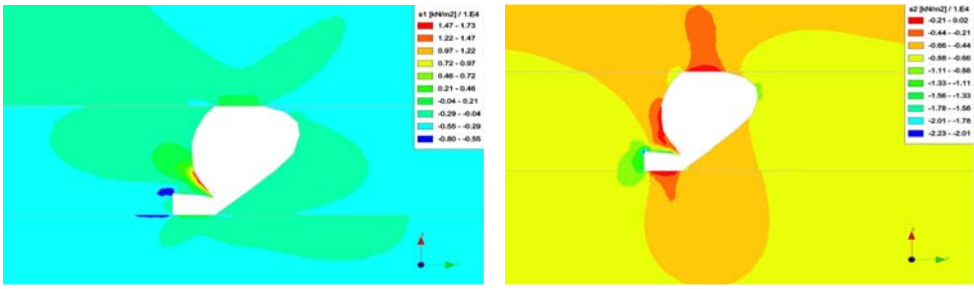
h_b, [m]	***The stress,* [KN/m^2]**						
	σ_x	σ_y	σ_{xy}	σ_1	σ_2	$\tau_{\max}$	σ_t
5	+800 ÷ -14 200	+400 ÷ -14 300	+5 230 ÷ -5 110	+1 790 ÷ -5 210	±0 ÷ -17 800	+8 290 ÷ -830	+2 570 ÷ ±0
10	+640 ÷ -9 490	±0 ÷ -16 600	+3 620 ÷ -4 970	±0 ÷ -5 670	±0 ÷ -18 000	+7 060 ÷ -10	+929 ÷ ±0

After a first analysis of the stress values, from table no.2, we observe that the two times increasing of the top coal (from 5m to 10m) determines, for the great majority of the stresses, an important increasing, with different values. That leads to the conclusion that the top coal stability decreases in the same time with the top coal increase.

The maximum values of the tensile stresses are distributed at the boundary of the top coal with the goaf, in the coal face and in the face ceiling, at 15m from the coal face (fig.5.a). Also, the maximum shear stresses are situated at the coal face level, in the superior and the inferior corner and in the inferior part of the top coal, toward the goaf (fig.5.b). These observations lead at the conclusion that the top coal has the tendency of a natural separation toward the goaf area and the danger of coal face sliding and coal detachment from the face ceiling exists. Also, the concentration rate of the tensile and shear stresses, generally, on the coal face line, determines a top coal fracturing (and because the tiling phenomenon) on this line, and the fractures' propagation, in time, inside the main and immediate roof rocks. Finally, generating the top coal block detachment and free gravitational loading of the face support.

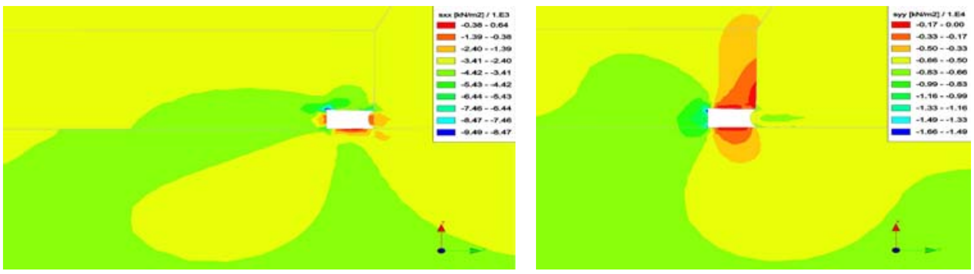
Even if in practice the successive top coal caving longwall faces (see the fig.2) [4] distanced at 20m (fig.6) do not exist, we had considered as necessary to make this study for to analyse, comparatively, the differences between a face situated under a natural roof and into a stress zone of influence and another face under an artificial roof. After a first observation, we see that the inferior face (under the artificial roof) suffers deformations and stresses much accentuated than the superior face (under the natural roof) and more important than the singular faces. Moreover, reporting to the singular faces situated under a natural roof, we observed, in the inferior face case, the arising of obvious traction stresses developed in the superior part of the top coal, on the coal face plane, which will lead, inevitably, to the natural detachment of the top coal, accompanied by the tiling of it and the arising of two detachment zones of the ceiling face.

Finally, we can conclude that the results obtained by numerical modelling with aid of the finite element method are in a total concordance with the results obtained from the in situ studies and from the known analytical models.



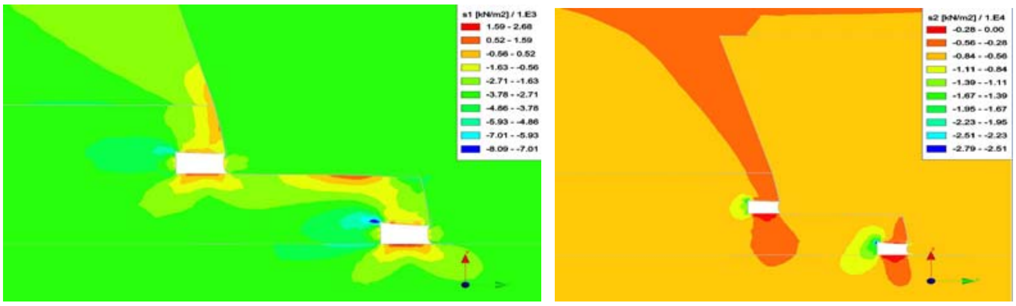
a) b)

Fig.3. The principal stresses- face in the starting stage: a) maximum σ_1; b) minimum σ_2



a) b)

Fig.4.The horizontal stress σ_x (a) and vertical stress σ_y (b) , for the faces, with h_b=10m



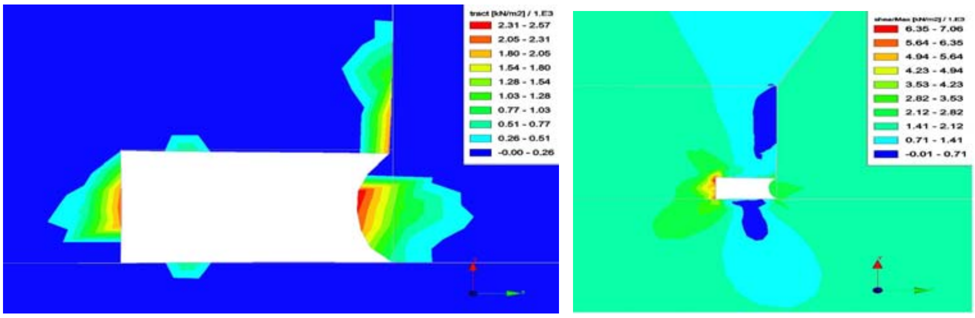
a) b)

Fig.6. The principal stresses- two faces with decalage: a) maximum σ_1 ; b) minimum σ_2

References

[1]. Onica,I. *Contribuţii la perfecţionarea tehnologiilor de exploatare cu fronturi lungi de abataj a stratelor groase de cărbuni din Valea Jiului, prin utilizarea unor susţineri mecanizate adecvate condiţiilor geominiere*, Teză de doctorat, Petroşani, iunie 1995.

[2]. Onica,I. *Introducere în metode numerice utilizate în analiza excavaţiilor miniere,* Ed. Universitas, Petroşani, 2001.



a) b)

Fig.5. The tensile stress σ_t , h_b=5m (a) and maximum shear stress τ_{max} , h_b=10m (b)

[3]. Onica,I., Chiril,G. *Exploatarea cu banc de cărbune subminat în abataje frontale*, Ed.AGIR, Bucureşti, 2005.

[4]. Onica,I., Cozma,E. et al. *Determination of Decalage Between Two Longwall Faces in the Case of Thick Coal Mining with Sublevel Caving* Proceedings of 9-th International Mining, Petroleum and Metallurgical Engineering Conference, Cairo University, February, 21-24, 2005.

[5]. Onica,I, Cozma,E., Goldan,T., Chiril,G., Roşioru,I. *Fatal Accidents in the Top Coal Caving Mining Faces of Jiu Valley basin (Romania)*, International Conference on New Technology for Surface and Underground Mining, Kolkata (India), 2006.

[6]. Roşioru,I. *Studiul caracteristicilor geomecanice ale rocilor şi cărbunilor în vederea dimensionării bancului subminat la metoda de exploatare cu subminare în condițiile Văii Jiului,* Teză de doctorat, Petroşani, 2007.
[7]. * * * *CESAR-LCPC, version 4 - Manual de utilizare.*

THE STOWING PROCESS OF SFÂNTA VARVARA AND IDA ADITS IN VIEW OF ENSURING THE GROUND SURFACE AND ROADWAYS STABILITY FROM THE COZLA MINE PERIMETER

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TUDOR GOLDAN**

Abstract: In the Cozla mine closure plan are involved the stowing of main shaft and the stowing of Sfanta Varvara and Ida adits with material from the dump of the mine, so as to ensure the ground surface's and roadways' stability. In this way, the geo-mechanic characteristics of the dump rocks and the ground stability analysis under the adits influence, using a finite element code, are presented in this paper.

1. Geomechanical characteristics of Cozla mine dump rocks

The knowledge of the rocks' geo-mechanical characteristics is essential in any rocks mechanics investigation, related to mining, industrial or hydrotechnical constructions.

In order to stow the underground workings, the toxic, chemical-active, biologic or radioactive infested materials can't be used. Also, the use of domestic waste or metallic materials is forbidden. To know the geo-mechanical characteristics of the Cozla rocks dump, which will be used to stow the main shaft and the two adits, the following determinations of rocks are performed: the mineralogical–petrographical analysis; the physical, mechanical, elastic and grading characteristics [1, 7, 5, 6].

The mineralogical – petrographical analysis

The rocks sampled from the Cozla mine dump were selected as representatives.

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The physical properties

The samples were macroscopically analysed, having the geological structure corresponding to the Cozla olistolite (Inferior Jurasic – Hettagian +Sinemurian + Pliensbachian) and the facies of Gresten.

The physical properties of rocks are conditioned by the fact that the rocks solidity parameters depend, in a great measure, on their physical state and influenced by the time passing and are modified under the various factors of influence.

The mechanical properties of the rocks

The most important strength parameters of the rocks are: uniaxial compressive strength statically and dynamically determined; static and dynamic tensile strength; bending strength; shear strength; cohesion, internal friction angle and the triaxial compressive strength (fig.1 and table no.1).

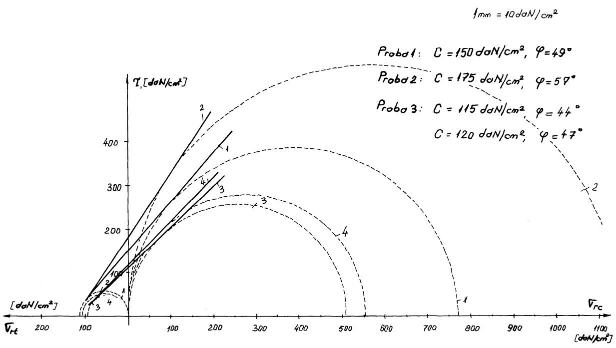


Fig.1. Cohesion and internal friction angle determination for the Cozla mine rock samples [5]

Elastic characteristics of the rocks

The rocks' elasticity can be represented by the characteristic curve, elasticity modulus and Poisson rate determined by the static and dynamic loads. For the Cozla mine dump, the elastic characteristics were determi-ned by the successive charging and discharging method.

Table no.1. **Geomechanical characteristics of Cozla mine rocks [5]**

Sp. no.	**Rock**	**Physical characteristic**				**Mechanical characteristic**				**Elastic characteristic**	
		γ x10^4 N/m^3	γ_a x10^4 N/m^3	*N*, %	K_d, %	σ_{rc}, MPa	σ_{rt}, MPa	*C*, MPa	φ, ^{0}	*E*, MPa	μ
1	Carboniferous dolomite sandstone	2.93	2.82	4	96	77	11.3	15	49	8000	0.16
2	Quartzite - micaceous fine-grained sandstone	2.85	2.6	9	91	114.8	10.7	17.5	57	9200	0.10
3	Silit black clay	2.74	2.63	4	96	50.8	8.2	11.5	44	7200	0.19
4	Quartzite sericit-carboniferous silit	2.7	2.61	3,4	96,6	55.5	8.66	12.0	47	7500	0.18

Rocks grading characteristics of Cozla mine dump

The Cozla mine dump represents a result of successive and periodical rock deposition (sandstones, clays, marls, conglomerates, shale's, etc.), resulted from the workings driving (galleries, shafts, etc.). During the time, under the atmospheric factors influence, the rocks with lower strength have suffered degradations, thus, in present, the entire rocks quantity deposed in these dumps could be considered involving both earthy rocks and crushing rocks.

Having in view the important role of the mineral fragments sizes on the physical and mechanical properties of the earths and on the qualitative appreciation of the crushed rocks, it is necessary to establish the percentage repartition after the components' sizes, operation which is performed by a grading analysis. In our case, being about a very non-homogenous material, we applied the screening-sieving method [5,6].

The graphical representation of the obtained results is shown in fig.2 by a grading curve and a histogram.

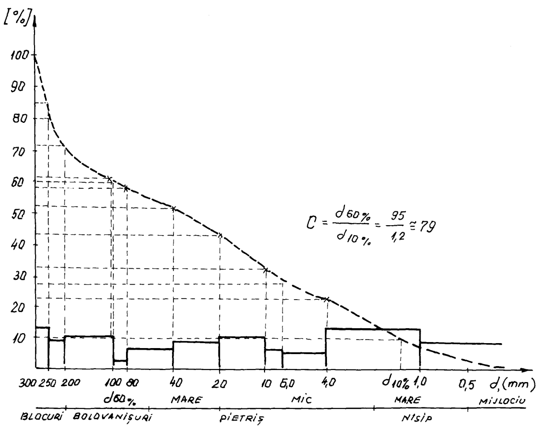


Fig.2. The grading curve and the histogram of Cozla dump [5]

In our case, the biggest percentage quantity (over 13%), from the total quantity of the material, ranging between 1 and 4 mm, results from the histogram. When the histogram presents more maximum ordinates (as our concrete case), the analysed material is formed from many phases (a normal situation, if we accept that the crushed rocks of the dump is produced from the blasting process). Also, approximately 50% of the total quantity has the sizes more that 40mm.

In fact, the rocks, deposi-ted in the dump, are very non-uniformed, as granulometry, conclusion confirmed by the Hansen coefficient:

$$C = \frac{d\,60\%}{d\,10\%} = \frac{95}{1.2} \cong 80 \quad \text{(very non-uniformed)}$$

where: *d* 60% represents the Hansen diameter, defined as the value of the grading curve abscise, corresponding to the ordinate which is 60% from the total weight of the analysed sample (in our case, *d* 60% = 95mm; *d* 10% - the diameter corresponding to 10% from the initial weight, being named the effective granule and characterises the rocks' permeability (in our case $d10\% \cong 1.2$mm).

Comparing these data with those prescripted by the norms and with those presented for the Cozla dump, it results that the entire quantity of dump material – with the exception of the granulometry bigger than 250mm- and which represents 20%- could be used for the shaft filling until a 50m depth and for the last portion, only the granulometry fractions less than 100mm (which represent 40% from total) will be used. Also, the stowing material from analysed dump could be used for the integral stowing of the adits.

2. The stress-strain state analysis around the Sfânta Varvara and Ida adits with the aid of CESAR-LCPC finite element code

The CESAR programme (code), which development began in 1981, is the successor of the ROSALIE system developed by the Central Laboratory of Bridges and Roads of Paris, between 1963 and 1983. CESAR is a computational general code, based on the finite element method, addressed to the followings areas: structures; soils and rocks mechanics; thermo-mechanics; hydrogeology [8].

The CESAR-LCPC code, version 4, which involves the Cleo2D processor, completed with the C0 option (linear and non-linear static mechanics & diffusion) [8] was used in this work, to perform the followings models:

1) The roadway stability under the Ida gallery influence;

2) The national roadway stability under the Sfânta Varvara gallery influence.

Despite the fact that the previous adits are executed in the very strong rocks (carboniferous dolomite sandstone, quartzite-micaceous fine-grained sandstone, silit black clay, quartzite sericit-carboniferous silit, etc.) with compressive strength ranging between 50.8MPA and 114.8MPa (see the table no.1), because of the alteration phenomenon produced during a long period and the vibrations induced by the heavy trucks, the designer of closing of underground workings network, afferents of Cozla mine, S.C. ICPMC S.A. Petroşani, decided the integral stowing of these workings, in conformity with actual norms, and the construction of a concrete plug, with B50 mark, along a distance of 15m, in the intersection zones between roadways and the Ida and Sfânta Varvara adits. Between the apex of the Ida gallery and the roadway, being a rock ceiling of 5m of thickness and, in the case of Sfânta Varvara gallery, of 2m of thickness [5].

In this way, in the models developed by us, we taken into consideration the most unfavourable situation when the filling of transversal section of workings with concrete could not be made, technically, until the gallery apex, taking into account the concrete contraction after the setting process.

The 2D modelling, in the plane deformation hypothesis [3], for every previous defined model, was gone over the followings stages: I) establishment of boundaries, interest zones and meshing of the model; II) determination of zones (regions) and computational hypothesis and the geomechanical characteristics input; III) boundaries conditions establishment; IV) initial conditions and loading conditions establishment; V) achievement of calculus and stoking of results [2, 4].

I) Having in view the vicinity of adits with the ground surface, for a better precision of the calculus, the models were performed until the surface, resulting the models with sizes Y=27.4m / X = 25m, for the Ida adit, respectively Y=25m / X = 25m, for the Sfânta Varvara adit. Also, the sizes of the interest zone around the adits were established so as to involve the model surface where the stress and strain variation is maxim. Model meshing, respectively of every region, was made by triangle finite elements with quadratic interpolation.

II) In order to make a qualitative description of the models, there were taken into consideration 4 regions with various geo-mechanical characteristics which, were defined: 1) the rock mass was represented by the weakest rock, namely silit black clay, considered being the most covered, from a calculus point of view (table no.1), in the conditions of a Mohr-Coulomb without hardening type of behaviour model, characterised by the apparent specific density ρ_r=0,26 MN/m^3, linear elasticity modulus E_r=7200MPa, Poisson ratio μ_r=0,19, cohesion C_r=11,5MPa and the internal friction angle φ_r=44^o; 2) the standard support of GDZ-9.7 gallery is monolithic concrete, with B300 mark, which in the hypothesis of elastic, linear and isotropic behaviour, having the following characteristics: ρ_s= 0,025MN/m^3, E_s=3150MPa , μ_s=0,15; 3) the filling is represented by the crushed rocks on the floor invert, in the hypothesis of Mohr-Coulomb without hardening behaviour and is characterized by the followings: ρ_u = 0,019MN/m^3, E_u=100MPa, μ_u =.0,25, C_u=0, $\varphi = 36^o$; 4) the concrete plug of the adits is represented by the weak concrete, with B50 mark, which, in the hypothesis of a elastic linear and isotropic behaviour, is characterized: ρ_d = 0,025MN/m^3, E_d=1100MPa şi μ_d =.0,2.

III) The superior side of the model is considered free and the lateral sides, blocked (for the inferior side the vertical displacements v = 0 and the horizontals $u \neq 0$ and for the lateral sides $v \neq 0$ şi u = 0).

IV) Initial loading conditions of the model were considered as geostatic $[\sigma_o]$, respectively $\sigma_{oy} = \rho \cdot g \cdot H$, $\sigma_{ox} = \sigma_{oz} = \frac{\mu}{1-\mu} \cdot \sigma_{oy}$. The induced stress by the excavation presence was $[\sigma_e]$, represented by the horizontal stress σ_{ex} and the vertical stress σ_{ey}, considered as tractions on inside surfaces of the excavation. Also, the presence of the support and the concrete plug was represented by their load capacity $[\sigma_s]$. Thus, the loading of the model was performed in the total stress: $[\sigma_T] = [\sigma_o] + ([\sigma_e] - [\sigma_s])$. Taking into account the fact that the roadways above the adits are circulated by the vehicles with various capacities and sizes, the models were loaded, at the roadways levels, on the axis of the adits, with an evenly distributed load of 0,04MN/m^2, along 6m length, corresponding to a truck type V-80 (4axels X 20 tf; length / width of vehicle = 6m / 4m) – from E class of loading, in conformity with the norms used in the roadways design.

V) The calculus was made taking 60 iterations per increment and a tolerance of 1% of the results, using for the resolution the initial stress method with non-linear behaviour of geomechanical problem. The calculus results were stocked in the graphical form on the model surface (isovalue, vector and tensor representation) and in the predefined sections. The results obtained correspond to the following parameters: the vertical displacement *v* and horizontal *u*, in mm; the horizontal stress σ_{xx} and σ_{zz} and vertical σ_{yy}; the shear stress τ_{xy}; the maximum principal stress σ_1 and minimum σ_2; the maximum absolute principal stress σ_{1a} and minimum σ_{2a}; the maximum shear stress $\tau_{\max}$; the compressive stress σ_c; the tensile stress σ_t (in kN/m^2).

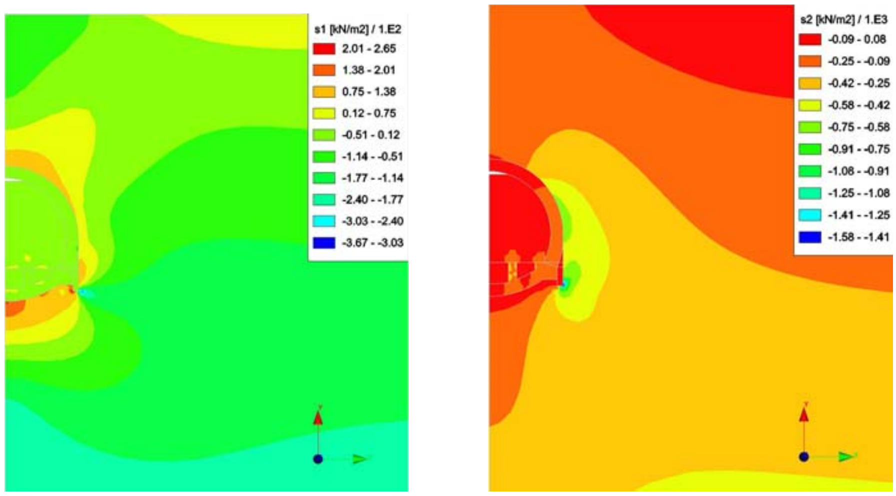
a) *The stress study* having in view the assessment of the surrounding rocks mass, adits supports and concrete plug stability and, finally, the assessment of ground surface and roadways stability. In this way, the stress concentration rate σ_y / σ_x and σ_1 / σ_2 (fig.3) could describe the stress disequilibrium and implicitly the arising possibility of failure and deformation phenomenon. A bigger rate leads to the fact that the principal stress circle intersects the rocks characteristic curve, thus developing the failure phenomenon and the opening of certain fissures and cracks inside of the rocks mass or of the concrete support structure. Also, from the point of view of stability, the tensile and shear stress study are very significant because the rocks and the concrete have very reduced limits of tensile and shear and, frequently, the failure arises when these strength limits are surpassed.

After a simple analysis of stresses, presented in the table no.2, we conclude that the stresses developed in the rocks mass and in the support structure are much under the admissible strength values, which shows a very good stability of the surrounding rocks, including the ground surface and afferent roadways.

Table no.2. **The stress values for Ida and Sfânta Varvara adits [5]**

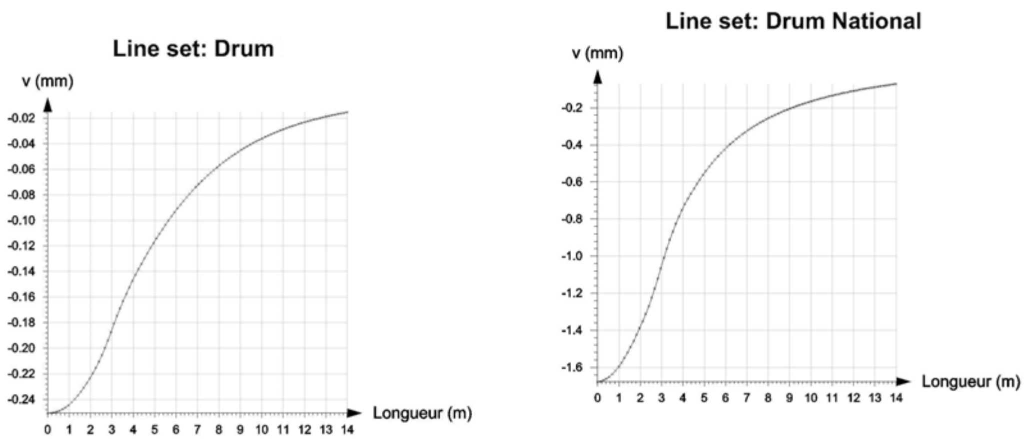
Model	***The stress*, [KN/m^2]**						
	σ_x	σ_y	σ_{xy}	σ_1	σ_2	$\tau_{\max}$	σ_t
Ida adit	+50 ÷ -748	+250 ÷ -1220	+315 ÷ -539	+ 265÷ -367	-80 ÷ -1580	+687÷ ±0	+264÷ ±0
Sfânta Varvara adit	+ 58÷ -383	+34÷ -669	+ 194÷ -232	+59÷ -335	+8÷ -669	+285÷ ±0	+61÷ ±0

b) *The vertical and horizontal displacements study* shows that, in both models cases, the displacements are less than 3mm (fig.4 and 5) and at the roadways levels, on the adits axis, the maximum vertical displacements (the most important for the roadways stability) are less than 0.24mm, for the Ida adit (fig.4.a), and less than 1.6mm, for the Sfânta Varvara adit (fig.4.b) and are much under the admissible value limits to ensure the maximum stability of the roadways situated over the adits.



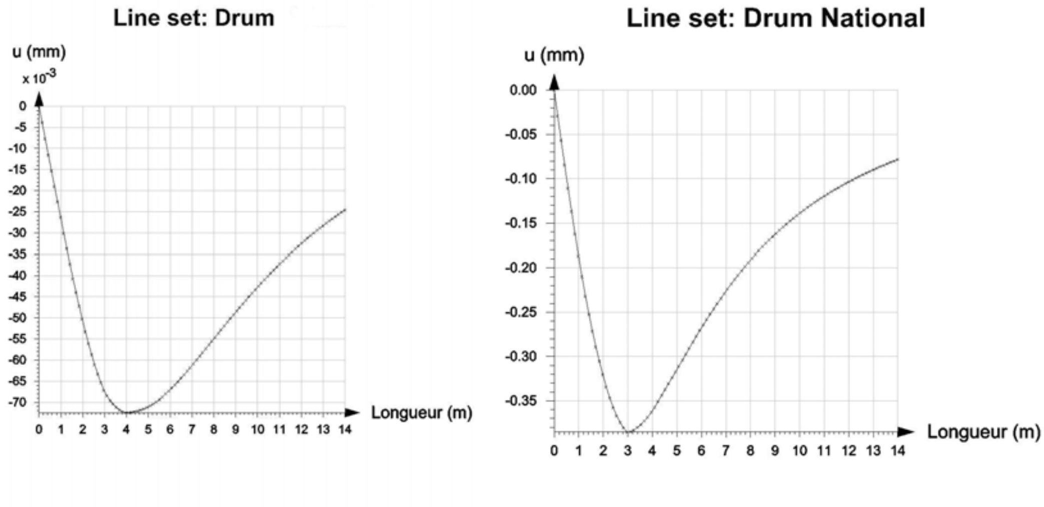
a) b)

Fig.3. The principal stresses, for Ida adit: a) maximum σ_1 ; b) minimum σ_2



a) b)

Fig.4. The vertical displacement variation *v* for: a) Ida adit; b) Sfânta Varvara adit



a) b)

Fig.5. The horizontal displacement variation *u* for: a) Ida adit; b) Sfânta Varvara adit

References

[1]. Hirean,C. *Mecanica rocilor*, E.D.P., Bucureşti, 1981.

[2]. Lețu,N., Onica,I., Madear,G. *The Stabillity Modelling of the Rectangular Underground Wide Excavations in Layered Rocks Using the Finite Element Method*, Procedeengs of MicroCAD'94, International Computer Science Conference, Misckolci, 3 March, 1994.

[3]. Onica,I. *Etude de la stabilité du toit des galeries quadrangulaires creusées dans des milieux stratifiés. Application aux houillères de Provence*, Rapport de DEA de génie civil et minier, Ecole Supérieure des Mines de Nancy (INP Loraine France), octobre 1991.

[4]. Onica,I. *Introducere în metode numerice utilizate în analiza excavațiilor miniere*, Ed. Universitas, Petroşani, 2001.

[5]. Onica,I., Cozma,E,. Hirean,C. *Studiu privind calitatea materialului de rambleu din haldele de steril din perimetrul minier Cozla, necesar rambleerii lucrărilor de legătură cu suprafața,* Contract Univ. Petroşani cu S.C. Miniera Banat S.A.-Anina, nr.8/2007.

[6]. Onica,I., Cozma,E,. Hirean,C. *Studiu privind calitatea materialului de rambleu din haldele de steril din perimetrul minier Anina, necesar rambleerii lucrărilor de legătură cu suprafața***,** Contract Univ. Petroşani cu S.C. Miniera Banat S.A.-Anina, nr.1/2007.

[7]. Todorescu,A. *Proprietățile rocilor*, Ed.Tehnică, Bucureşti, 1984.

[8]. * * * *CESAR-LCPC, version 4 - Manual de utilizare.*

THE ANALYSIS OF UNREPAYED TECHNOLOGICAL EQUIPMENTS AND MACHINERY UTILIZATION FROM LIGNITE OPEN-PIT MINES AND ASSESSMENT OF THEIR DESTINATION

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ŞTEFAN GHIOC**

Abstract: The replacement of equipments represents a new practice in investment economical decision-making processes, taking into consideration the equipment's initial cost price and the cost related to the entire life cycle of the equipment. Consequently, there were developed analysis and assessment of the life cycle cost for industrial technological equipments, models accepted in new investment projects evaluation or in maintaining the existing ones.

Key words: economical decisions, life cycle, analysis models, investment project assessment.

1. Replacement costs estimation for leading machineries in technological equipments

General considerations regarding the replacement cost concept

Equipment replacement represents a responsibility of the management staff from industrial units, having as major goal to determine the optimal replacement timing for technological equipment and machinery. To achieve this purpose, the maintenance responsibles and analysts should find an answer to the following question "How long should be maintained in operation older equipment, if he requires ever growing operational costs?"

The answer imposes the operational life span optimization for equipment, and when the acquisition decision is adopted, the following criteria must be considered:

- the life cycle cost (LCC);

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- the average global cost per time period' unit.

On long standing, the industrial economical unit has as objective the life cycle global cost optimization. This concept was defined in U.S.A., and denominated as Life Cycle Cost (LCC). According to American Budget Agency, the concept is defined as it follows: *"LCC represents the total costs, direct or undirect, reproductible or not, ocasioned or estimated in all the conception, development, construction, operation, maintenance processes and logisticaly sustained in any high scale system, during their predicted validity duration"*. The term "life cycle cost" was for the first time employed in the american army, who had imposed it for investment evaluation, generally for complex projects, using the notion "cost associated to life cycle related to utilization", mostly in order to facilitate the analysis of present value for an equipment or his annual equivalent value.

For the U.S. army, introducing this concept had represented a new practice in economical investment decision-making processes; consequently, not only the initial cost price of equipments and machineries were taker into account but also the cost related to its entire life cycle. Subsequently, the economy engineers in U.S.A. and from other developed countries had improved the existing analysis and assessment models, models accepted by the governmental bodies in evaluation of new investment projects and maintaining the existing ones.

The economical analysis of replacement decision for any equipment should start from cash-flow situation, will this on allows to consider the cash transactions issuing from the studied decision alternative. Subsequently, the analysis continues by studying the cash-flow representations on the entire life cycle of the equipment. It must be noted that not all the expenses comprised in the analysed cash-flow are really necessary, that is why it is compulsory to identify all expense items and to estimate the predicted influences.

Within the proposed analysis concerning technological equipment utilization we can meet several cases, such as:

- cash-flow transaction are occuring in a divided economical horizon of time (years, months, weeks), so that the analysis horizon will comprise a number of "N" periods;
- associated repayment rates can be expressed in percentage, for each identified period;
- expenses can be represented at the beginning or at the end of each period;
- investment decision assessment can be also regarded as a way to improve the enterprise value and efficiency, representing an useful tool for the stakeholders.

In order to decide if an investment should, or not be done it is important to know if, in a certain moment, the equipment proposed for replacement generates profit, and at what level. This analysis can be graphicaly illustrated as in the diagram comprised in figure 1.

The definition of the **global cost of the life cycle** comprises the sum of costs related to an equipment or technological machinery on its entire life cycle, including:

• ***the equipment's acquisition cost*** (A), which can be assimilated real cost of the equipment, based on the investment required for acquisition;

• ***actual operational costs of the equipment***, including:

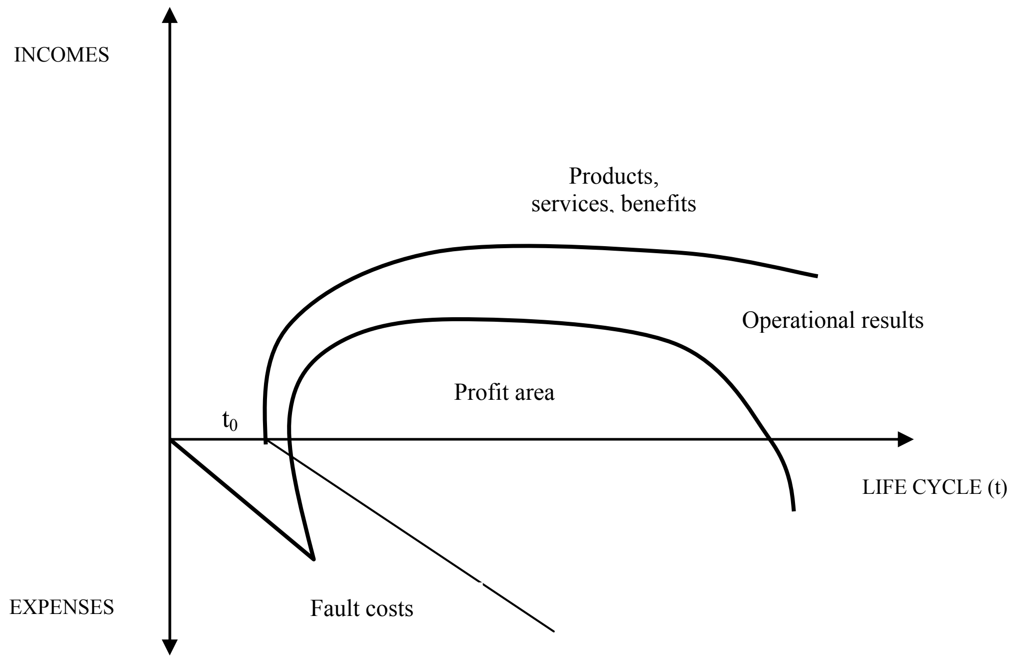

Fig. 1. Cash flow representation in performance analysis of an equipment

- ***cumulated operational cost*** (F): expressing the expenses with spares, energy, services:
- ***cumulated cost of maintenance actions*** (M).

Acording to the above-mentionned items, the global cost is

$$C_g = A + F + M \quad (1)$$

If in the global cost relationship is introduced also the capitalization value (V_v) for the analysed equipment at the end of his life cycle, the relationship becames:

$$C_g = A + F + M - V_v \quad (2)$$

To avoid errors in global cost estimation it is needed to express all the elements in a single and constant currency; nevertheless, employing these relationships assumes that the analysed equipment had a constant operating rate in time, over his entire life cycle.

This concept of life cycle global cost can be applied with convenient results also for operational technological equipments. So, for technological equipments for whom the maintenance cost becames increasing, for constant operating rates, it issues the question of assessing the duration time T at the end of whose the global cost per time unit has a minimum value. In order to achieve this, the relationships (1) and (2) will be expressed as average costs per time unit, respectively:

$$m_1 = \frac{A + F + M}{T} \tag{3}$$

$$m_2 = \frac{A + F + M - V_V}{T} \tag{4}$$

The denominator T can be replaced by the total utilization unit number (N), for example by: total number of tons (m^3) of coal mined out by an equipment, total number of metres of gallery digged with a continuous miner machine, total number of kilometres covered by a vehicle etc. As when employing the T value, also in this cases it has to be determined the utilization unit number at which the cost of realized products is minimum.

$$m_2 = \frac{A + F + M - V_V}{N} \tag{5}$$

This relationship offers the advantage of applicability also in the case of a variable operational rate of the considered equipment. Thus, relationship (3) and (4) are giving the global cost per timp unit, or generaly, according to relationship (5) per utilization unit.

The decision-making concerning the keeping or replacing an operational equipment requires the determination of T or N value for which a minimum global cost value is obtained. To solve this problem a graphical method is proposed, implying the use of informatics in maintenance activity management. Thus, based on existing data within the informatic system's database the global cost curve is drawn versus the equipment's operating period and than, employing dedicated softwares this curve can be drawn for the whole standardized operating cycle.

Based on this curve, the optimum life span duration, denoted T*, will be determined, corresponding to minimum global cost and given the tangent point drawn to this curve. This assessment model corresponds to the global minimum cost of the equipment's operation in the standardized period, being graphicaly represented in figure 2.A, for negligible capitalization value, respectively in figure 2.B for the case when capitalization value is taken into account.

2. Optimal equipment replacement model without cost updating, but considering several different functions to describe cost and equipment selling values evolution in time

The application of this computation model for equipment replacement optimisation has as first goal the assessment operational costs and life span of involved equipments.

In order to achieve this, the following notations will be clone:

A_o – equipment's acquisition cost;

$\varphi(t)$ – equipment's depreciation function;

$\psi(t)$ – maintenance cost function.

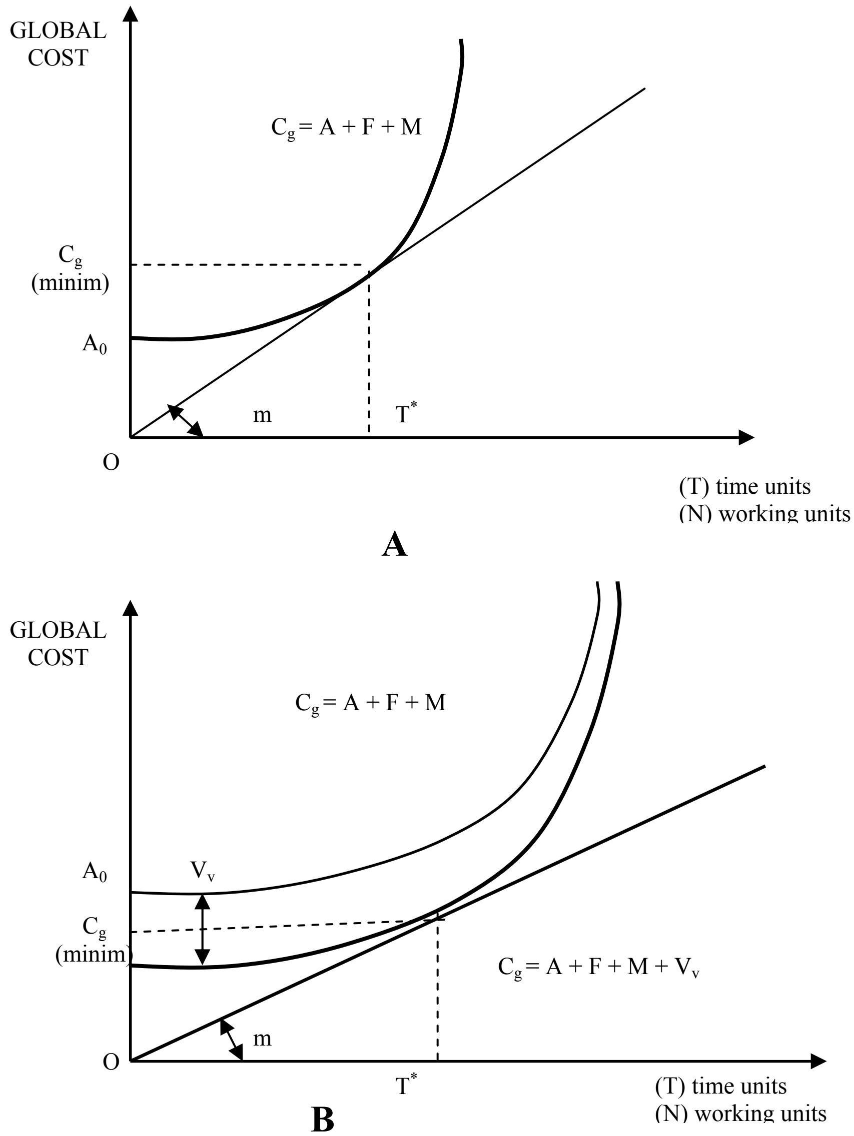

Fig.2. Global cost optimisation for cases A and B

Based on the above presented models it can be written the global cost versus time function as below:

$$\Gamma(t) = A_0 - A_0\varphi(t) - \psi(t) \quad (6)$$

and the average cost during the utilization operational period as it follows:

$$\gamma(t) = \frac{\Gamma(t)}{t} \quad (7)$$

Computation of optimum replacement time involues to minimize the γ(t) function. The analytical study of this function reveals that to obtain a minimum value it is necessary to derive the expression with respect to time and than to equal it to zero.

$\gamma^{'}(t) = 0 \rightarrow t$ replacement optimum

$$\gamma^{'}(t) = \frac{t\Gamma^{'}(t) - \Gamma(t)}{t^2} = 0 \quad (8)$$

replacing Γ(t) in relationship (8), Γ′(t) will be:

$$\Gamma^{'}(t) = \varphi^{'}(t) + \psi(t)$$

and substituting Γ(t) and Γ’(t) in γ′(t), the following equation will be obtained:

$$A_0\left[1 + t\varphi^{'}(t) - \varphi(t)\right] + \psi(t) - t\psi^{'}(t) = 0 \quad (9)$$

The above relationship can be analysed with respect to different types of φ(t) and ψ(t) function. The following cases will be considered:

2.1. Linear φ(t) and ψ(t) functions

The function φ(t) is a decreasing function which equals 1 for t = 0, respectively when the equipment is bought, having his investment value, and after a T_0 lapse of time (according to the diagram in figure 3) it intersects the abscissa in point t_o, meaning the value at wich equipment’s resale is null, where from it comes:

$$\varphi(t) = 1 - \frac{1}{T_0} \quad (10)$$

ψ (t) function is an increasing function with ψ(0) = 0, graphicaly represented in figure 4, from which results:

$$\gamma(t) = \frac{1}{t}\left[A_0 - A_0\left(1 - \frac{1}{T}\right) + a \bullet t \right] \tag{11}$$

$$\gamma(t) = \frac{A_0}{T} + a \tag{12}$$

and consequently: $\gamma'(t) = 0$.

Conclusively, the average utilization cost is constant, and the replacement period should be determined based on other criteria.

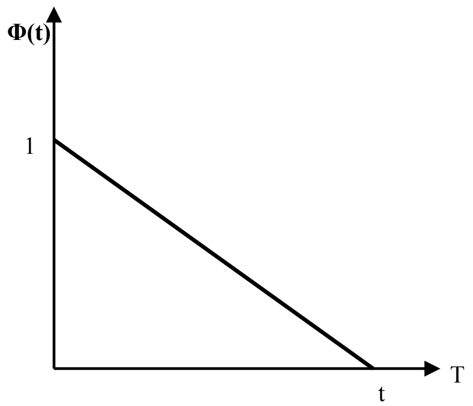

Fig.3. Linear type depreciation function φ(t) for an equipment

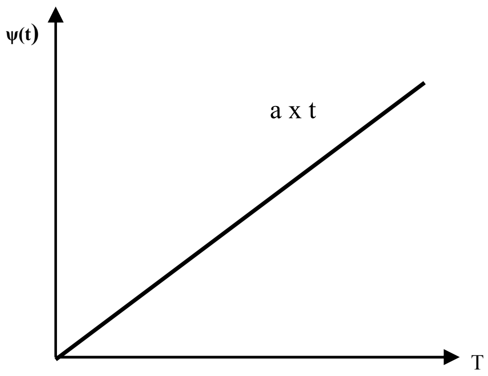

Fig.4. Linear type function ψ(t) for an equipment's maintenance

2.2. Exponential φ(t) and linear ψ(t) functions

The function φ(t) being of exponential type, the exponential reliability law can be applied regarding the equipment's depreciation, which means that the resale price is a function of its wear degree. So, in this case, it will be analysed the equipment's replacement in conjunction to its resale value.

The φ(t) function is given by the expression $\varphi(t) = e^{-\lambda t}$, a decreasing function in time, which equals 1 for t = 0, and ψ (t) = a · t is a linear type one, having the same shape as in the former case.

Replacing in equation (6) and dividing the expression by "t" we will obtain the relationship:

$$\gamma(t) = \frac{1}{t}\left[A_0 - A_0 e^{-\lambda t} + at\right] \tag{13}$$

which derived gives:

$$\gamma^{'}(t) = A_0\left[\frac{\lambda t \cdot e^{-\lambda t} + e^{-\lambda t} - 1}{t^2}\right] \tag{14}$$

Studying $\gamma'(t)$ function it can be seen that she is null for $t > 0$.

As a conclusion, it results that there is no minimum value for $\gamma'(t)$, so it is recommended to adopt adequate measures of preservation and maintenance of the equipment, to provide an as much as possible longer operating time.

2.3. Both φ(t) and ψ(t) are exponential functions

The function $\varphi(t)$, is the same function as in the former case:

$$\varphi(t) = e^{-\lambda t} \tag{15}$$

The function $\gamma(t)$, is a growing function for which the condition $\varphi(0) = 0$ is imposed, thus obtaining:

$$\psi(t) = a\left(e^{\mu t} - 1\right) \tag{16}$$

Substituting, the expressions (15) and (16) in relationship which gives $\gamma'(t)$, we have:

$$\gamma^{'}(t) = \frac{\left(A_0\lambda e^{-\lambda t} + a\mu e^{\mu t}\right)t - \left\{A_0\left[1 - e^{-\lambda t} + a\left(e^{\mu t} - 1\right)\right]\right\}}{t^2} \tag{17}$$

for $\gamma'(0) = 0$, it results that:

$$\frac{1 - e^{\mu t}\left(1 - \mu t\right)}{1 - e^{\lambda t}\left(1 + \lambda t\right)} = \frac{A_0}{a} \tag{18}$$

The value of"t "can not be obtained by computations based on this relationship, for this reason a TURBO PASCAL software was conceived entitled "Software for optimum resale time computation". This software allows determining the optimum resale time (denoted by T) for given equipment and also the average cost per time unit.

3. Model for updating the worn out equipments resale costs

This model takes into account the maintenance costs (R_i) and value losses induced by equipment resale (P_i). Assumptions and notations:

A_o – represents the initial acquisition cost of the equipment;

R_i – represents the acquisition cost on time interval “i”;
P_i – represents the equipment’s devaluation on time interval “i”;
r – represents the updating rate of investments;
T_n – represents the global cost at the end of “n” periods (T_i, for “i” periods).
Thus, it follows:

STEP 1. If the equipment is resold after only one period of operation, then global cost Γ_1 becames:

$$\Gamma_1 = A_0(1+r) + R_1 - (A_0 - P_1) \quad (19)$$

with the following interpretation:
term 1: Γ_1 – global cost at the end of year 1°;
term 2: A_o – updated acquisition cost:
term 3: R_1 – maintenance cost in year 1°;
term 4: P_1 – resale price.

STEP 2. If the equipment would resold at the end of year 2, the cost of invested capital will be (A_o – P_1), and the global cost Γ_2 is:

$$\Gamma_2 = \Gamma_1 + (A_0 - P_1)\cdot r + R_1 r + R_2 + P_2 \quad (20)$$

where :
term 1: Γ_2 – global cost for equipment’s resale after 2 years of operation;
term 2: Γ_1 – global cost of the first year of operation:
term 3: (A_o – P_1) – updated value of the equipment in the second operational year;
term 4: R_2 – maintenance cost in second year;
term 5: P_2 – loss of value in the second year.

Subsequently, based on this kind of judgement and arranging the corresponding terms, the global cost after “n” years of operation for an equipment or machinery, can be expressed as it follows:

$$\Gamma_n = nAr + R_1(1+r)^{n-1} + \ldots + R_i(1+r)^{n-i} + \ldots + R_{n-1}(1+r) + R_2 + \\ + P_1[1-(n-1)r] + P_2[1-(n-2)r] + \ldots + P_i[1-(n-i)r] + \ldots + P_{n-1}(1-r) + P_n \quad (21)$$

The relationship above can be rewritten in the shape below:

$$\Gamma_n = nAr + \sum_{i=1}^{n} R_i(1+r)^{n-1} + \sum_{i=1}^{n} P_i[1-(n-i)r] \quad (22)$$

The average yearly cost is:

$$\gamma_n = \frac{\Gamma_n}{n} = Ar + \frac{1}{n}\sum_{i=1}^{n} R_i(1+r)^{n-1} + \sum_{i=1}^{n} P_i[1-(n-i)r] \quad (23)$$

In order to determine the optimum value of equipment's replacement time, according to those highlighted in the above model it is required the use of a computer program, the optimum value depending on R_i and P_i. The computer software was developed in TURBO-PASCAL, the data needed for its use being:

- the acquisition cost (A);
- the updating rate of investmens (r);
- the maintenance costs on different time periods (R_i);
- the equipment's value losses per year (P_i), with "i" ranging from 1 to n.

4. Conclusions and proposals

A replacement economical study has the same features that any economical study with two alternatives, the only difference consisting in the fact that an alternative is represented by keeping operational the existing equipment, by improving him and using it in a new working face, and the second one is to replace it by one or more new equipments, with the consequence of its cassation and partial recovery of his value.

Only a detailed analysis of the replacement solutions can offer a proper answer to the timing and specific new equipment needed for replacing the existing one.

In order to select an assessment model of an equipment's replacement costs, the following items should be considered:

- accountability data and informations available regarding actual costs, based on formerly proposed conditions and less important for the future period of time;
- equipment's and occupational safety, with respect to the fact that output can be compromised when postponing the replacement decision;
- the unavailability cost of parts included in different equipments, if faults are occuring;
- average costs comparison for faults occurence, based on data gathered before in operation, on observation of wear evolution in time, which allows the selection of an optimum strategy for the basic or leading equipments;
- assessment of operating time span (repayment or investment recovery) for new equipments is a basic requirement;
- the economical duration of maintaining in operation an older equipment is a function of the wear associated costs.

It can be stated that to fullfil the two major requirements imposed for open-pit mines, namely to supply enough lignite for the national economy needs and the achievment of economical efficiency indexes on the energetical market competition it is recommended to update the perimeters of existing quarries in view of achieving a maximum benefit, considering also the structure of present output capacities and the distribution of excavation and dumping technological equipments in future possible mining perimeters.

For continuous flow technological endowment, technological equipments available in other quarries will be employed, mainly from the quarries located in the proximity. Consequently, even if basicaly the direct investments in equipment acquisition are avoided, certain expenses will be needed in the purpose of bringing these equipments to a reliability level close to the initial one.

References

[1]. Biber E., *Procesul investiţional în economia de piaţă*, Editura Infomin, Deva, 1998.
[2]. Fleşer T., *Mentenanţa utilajelor tehnologice*, Editat de O.I.D.I.C.M., Bucureşti, 1998.
[3]. Cucu I., *Managementul activităţii de mentenanţă industrială*, Editura Universitas, Petroşani, 1999.
[4]. Fodor D., Vulpe I., Lazăr M., *Reabilitarea tehnică şi tehnologică a carierelor de lignit*, Editura Infomin, Deva, 2003.

STATISTICAL MODELS OF SUPPORTS' BEHAVIOUR IN LONGWALL MINING FACES OF COAL SEAMS

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Abstract: A better assessment of supports behaviour from longwall mining faces represents a very important problem in view to optimise the load capacity of these. In this paper is presented a synthesis of main statistical models of support behaviour for certain coal deposits from France, India, Russia and Romania developed along the time.

1. Introduction

Between all of the analytical, numerical, physical, etc. models used to simulate the supports' behavior of the longwall mining faces in order to choose and design them for certain mining conditions, the closest to reality are the models resulted from the in situ data statistical analysis. In order that the statistical model to be closest to reality, it is necessary to be taken in consideration many parameters, with most significant influence on the model.

The majority of the authors of statistical models have used, as an in situ data analysis method, the linear regression analysis. In principle, this method consists in determining a correlation between a dependent (explicated) variable which, in the great majority of cases, is the specific face convergence C and a series of independent (explained) n variables X_i , for example: the face length; slice height or face height; coal seam vertical height already mined, measured from the starting level; dip of coal seam; deep level of the faces, measured from the surface; average roof and floor rock strength; the number of rocks' strata on the 10 m of the roof, etc.

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In order to obtain a further more concentrated relation, the linear multiple regression relation is written into a logarithmic form: $\log C = a_o + \sum_{i=1}^{n} a_i \cdot \log X_i$, where: a_o, a_1, …, a_n are the regression coefficients.

In the followings, there are presented certain more significant statistical models obtained, along the time, by different authors, for various mining conditions of some coal deposits from France, Russia, India and Romania.

2. The French's models

Chambon [2, 13, 7], analysing by the linear multiple regression method the statistical data from more than 100 longwall faces, obtained the following equation:

$$C = 200 \cdot (q \cdot m)^{3/4} \cdot H^{-1/4}, \text{ [mm/m]} \quad (1)$$

Where: C represents the specific convergence of the face, in mm/m face advancement; q – the roof control factor (q=1 for roof caving, q=0.6 for the pneumatic stowing and q=0.2 for hydraulic stowing); m- the seam thickness, in m; H - the deep of the face, in m.

Correcting the previous relation (1) with the rapport between the measured and calculated convergence, in function of the load capacity of the face support P, in tf/m, Josien and Gouilloux [1,3, 5, 6, 8, 9, 12] arrive to the following relation:

$$C = 200 \cdot \left(\frac{34}{P} + 0.33\right) \cdot (q \cdot m)^{3/4} \cdot H^{-1/4}, \text{ [mm/m]} \quad (2)$$

Analysing the relations (1) and (2) it can be observed that in the same time with the deep increasing, the face convergence is more reduced. This phenomenon is explainable in the case of the longwall faces situated at the high depths, where the natural stress is in certain equilibrium.

Piguet [13], using Chambon's formula (established for the gentle seams with thin and medium thickness) for the thick seams' conditions, extends the application of the relation until the 12m of seam thickness.

Also, Mahmoud [9], analysing the data from more than 50 longwall faces obtains the following relation for the face convergence:

$$C = M \cdot m \cdot X^{0.75} \cdot P^{-0.66} \cdot N_b^{-0.125}, \text{ [mm/m]} \quad (3)$$

where: X is the face width, in m; N_b –the number of rocks strata on the 10 m of roof; M- constant which depends on the roof type (M=140, for the medium strength of the roof, $R_c \leq 60$ MPa; M=168, for $R_c \leq 60 \div 100$ MPa and M=98, for $R_c \geq 100$ MPa).

Onica [12] correcting the deviations of Mahmoud's relation, applied for the coal seam no.5 of Jiu Valley basin, obtains the following corrected relation:

$$C = 70 \cdot M \cdot m \cdot X^{0.75} \cdot P^{-0.66} \cdot N_b^{-0.125} + 7\text{, [mm/m]} \quad (4)$$

3. The Indian's model

Sarkar e.a. [14] considers that if we succeed to estimate the face convergence we can establish the roof behaviour. The maximum values of the convergences coincide with the cyclical failure of the roof rocks. If inside the roof, many roof rocks with large strength exist, there could be seen the many peaks of convergence with different values.

The following relation gives the maximum value of the convergence, during the roof rocks' failure phenomenon:

$$C = \left(\frac{1440}{P} + 9.6 \cdot m\right) + \left(\frac{K \cdot I}{K'+1.5} - 23\right),\ \text{[mm/m]} \quad (5)$$

Were, the caving factor is:

$$I = h^{0.6} \cdot \left(\sigma_c \cdot \frac{RQD + 10}{100}\right)^n$$

In the previous relations: *m* is the front face height, in m; *K*- constant equal to 0.25 for certain Indian deposits; *P*-load capacity of the face support, in 10^{-2} MPa; *K'* – factor that depends on the other factor *t* (*t* is the rapport between the caved roof rocks and the face height: for *t* < 2, *K'*=2; for *t* =2-4, *K'* =3; for *t* > 4, *K'*=5); *h*-is the thickness of the roof rocks, in m; σ_v-compressive strength of rocks, in 10MPa; *n* - factor depending on the *RQD* value of roof rocks (*n* =1.1-1.3).

4. The Russian's model

Nikichev, Thisenko and Vlasenko [10], for the thick coal seams in the inclined slices' mining from the Raspadskaja, Kuznetz basin, analysing the in situ data, obtain the following model for the powered supports' behaviour:

$$P = (k+1) \cdot \left[44.83 + 1.41 \cdot H^{1/2} + 0.96 \cdot h_p + h_{ex}^{-1} \cdot \left(0.56 \cdot h_d^2 - 7.11 \cdot h_d\right)\right],\ [10^{-2}\ \text{MPa}]$$

(6)

where: *P* is a maximum value of the external loads on the support units in the middle zone of the coal face, in 10^{-2} MPa; *H*- the deep of the coal face, in m; h_p, h_d – thickness of the main roof, respectively the immediate roof, in m; h_{ex} – the coal mined height, in m; *K*- coefficient that takes into account the powered support type and which, for the shock- shield type, is calculated with the following relation: $K = 1.29 \cdot \ln h_{ex} - 1.25$.

5. The Romanian's models

The Romanian's models were obtained by Onica [12], analysing the measurements data provided into the different longwall mining face conditions of the Jiu Valley coal basin, made since 1960.

In the conditions of the coal seam no.5, it was obtained, by the linear multiple regressions, the following relation [12]:

$$C = 5.72 \cdot 10^{-6} \cdot h_{ex}^{0.7} \cdot H^{3.73} \cdot P^{-2.24}, \text{ [mm/m]} \quad (7)$$

where: l_{ab} is the coal face length, in m; h_f – the coal slice height, in m; h_{ex} – the total mined coal seam height, measured from the roof level at the face, in m; H- the face deep, measured from the ground surface, in m; R_a- the average compressive strength on the 10m of roof rocks, in MPa; v_{ab} – the average face advancement speed, in m/day; N_b- the number of the roof rocks' strata along 10m of roof; P- the average support load capacity, in 10^{-2} MPa.

In the conditions when, in the previous relation (7), an admissible maximum value for the specific convergence of the face is imposed, which must ensure a maximum security of the coal face, we can explain the average support load capacity P, in function of the other variables of the model. For example, Josien and Gouilloux [8] consider that the optimum value of the face convergence is about 40mm/m of the face advancement. For the high variation of the support height and 0.63 m cutting strip, it is possible to take an optimum value of about 100-150mm/m. Therefore [12]:

$$P = 4.57 \cdot 10^{-3} \cdot h_{ex}^{0.313} \cdot H^{1.665} \cdot C^{-0.446}, \text{ [}10^{-2}\text{ MPa]} \quad (8)$$

The application conditions of the relations (7) and (8) are the followings: the integral or in the slices mining by the roof caving control of the coal seam no.5 of the Jiu Valley coal basin; the coal seam dip is a maximum of 18^o; the coal seam thickness, h_{ex}=2-11m; the deep of the face (the overburden strata), H=300-350m.

After a data analysis, by the multiple regression method, of the faces' measurements observations in the case of the coal seam no.3, mined in horizontal slices, with the caving rocks roof control, it was obtained dependence between the specific face convergence and certain independent variables [4,11,12]:

$$C = \frac{0.021 \cdot l_{ab}^{0.668} \cdot h_f^{7.89} \cdot H^{1.504} \cdot R_c^{2.552}}{h_{ex}^{0.548} \cdot \alpha^{0.812} \cdot R_d^{3.977} \cdot P^{0.183}}, \text{ [mm/m]} \quad (9)$$

In the most difficult Jiu Valley conditions the indigenous powered supports used, ensure a maximum convergence of 125mm/m. By consequence, the support average pressure acting on the middle face is calculated with the following relation [4,11,12]:

$$P = \frac{6.789 \cdot 10^{-10} \cdot l_{ab}^{\ 3.65} \cdot h_f^{\ 43.115} \cdot H^{8.218} \cdot R_c^{\ 13.945}}{h_{ex}^{\ 2.995} \cdot \alpha^{4.437} \cdot R_a^{\ 21.732} \cdot C^{5.464}}, \ [10^{-2} \text{ MPa}] \qquad (10)$$

where: l_{ab} is the face length or the horizontal seam thickness, in m; h_f – slice height or face height, in m; h_{ex}- coal seam vertical height already mined, measured from starting level, in m; α - dip of coal seam, in degree; H-deep level of the faces, measured from the surface, in m; R_a and R_c –average roof and floor rock strength, in MPa; C-maximum admissible face convergence, in 10^{-3} m/m face mining advancement.

The applied conditions of the previous relations (9) and (10) are the followings: l_{ab}=20-110 m; h_f=2.5-3m; h_{ex}=10-380 m; α =30-80°; H=65-580 m.

References

[1]. Birön,C., Arioğlu,E., *Design of Supports in Mines*, John Wiley & Sons, New York, 1983.

[2]. Chambon,C. *Mécanique des terrains houillers dans le cas de déformation planes*, Thèse docteur es sciences, Nancy, mars 1967.

[3]. Ghose,A.K. *Estimation of Support Resistance at Longwall Face - a Critique*, Journal of Mines, Metals/Fuels, March, 1985.

[4]. Iliaş,N., Onica,I. *Analyse de l'influence de l'espace exploité sur les zones approchées des longues tailles d'abattages, dans les conditions des couches puissantes et pqntées de charbon de la Vallée de Jiu* , III Congresso Italo Brasiliano di Ingegneria Mineraria, Verona, 26-27 Septembre, 1994, Edizia da Edizioni dei Parma.

[5]. Jacobi,O. *Praxis der Gerbirgsbeherrschung, Verlag Glückauf GmbH*, Essen, 1981.

[6]. Jacobi,D. *Upravlenia gornîm davleniem*, Nedra, Moskva, 1987.

[7]. Josien,J.P. *Contrôle de terrains dans l'exploitation par taille*, Thèse, Nancy, 1974.

[8]. Josien,J.P., Gouilloux,G. *Present and Future Roof Control and Support in Longwall Face in Coal Mines*, Colliery Guardian 226,No.11, October 1978.

[9]. Mahmoud,Y.S.E. *Analyse de l'influence des différents paramètres d'exploitation et facteurs naturels sur le comportement des terrains dans l'exploitation par longues tailles*, Thèse, Nancy, 1974.

[10]. Nichichev,B.G., Tishenko,S.M., Vlasenko,B.V., *Trends in the Development of Strata Control with Powered Supports in South Kuzzbass Coal Seams Extraction*, World Mining Congress, Madrid, 1992.

[11]. Oncioiu,G., Onica,I., *Ground Deformation in the Case of Underground Mining of Thick and Dip Coal Seams in Jiu Valley Basin (Romania)*, Procedeengs of 18th International Conference on Ground Control in Mining, 3-5 August, 1999, Morgantown WV, USA.

[12]. Onica,I. *Contribuţii la perfecţionarea tehnologiilor de exploatare cu fronturi lungi de abataj a stratelor groase de cărbune din Valea Jiului, prin utilizarea unor susţineri mecanizate adecvate condiţiilor geominiere*, Teză de doctorat, Petroşani, 1995.

[13]. Piguet,J.P. *La mécanique des terrains dans les couches puissantes des charbonnages*, Thèse, Nancy, 1974.
[14]. Sarkar,S.K., Chatterjee,T.K., Singh,B. *Modèle empirique-statistique de prévision de comportement du terrain et du soutènement dans une longue taille foudroyée*, 8éme Conf. Int. Sur les Pressions de Terrains, Düsseldorf, 22-26 mai, 1989.

CHARACTERISTICS OF SOLID FUELS USED FOR SUPPLYING THE THERMAL-ELECTRICAL PLANTS IN ROMANIA

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Abstract: Coal will keep its important share between the resources used for the production of electric and thermal power, which requires properly knowing the characteristics it has in each exploited mining field. The preparation of solid fuel for burning can greatly ameliorate those poor qualitative parameters of some coal originating areas, leading to obtaining an improvement of the energetic conversion output and to significantly reducing the environmental impact of the combustion products.

Coal is subject to certain **constraints** which put it at a disadvantage compared to petroleum and gas, its direct competitors. Being a solid, heavy ore, it is bulky and requires large storing surfaces, it has lower heating power than that of petroleum and natural gas and, in addition, it generates pollution in any production and operation cycle stage. On the other hand, coal's sea transport (90% of the coal sold worldwide being transported by sea) does not have the same environmental risks as compared to the transport of petroleum and natural gas.

Coal's physical disadvantages significantly reduced its markets, but, during 2000-2030, it is estimated that there will be a slight **increase of its consumption** in the European Union (figure 1.2). In the countries where it is not a dominant resource within the electric power production field (for example in Denmark, Germany, Greece, Ireland and England, where more than 45% of the electric power is produced from coal), it is often used as **supporting fuel**.

The hydro-electrical power fluctuations have a significant impact on the coal consumption, the likeliest countries to have these fluctuations being Austria, Sweden, Portugal, Finland, Italy, France and Spain.

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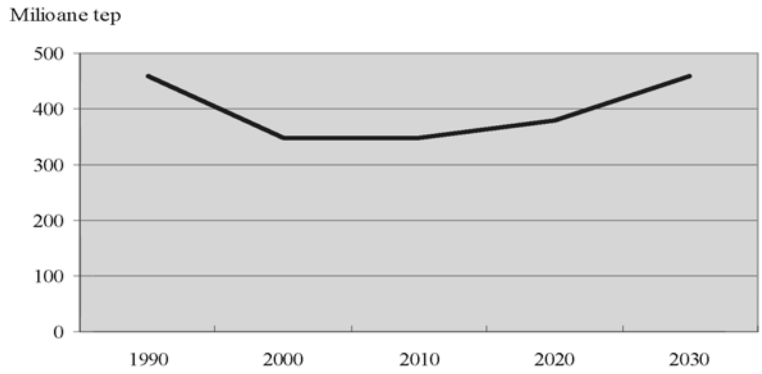

Fig. no. 1. The evolution of solid fuels consumption in the European Union, 2030 estimation

Under these circumstances, it is necessary to maintain a base production that could give access to reserves in case of a serious crisis, at the same time employing the most beneficial technologies.

Although for the short and medium term there are no major problems concerning the safety of solid fuels supply, the coal's future largely depends on the development of technologies that ensure easier usage (such as coal distillation) and minimize the environmental impact in terms of polluting emissions by means of clean burning and CO_2 seizing technologies.

The European coal industry will only supply a small portion of the European Union's needs.

The Romanian mining field has a raw materials basis with *low qualitative characteristics* and, in general, difficult geo-mining conditions that generate *high utilization costs*. Coal production is almost entirely meant for obtaining energy, out of which approximately 80% goes to S.C. Termoelectrica S.A, the evolution of coal sector depending on the dynamics of the energy sector.

The existing electrical and thermal energy production capacities by means of coal burning will continue to play an important part in the power industry, considering the increase of prices for imported oil and gas. As a consequence, the increase of the power field performance will be tightly connected to the efficiency capacity of the coal extraction and preparation activities.

Our country still has important brown coal resources, which, naturally, represents an advantage we must render profitable. Taking into consideration the brown coal's qualities and the performance of the electric plants that use this fuel, the justified economic limit of brown coal production/consumption is approx. 25 - 30 million tons /year, with no forecasted increase above this level. The usage of power pit-coal in the power plants is limited by the existing capacities and by the high operation cost to approx. 3 million tons/year.

Main characteristics of solid fuels those are important for the design and operation of plants:

Humidity. The fuel's water content directly, unfavourably influences its storage capacity and plays an important part in the fuel's self-ignition. To a certain extent, the water vapours positively influence the burning process, acting as catalyst. The water vapours also increase the gas radiation within the heating chamber. Nevertheless, greater water content is unfavourable, both for transportation and for the heat loss along with the combustion gases exhausted through the vent shaft.

Mineral mass. The minerals that are most frequently found in pit coal are clayey minerals and iron sulphite. An approximate formula for the calculation of the real quantity of mineral mass within the ashes content is:

$$M = 1.11 \cdot A + 0,35 \cdot S \quad (\%);$$

Where: A – quantity of ashes (%);
S – quantity of sulphur (%);

Sulphur. The quantity of sulphur of the Romanian power coal ranges between 0.4-5 %. The total sulphur is composed of organic sulphur originating from plants, pyrite sulphur, and sulphate. In case of organic sulphur burning and generation of SO_2 in the presence of subcarbonates and base silicates, the sulphur dioxide is largely connected and passes to slag.

Heating power. *The inferior heating power* [Q_i] does not include the water vaporization heat, heat which cannot be used.

The heating power can be calculated with certain approximation if the elementary analysis is known, by means of the formula:

$$Q_i = 81.3C + 297H + 15N + 45.6S - 23.5O - W \quad (kcal/kg);$$

Ignition temperature. The burning process cannot take place unless ignition occurred first. The fuel's oxidation begins at low temperatures. Above a certain temperature level, the reaction speed increases to such extent that the inner heat greatly exceeds the duty heat, which leads to the fuel ignition and intense combustion.

The ignition depends on the fuel's reaction capacity, on its granulosity and humidity, on the environmental temperature, on air speed, etc.

The ***volatile matter*** contained in the fuel's mass critically influence the ignition temperature. In order to prevent self-ignition, in case of fuel storing, it is necessary to prevent as much as possible the air circulation in the coal mass, the storage height not to exceed 6m.

Crushability. The dependence of the mechanical work necessary for crushing on the nature of fuels, on their physical-chemical characteristics and on the conditions in which the process takes place is complex and, therefore, it cannot be expressed by means of a mathematical law.

In practice, the resistance to crushing is expressed by means of the *crushability coefficient* which is determined by means of different laboratory methods.

Behaviour during ashes fusion. The ashes synthesizing and melting process is very important for the practical operation of heating chambers, especially in case of heating chambers with liquid slag exhaustion. Currently, the most often used procedure for determining the ashes fusion behaviour consists of the photographic record of the size and shape of a test body heated in the heating oven equipped with a microscope.

A series of photos of the 7mm-diameter and 7mm-high test body's shape determine the characteristic temperatures for the *heat distortion point* (the first modification of the test body's shape), of the *melting point* (half-sphere point) and the *pour point* (test sample's expansion due to the flow of the completely melted mass). If the melting point and the pour point are very close, then the slag has a short melting interval; if these points are far apart, the slag has a long melting interval.

Combustive power – carburant quantity enough to burn 1kg of solid, liquid fuel or 1 Nm^3 of gaseous fuel.

Smoke-producing power – quantity of burnt gases produced by burning 1kg of solid, liquid fuel or 1 Nm^3 of gaseous fuel.

Net heat – heat provided by the burning of 1 kg or 1 Nm^3 of consumed fuel; for the same fuel, the efficiency of the inferior heating power is lower than the efficiency of the superior heating power for the solid fuel; our country uses PCI and it is marked Q_i.

$$\eta(PCI) > \eta(PCS) \ (\%)$$

This temperature can be practically controlled by measurements, having for a steam boiler values amounting to approx. 1500°C.

The *Flammability* of a fuel is a fuel's property of igniting spontaneously or in the presence of a hot point. The flash point is the temperature at which a fuel heated in air, under atmospheric pressure, burns spontaneously or in the presence of a hot point. The flammability limits are the characteristics specific of fuels.

The thermal-electrical plants generally use double and even triple fuel supply systems; thus we have:

a) The thermal-electrical plants that use coal as solid fuel also have a gaseous fuel and methane gas supply.

b) The thermal-electrical plants that use naphtha liquid fuel also have a methane gas fuel supply.

c) The thermal-electric plants that use all the three types of fuel, respectively: Solid fuel - coal, liquid fuel – naphtha and gaseous fuel – methane gas;

d) The thermal-electrical plants that only use gaseous fuel – methane gas.

Table 1. The physical-chemical characteristics of the Valea Jiului pit-coal, used in the Paroseni and Mintia thermal plants:

Crt. no	Physical-chemical characteristics' name	Lower limit [%]	Average [%]	Upper limit [%]
1	humidity	11.2	**10.7**	6.0
2	ashes content	46.0	**38.0**	33.7
3	volatile matter	25.0	**24.5**	24.5
4	carbon content	75	**78**	78
5	hydrogen content	3.5	**4.7**	4.7
6	nitrogen content	0.7	**1.2**	1.5
7	oxygen content	12	**12**	12

Table 2. Presents the ashes content of the pit-coal in Valea Jiului:

Crt.n	Component name	Lower limit [%]	Average [%]	Upper limit [%]
1	distortion temperature	1250°C	**1410°C**	1470°C
2	silicon oxide	40	**46.43**	57
3	aluminum oxide	17	**17.5**	20
4	iron oxide	7.1	**10.3**	15
5	calcium oxide	6.7	**6.7**	7.8
6	magnesium oxide	1.0	**1.2**	1.6
7	sodium oxide	2.7	**3.8**	3.8
8	potassium oxide	0.7	**0.74**	0.9
9	sulphur oxide	1.8	**3.1**	3.4

The main characteristics of the brown coal in Oltenia, used by the Turceni, Rogojelu, Halanga and Craiova thermal plants are: Humidity content 27- 48%, ashes content 20-45% and the inferior heating power 1500-3100 kcal/kg

Table 3. The quality of these fuels is different by mining fields:

Crt. no.	Coal origin	*W* (%)	A^1 (%)	(kcal/kg)
1	Motru brown coal	40-46	20-24	1600-2000
2	Rovinari brown coal	40-46	20-24	1600-2000
3	Husnicioara brown coal	20-52	14-48	1400-2800

All the presented characteristics influence in different shares and modalities the solid fuel's behaviour during burning, the efficiency of the energetic conversion, the wear of the equipment used in the burning preparation as well as post-burning cycle, polluting emissions, etc.

Knowing the inferior and superior variation limits of these characteristics allows the taking of those measures that ensure obtaining optimum thermal-energetic installation operation, avoiding the high costs of electrical and thermal energy production.

The qualitative variations of the coal used in the energy domain can be very much diminished by homogenizing the production originating from the various mining units, by employing ecologic preparation technologies for fuels in view of burning and by capitalizing / storing the burning products (ashes, suspended dust, sulphur, nitrogen, carbon oxides, gaseous hydrocarbon, etc.) according to the requirements imposed by the limitation of the environmental impact to the European acceptable levels.

The operation of the fossil solid-fuel or various combustible waste burning thermal plants will be possible in the future if technological solutions specific of "clean-burning" and of the greenhouse effect emissions reduction are adopted. The reduction of the underground mining activity offers a series of study opportunities concerning the possibility of storing the polluting burning gasses within these spaces by reconsidering the designing of the closing of the mines that fit such a future utilization.

The EU grants research and in situ trials funds that can be accessed for thermal plants such as Paroseni, Rovinari, Halanga.

References

[1]. Preda Gh. (coordinator) – Treaty: *Valorificarea resurselor naturale (Utilization of natural resources)*, volume I – *Bazele resurselor naturale (Bases of natural resources)*, volume coordinators Marinescu M., Năstase G., Publishing House "International University Press", Bucharest, 2004

[2]. Ungureanu, C. – C*ombustibili. Instalaţii de ardere. Cazane,* Editura Politehnica, Timişoara, 2006.

[3]. International Energy Council – *Trăim pe o singură planetă (We live on one planet). Dezvoltarea durabilă văzută dintr-o perspectivă energetică (Lasting development seen from an energetic perspective)*, Romanian Academy Publishing House, Bucharest 2003. *Despre politica de energie a Uniunii Europene (About the energy policy of the European Union)*, paper elaborated within the Phare RO 0006.18.02 Project.

[4]. G.D. no. 1535 *of 18 December 2003* concerning the approval of *The Strategy for the utilization of the recoverable energy sources,* published in the Official Gazette, Part I no. 8 of 7 January 2004.

INFLUENCE OF COAL DUST ON THE PERFORMANCES OF THE BOILERS WITHIN HEATING PLANTS

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Abstract: *Thus, each type of fuel, each installation, is characterized by a certain economic grinding fineness which is determined depending on the fuel's qualities and on the installation's special characteristics. The equipment wear currently remains arguments that are against the introduction of high granulosity pulverized coal burning. The pneumatic transport needs relatively high speeds of the carrying fluid which produce significant pressure rises, friction and clashing between the solid phase particles and thermal plants erosion. A high concentration leads to the intensification of wear. The quality of the materials the components subject to wear by the fuel dust are made of will influence the wear speed.*

Physical properties of coal dust

The coal dust is made of a mixture of particles with dimensions up to 300-500-1000 microns where the particles with dimensions between 20 and 50 microns prevail.

Under microscope examination, the dust particles have an irregular shape that, in most cases, depends on the fuel's nature and, to a lesser extent, on the dust preparation method. The great difference between the dust particle's shape and the regular geometrical shapes (cube or sphere) constitutes the main difficulty in calculating the size of the dust particle's surface. Due to the great quantity of fibre residues within the pit-coal dust particles, their shape differs a lot from the regular geometrical shapes.

The coal dust absorbs a large air quantity and, therefore, the freshly poured dust is a spongy mass which travels easily and which, under poured state, has a low weight. In time, under the influence of light vibrations that are produced in each installation, as well as due to the pressure created by the weight of the superior layers, the dust mass becomes more compact. The density of poured and pressed dust depends on the nature of the material and on the grinding fineness, being as an average equal to

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0.8-0.9 t/m. Upon calculating the bunkers capacity, the density of the poured dust must be taken as an average of 0,7 t/m^3.

The natural slope of the slowly poured dust is 25/30 g and varies depending on the fuel's quality and on the grinding fineness. Under the influence of light shocks, the dust in the vibrating or rotating recipient behaves like water. One can sink within a coal dust bunker, for this reason it is forbidden to descend into a coal dust bunker without prior precautions. The efficiency of dust elimination through small orifices depends on the fuel's quality and on the dust's granulometric composition.

In the presence of fine particles with high content of volatile matters that tend to aggregate rapidly, it is possible that the coal dust will not pour out through small orifices. Grinding the coal dust to high granularity or separating the fine particles improves the elimination process.

When mixed with air, the dust forms a fluid-structured emulsion which, the same as liquids, is easily transported. Due to this property, both in case of long distances (at 25 to 1 concentration) as well as in the usual dust preparation systems (1 to 29 concentrations), pneumatic transport is used.

The coal dust stores are exposed to ignition risk, combustion points being formed inside (flameless burning) due to the high content of volatile matter and there is a risk of explosion.

Granulometric analysis of coal dust

The granulometric analysis of coal dust consists of sample acquisition and sifting through several sieves which differ by orifice sizes.

The operation of granulometric analysis power installations usually employs two types of sieves, with 88 and 200 orifice sizes. In order to obtain more complete dust characteristic, it is sifted by means of five sieves whose orifices are usually 60, 75, 88, 120 and 200 microns. The value of the reject determined on a conventional sieve constitutes the characteristic of grinding fineness and it is marked with "R".

The dimension of the sieve orifice or the sieve's number is marked as an index. Therefore, markings such as R_{88} or R_{70} indicate the value of the reject per sieves whose orifice size is 88 or 70 μm.

The dust quantity passing through the sieve is the so-called "passing" and it is marked with "D". The dimension of the sieve orifice is also marked as an index. The sifted dust quantity is expressed in percentage of the initial sample quantity. Therefore, for each sieve characterized by a certain number, the following equation can be written:

$$R_x + D_x = 100 \quad [\%]$$

Thus, the dust quality can be appreciated both by means of the reject as well as by means of the sifted dust quantity.

The optimum coal dust grinding fineness

During the grinding process, when the rejects by sieve are reduced in case the dust is ground to a finer state, the uncovered sieve surface increases. Proportional to the surface size, the specific energy consumption necessary for the dust preparation also increases. For this reason, in order to increase the flow rate of the dust preparation equipment, it is recommended that the ground dust have larger particles. Nevertheless, the installation's lucrative ness is not only determined by the dust preparation equipment's operation.

The usage of the large particle dust burdens its burning process and causes the increase of fuel loss through incomplete burning in the heating chamber. The entire installation will be very profitable when the sum of the expenses necessary for the dust preparation and burning will be minimal. The grinding fineness for which the general losses are minimal is called the economic grinding fineness.

It is generally difficult to determine the economic fineness, because it is influenced by several local factors. For this reason, generally speaking, the economic grinding fineness can be determined with sufficient accuracy only when it is determined separately for each installation. If one relates the sum of the expenses necessary for the dust preparation and burning to 1 ton of fuel, this relationship can be expressed as follows:

$$c_t=c_e+c_m+c_{serv}+c_c \qquad \text{[thousand lei]}$$

Where: c_e – are the expenses referring to fuel, namely to the price of energy consumption necessary for the dust preparation, in lei/ton;

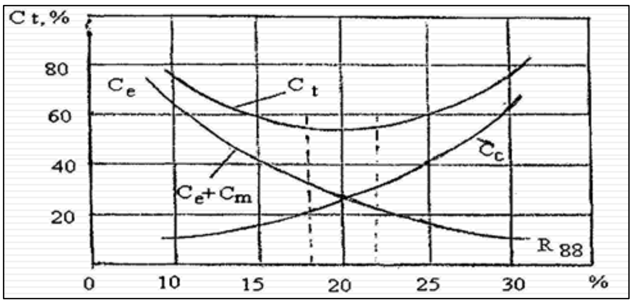
c_m- expenses referring to metal losses, equipment wear and to the dust preparation in lei/ton;

c_{serv}- other expenses for various services: oiling, servicing, redemption;

c_c - cost of fuel loss by burning, in lei/ton.

Figure 1 illustrates the curves drawn in view of determining the economic grinding fineness. The ascending curve, c_e, indicates the variation of fuel losses during burning; the descending curve, c_e+c_m, indicates the variation of energy consumption necessary for the dust preparation. The curve with downward convexity represents the variation of the sum of expenses.

The optimum grinding fineness corresponding to the minimum sum of these expenses is situated, in this special case, between the R_{88}=18-22% limits.



Thus, each type of fuel, each installation, is characterized by a certain economic grinding fineness which is determined depending on the fuel's qualities and on the installation's special characteristics. At the same time, in practice, good results were obtained for a less fine grinding, as one goes from fuel with low volatile material content to fuel with high volatile material content.

Equipment wears during coal dust burning

The usage of high granularity coal dust increases, in certain cases, the fear of equipment wear.

The equipment wear currently remains the basic argument used by those that are against the introduction of high granulosity pulverized coal burning. Nevertheless, after several years of burning high granulosity dust within various boiler systems of various constructions within a series of plants and after the grinding granulosity reached a relatively high value, R_{88} = 50% and more, one can state that no increase in the equipment's wear can be noticed.

If the elements of the boiler system and its auxiliary equipment were well built, they do not tend to wear due to ashes and do not have such relevant spots: passing to the burning of large particle dust does not change the situation in any way. The special experience after the operation of boiler systems within thermal plants which is described by the burning of large particle dust with Rgs up to 50% is an additional and convincing proof for the above. The wear problem is reduced, therefore, to the problem of the speeds of the gases saturated with ashes residues. The boiler systems that operate with fine dust or with large particle dust did not show differences in wear. Even by operating with fine dust, the exhausters' life span was maximum 1.5 – 2.0 months.

The cleaning of burning gases by means of a cyclone system made it possible to almost double, up to 3-4 months, the exhausters' operation life. From the data resulting from the sifting of the dust sample that was taken directly from the cyclone system's elimination devices, when the boiler system operates with large granulosity dust and with R_{88} up to 50%, it is demonstrated that the cyclone system entraps the quite fine dust, the sifting through the 88 sieve being 29-50%.

Table 1 shows the values of the average speed of the burning gases upon their passing through the different elements of the boiler system, at a load of 160 t/h. In those elements wear is noticed for a series of plants.

Table 1. The values of the average speed of the burning gases upon their passing through the different elements of system

Boiler system name	Built boilers	
	first phase v, m/s	**second phase v, m/s**
Steam overheater	8.75	6.1
Economizer	10.3	8.0
Air pre-heater: tubular or with plates	12.4	9.4
Exhauster's aspiration	13.7	12.4
in the general burnt gases channel	15.4	16.8

Coal dust's influence on the connection pipes between the separator and the boilers' burners

The direct burning dust preparation schemes also contain a pneumatic transport section where the dust particles are led to the burner by means of a carrier fluid.

The pneumatic transport needs relatively high speeds of the carrying fluid which produce significant pressure rises, friction and clashing between the solid phase particles and the transport pipes' erosion. In order to maintain these effects as minimum as possible, the transport speed must be as low as possible. The inferior limit of this speed is the one at which the particles begin to separate from the current.

As far as the horizontal pneumatic transport is concerned, the minimum speed is the speed at which the particles begin to lay on the pipe's bottom; as for the vertical speed, the speed at which the pipes or grinder's clogging begins. Both the sedimentation speed as well as the clogging speed depends on the nature of the carrying agent, on its temperature, on the specific weight of the solid phase, on the particles' average diameter, on the solid phase concentration, on the pipe's length and on the pipe's tightness resistance.

The dedicated literature recommends the following pneumatic transport speeds for the coal dust:

- for air 20-25 m/s, for burning gases and air mixture 12-20 m/s, within the descending drying pit 20-35 m/s, within the grinder's exhaust pipe with fan 22-30 m/s.

It is recommended that the pipe's slope be at least 45°. If one part of the pipe must be placed horizontally or with a slope which is less than 45°, then the transport speed will have to be increased. The pipes' bends must be built with an average curve radius $R_{ave} > 3$ d in order to reduce the pressure losses and the erosion.

Generally, bends with two 45° returns are used, which avoid the occurrence of pulsations an of the dust concentrations noted in the case of 90° bends, ensuring a continuous flow and a good dust distribution within the burner's cross-section. The coal dust pipes are usually made of steel or steel sheet pipes with rectangular section, joint by welding, the pipe's wall thickness being 10-20 mm, after the coal dust's abrasive effect.

In order to reduce the bends' wear, the parts that are exposed to high wearing are built with greater thickness, are easily interchangeable, and are possibly made of special materials (basalt, concrete), etc. In the case of metal sheet pipes designed for brown coal, the exposed areas reach operation periods of approx. 16,000 hours.

Coal dust's influence on the erosion of the heat exchange surfaces

A problem which is still not completely solved in the construction of the inferior solid fuels' burning installations is the eroding effect of the ashes. The material's erosion by the ashes particles takes four different forms: "adhesive" wear which occurs during the materials' sliding processes, the wear by "grooving" when the material is deeply scratched, the "layer" wear, when the process is limited to the external surface of the material and the decisive part is played by the existing superficial layer or the one created by wear; wear by "fatigue" which occurs in the superficial layer of the material under the impact of the ashes particles or of the variable stress indicating that the erosion can have two different causes: repeated deformation caused by the impact of particles which displaces a certain volume of the material and the material's cutting by the particles.

In the case of hard and fragile materials, the wear by repeated deformation prevails and, for the soft materials, the erosion by cutting prevails.

In order to reduce the erosion caused by the solid particles dislodged by the burning gases during the construction and operation of the steam boilers which use solid fuels, a series of measures are taken, some of them depending on the erosive agent and on the dislodging fluid, others depending on the pipes' material and their arrangement in clusters. Among these, we mention the reduction of the ashes concentration within the burning gases and of the particle's speed. A high concentration leads to the intensification of wear. The high ashes concentrations appear during the changing of the dislodging fluid.

Generally, for boilers with high parameters, a pipe erosion of approx. 0.2 mm/year is acceptable, which leads to an approx. 2 mm erosion of the pipes in a period of approx. 10-12 years, the equivalent of the yield period. This thickness loss falls within the surplus corresponding to the safety coefficient of the pipes builders, the provision of an additional surplus for erosion not being necessary, as compared to the one resulting from the pipe's resistance calculation. In this way, the optimum speed is thus chosen so that the pipes can last for a period of minimum 10-12 years. This speed limitation is supported by local protection methods in the dangerous areas, as presented.

Another group of methods seeks the modification of the erosive agent's properties, among which the increase of the fuel's grinding fineness, the reduction of its ashes content, the modification of the erosive particle's shape.

As far as the quality of the steel used for the construction of serpentines is concerned, it must be noted that steel with large granulosity is recommended, that carbon steel resists better than the alloy steel, as a consequence of the surface cold-hardening carried out by means of the particles' impact.

Conclusions

- The grinding behaviour of the coal depends on its origin, on the mineral and petrographic composition, on the ashes content, on the equipment used for grinding-sizing and on the working conditions.
- The particles' dimensions determine different effects concerning wear in the case of the majority of equipment which they come into contact with, in this case only the post-grinding circuits being analysed.
- The pneumatic transport conditions depend on the material's granulometry and it will determine, at high transport speeds, an increase of the wear of the pipes and of the other components in the transport system, especially exhausters.
- The quality of the materials the components subject to wear by the fuel dust are made of will influence the wear speed and the choice of those structures that cover

the costs either by reducing the necessary replacement parts, or by means of the low acquisition cost of these components.

Bibliography

[1]. Angelescu, A., *Mediul ambiant şi dezvoltarea durabilă (The environment and the long-lasting development,)* A.S.E. Publishing House, Bucharest, 1999.
[2]. David, I., *Transportul poluanţilor în medii fluide (Transport of pollutants in fluid media)***,** U.P.T. Publishing House, Timişoara, 1996.
[3]. Ungureanu, C., *Combustibili. Instalaţii de ardere. Cazane (Fuels. Burning installations. Boilers.),* Politehnica Publishing House, Timişoara, 2006.

SULPHUR REMOVAL TECHNOLOGIES FOR THE FOSSIL SOLID FUELS BURNING INSTALLATIONS

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Abstract: The SO_2 retention efficiency depends on the sulphur content within the coal subject to burning, on the nature of the used reactive substance, on the working temperature, on the sorbent concentration and on the contact time. The economic aspects will be the ones that will lead to the choice of the sulphur removing agent.

The New Power Strategy of Romania is based on the current realities and trends in the power sector, namely:

- Present state of the power sector;
- Power resources reserves and internal production;
- High power intensity throughout the entire chain: - primary resources, production, transport, distribution, including the final consumer;
- The high pollution level generated by the power sector and the necessity of observing the limits negotiated with the EU;

From the directions taken by the Romanian power policy that are consistent with the European Union's power policy, those that directly refer to the production of power based on solid fuels are:

- the choice of a balanced varied energy group, with emphasis on the usage of coal, nuclear energy and recoverable energy sources, including by means of employing the non-exploited hydrological potential, which would offer the power sector competitiveness and safety of supply;
- achieving the environment protection and CO_2 emissions reduction objectives;

Increasing the investment in the domain of coal and uranium ore extraction, in the modernization and rehabilitation of equipment, in continuing the support of pit-coal and uranium ore production by means of State support, according to the EU

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regulations, in intensifying the geological research and the exploitation of new deposits, in closing the mines whose activity has ceased.

In the domain of electric power production, a process of reorganization and renewal of power capacities will take place, by means of rehabilitating the viable existing units, closing the non-viable units and by constructing new production units.

The **fossil** fuels represent the energy sources that are the most often used today. The result of their burning has a relevant and, in time, significant impact on the whole environment. The **burning** process leads to the generation of air, water and soil emissions, among which the air emissions are considered to be one of the main environmental problems.

The most important air emissions resulting from the burning of **fossil** fuels are SO_2, NO_x, CO, dusts (PM_{10}) and the green-house effect gases, such as N_2O and CO_2. The other substances, such as heavy metals, halogenated compounds and dioxins are emitted in small quantities.

The total sulphur contained by coals is made of organic sulphur, pyrite sulphur and sulphur sulphate. During the combustion process, it transforms into sulphur dioxide and, to a lesser extent, into sulphur trioxide.

A simple checking modality for the formation of these two oxides can be represented by means of the following equations:

$$S + O_2 \rightarrow SO_2 \quad (1)$$

$$2SO_2 + O_2 \rightarrow SO_3 \quad (2)$$

The relative quantity of each compound does not depend to a significant extent on the quantity of present oxygen. Even in the presence of great air quantities, a larger quantity of SO_2 is formed. The sulphur dioxide is a colourless gas, with stifling, penetrating smell.

The total sulphur content within coal varies in large margins for different deposits, depending on the conditions of their formation.

Romanian coal has an average content of sulphur of 2-3%.

The quantity of SO_3 formed during the burning process depends on the reaction conditions, especially on the temperature. The most ecologically dangerous is SO_3, responsible for the formation of acid rain.

These oxides are transported to great distances due to the fact that they are easily fixed on dust particles. In the atmosphere, reacting with the water vapours, they form sulphuric or sulphurous acid which create the acid characteristic of rain.

The presence of sulphur dioxide in the atmosphere over certain limits has negative effect on plants, animals and Man. As far as plants are concerned, the sulphur dioxide induces local lesions in the foliar system, reducing photosynthesis. As far as Man and the animals are concerned, in small concentrations, it leads to irritation of the breathing system and, in larger concentrations, it induces bronchial spasm. Also, the sulphur dioxide produces disorders in the glucides metabolism and enzyme processes. The toxic effect of sulphur dioxide is emphasized by the presence of dusts.

The reduction of the SO_2 emissions is carried out by:

a)Processing the raw material that contains sulphur before they are inserted in the technological process;

b) Removing sulphur from the combustion gases.

The coal sulphur removing procedures are classified as:

1. Chemical pre-treatment followed by the mechanical removal of the sulphur contained as impurity in pyrite (the organic sulphur cannot be removed). The reduction of pyrite sulphur is carried out in proportion of 90%.
2. Chemical transformation of sulphur within coal into soluble or volatile compounds.
3. Sulphur removal by means of removal-liquation, followed by product solidification and various coal distillation procedures.

Removal of sulphur from industrial gases

In view of reducing the noxiousness of the gas emissions, the most researched and applied method is the removal of sulphur from the combustion gases.

The retention of sulphur from the residual gases can be achieved by means of conventional procedures which are based on processes such as: absorption, adsorption, catalytic oxidation, catalytic reduction and non-conventional procedures by irradiation with accelerated electrons beam – microwaves.

Theoretical aspects concerning the removal of sulphur from residual gases by absorption, at low temperature

The low temperature sulphur removal is characterized by the absorption of sulphur oxides into an alkaline solution based on calcium, magnesium, sodium, ammonia combinations, and the resulting final products being the sulphates in question.

The water solubility of sulphur dioxide is low and it decreases as the temperature rises.

During the absorption into water, a hydrolysis process occurs, according to the equation:

$$SO_2 + H_2O \rightarrow H^+ + HSO^-_3 \qquad (3)$$

In order to increase the SO_2 absorption degree into watery solutions it is necessary to insert in the absorption system a substance that removes the proton (H^+) or that connects the bisulphite anion (HSO_3-). To this purpose, solutions of substances with base characteristics are used.

The process of SO_2 absorption into alkaline solutions is a heterogeneous process, in most cases the chemical reaction taking place during the liquid phase and at least one of the reacting substances originating from the gaseous phase.

The chemical reaction and the mass transfer influence one another.

The presence of the chemical reaction at the same time with the mass transfer can be quantified as defining the mass transfer amplification factor and the liquid phase usage factor, named limit factors.

Due to the fact that, for the three classic models of mass transfer (film model, penetration and surface renewal), the mass transfer amplification factor has the same value; the film model is chosen for the mass transfer. In the film theory, the resistance to mass transfer is considered to be concentrated into two relatively small areas, located on each side of the interface, the complex phenomena taking place in the liquid film being based on the diffusion mechanism.

The SO_2 retention efficiency depends on the sulphur content within the coal subject to burning, on the nature of the used reactive substance (chalkstone, lime, sodium hydroxide, hydrogen peroxide, etc.), on the working temperature, on the sorbent concentration and on the contact time.

The chemistry of the sulphur removal process

In the wet sulphur removal technologies, depending on the sorbents used for the reduction of SO_2, depending on the injection location, the following reactions can take place:

- Calcium hydroxide in solutions with different concentrations:

$$Ca(OH)_2 + SO_2 \rightarrow CaSO_3 + H_2O$$

- Chalkstone injected directly in the heating chamber:

$$CaCO_3 \rightarrow CaO + CO_2 \qquad \text{at approx. } 800 - 900°C$$

$$SO_2 + CaO + \tfrac{1}{2} O_2 \rightarrow CaSO_4 \qquad \text{at approx. } 900 - 1100°C$$

- Sodium hydroxide in solutions with different concentrations:

$$4\ NaOH + 2\ SO_2 + O_2 \rightarrow 2\ Na_2\ SO_4 + 2\ H_2O$$

- The ammonia passes through the phases of hydrogenated ammonium sulphite (NH_4HSO_3), ammonium sulphite $(NH_4)_2SO_3$, and finally:

$$(NH_4)_2SO_3 + \tfrac{1}{2} O_2 \rightarrow (NH_4)_2SO_4$$

- The combined usage of ammonia and carbamide:

$$H_2N\text{-}CO\text{-}NH_2 + H_2O \rightarrow CO_2 + 2\ NH_3$$

$$SO_3 + 2\ NH_3 + H_2O \rightarrow (NH_4)_2SO_4$$

$$8\ NH_3 + 6\ NO_2 \rightarrow 7\ N_2 + 12\ H_2O$$

The economic aspects will be the ones that will lead to the choice of the sulphur removing agent.

The capital costs depend on the specific location conditions, on the installation size, on the SO_2 concentration upon admission, on the limit value of SO_2 emission, on the condition of practice, on the usage of gypsum or solid residues.

In order to cover the investment and operation costs of the sulphur-removal installations that must be attached to the thermal plants according to the European norms, it is necessary that the management be oriented towards increasing the energy production efficiency.

BIBLIOGRAPHY

[1]. Ashline,. *A Case Study: The Commercial Deployment of Pure Air's Clean Coal Technology*, Pure Air. Second Annual Clean Coal Technology Conference, Atlanta, Georgia, September 1993.

[2]. Ionel, I., Ungureanu, C. *Thermal - energetic and the environmental,* Editura Tehnică (Technical Publishing House), Bucharest, 1996.

[3]. Savu, A. *Reducerea emisiilor de SO_2 în focarele cazanelor energetice cu funcționare pe combustibil solid (Reduction of SO_2 emissions in the heating chambers of solid fuel energy boilers),* ICPET, Bucharest, 2000.

[4]. x^xx *Strategie Energetică a României pe perioada 2007 – 2020 (Romania's Energy strategy during 2007 – 2020).*

AUTOMATED SYSTEMS OF MEASURING AND CONTROL OF PARAMETERS IN NEUTRALIZATION PROCESS INSIDE EFFLUENT TREATMENT PLANTS

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Abstract: Effluents in mining industry, metallurgy and chemical industry are treated inside plants featured by the existence of stages for mechanical, physical-chemical and biologic treatment. In the first part of the work there is an account on the structure of two effluent treatment plants depending of their pH as well as the structure of an effluent mechanical-biological treating plant. In the second part systems are presented for measurement of effluent process parameters. The biological stage of effluent treatment requires to reach a solution having $pH = 7{,}5$ Neutralization of waste waters is a chemical process to be achieved inside chemical reactors of the type with mixing, large volume and appreciable inertia. One of the way to mitigate the duration of neutralization reaction and to diminish consumption of neutralizer was found in the implementation of an evolved system to manage the neutralizing reactor. The third part is dedicated to mathematical modelling of neutralization process depending on the effluent pH.

Key words: effluents, neutralization, transducers, modelling, control.

1. Introduction

The mining industry generates multiple negative effects on environment in all its components: water, soil and air. Negative effects are due to both operation activity and reservoir preparation process. The ore operation activity results in impressive amounts of sterile rocks stored in not covered stockpiles subject to actions of rain and

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wind. By solubilising meteoric water carries chemical compounds to the soil in surface water or in underground. Preparation of ore is achieved by wet, procedures, procedures consuming large amounts of water taken over out of the closest rivers. Waste waters resulted further to the ore preparing process are discharged into settling pits and from here after treatment they reach again the outlet [1]. In this context the effluent treatment plants stand for an objective necessity for both mining and oilfield processes.

The present work deals with aspects of effluent treatment for waste waters resulted out of mining, metallurgic and chemical industry. A typical treatment plant is subject to analysis that is associated to the mining industry. Performances of treating plants also depend on the related measurement and control systems [2]. In this respect the work accounts for the main measurement systems in an industrial effluent treatment plant. A particularly significant issue is the pH control at inlet in the effluent treatment biological stage. There are presented in this work authors' research within the field of pH evolving control.

2. Effluent treatment plants

Given the significance of mining and oilfield industry in Romanian society there will be hereinafter presented and analysed aspects of the construction and operation of specific effluent treating plants.

Particularities of Mining Treating Plants. Water polluting emissions may include reagents used in ore processing such as: metallic ions (e.g. iron, zinc, aluminium), cyanides, xanthenes, acids or alkali leading to decreasing or increasing the *p*H, metals (either solid or dissolved or metallic compounds), dissolved salts (coal mines), radioactivity (in coal sterile/waste stone stockpiles), foaming agents, oils, suspensions of solid particles. The *p*H indicator varies from strongly acid (*p*H =3) to intensely alkali (*p*H =10...11) in waters originated in ferrous and non ferrous ore processing and from *p*H =3 to *p*H = 8...9, in charcoal processing.

A technique used to reduce water acidity is the active treatment. It involves neutralizing polluted water having acid character by making use of calcium carbonate. A typical process flow of a water treating plant with low *p*H is shown in figure 1 [3].

Mitigation of alkalinity of *p*H =10 waters is reached by the following methods: splashing with burning gases rich in SO_2, addition of sea water for reaction of $MgCl_2$ with sodium hydroxide with addition of sulphuric acid.

Particularities of Oilfield Treating Plants. A typical oilfield effluent treating plant is composed of stages: mechanical, physical-chemical and biological. The main flows associated with such a plant are as follows: effluent, slime in excess, water in mud, recirculated treated water, figure 2 [4]. The structure of the plant automation contains a system to measure the effluent *p*H at inletting the plant as well as *p*H control in physical-chemical stage. As the volume of solution in the reactor is very large of $20\ldots60$ m^3 order, the time constant of neutralization process is very high of tens of minute order and the quality of control is significantly affected [5].

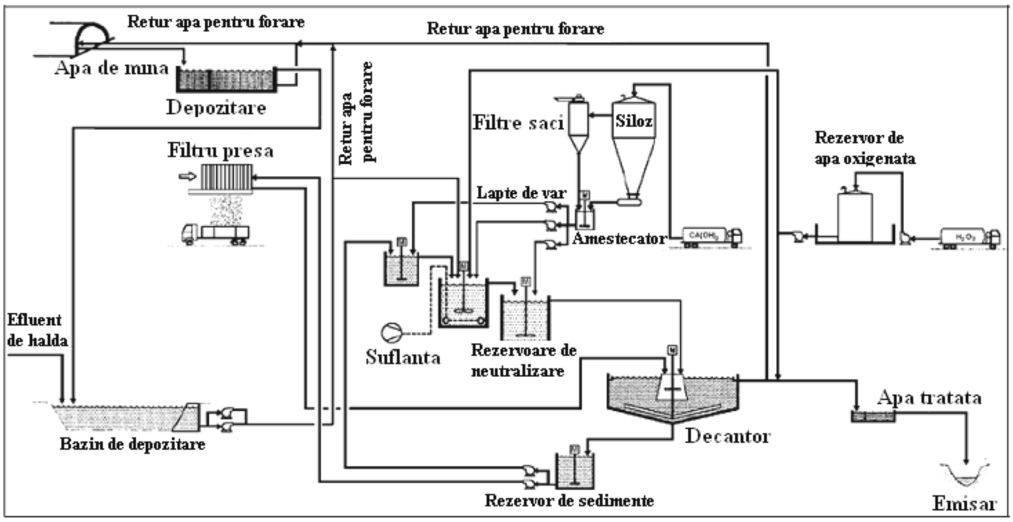

Fig 1. Process flow of a low pH water treating plant.

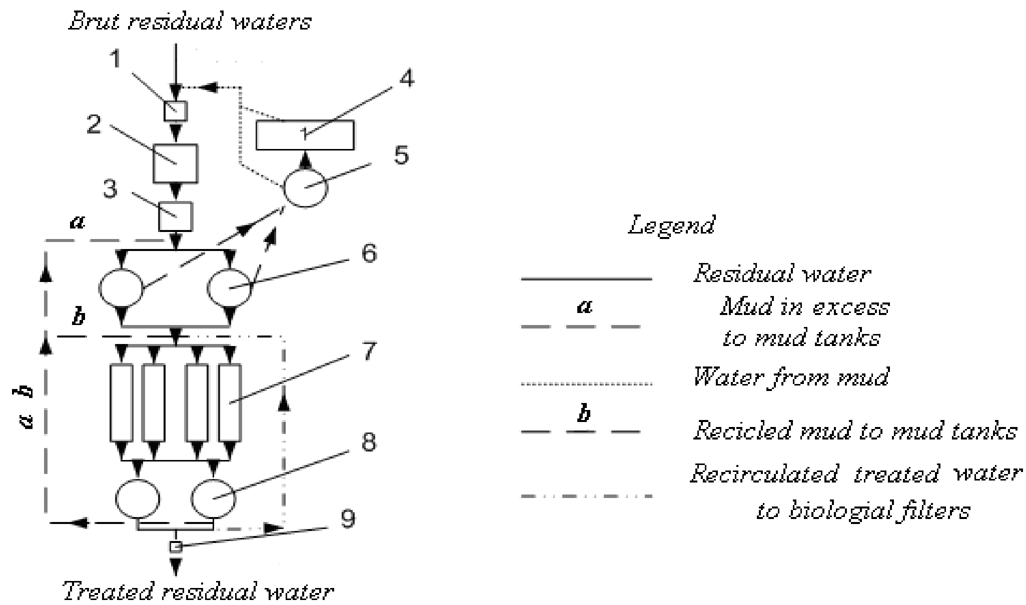

Fig. 2. Sketch of artificial mechanical-biological treatment:
1 – gratings; 2 – desanders; 3 – grease separators; 4 – structures for sludge dehydration; 5 – tanks for sludge fermentation; 6 – primary settlers; 7 – structures for artificial biological treatment; 8 – settlers; 9 – chlorination station.

3. The parameter measuring systems in neutralization plant

Systems of measuring the process of effluent treatment include the system of measuring *p*H, the system of measuring the effluent flow rate and the system of measuring the level in the sensitive level of the flow rate transducer.

3.1. The Measuring System of pH

To industrial scale measuring of industrial to factor *p*H is done with electrical methods based on electrochemical effect of the analysed solution on a pair of electrodes, working electrode and reference electrode. The electric potential of the working electrode depends on the factor pH of the solution while the electrical potential of reference electrode is practically constant.

Working Electrode the most frequent is the glass made electrode, figure 3. Its lower part is made of a special soda glass with electrode properties and the upper side of common glass. At the contact surface between soda glass and solution subject to analysis there is a difference of potential E_x, depending on pH factor of this solution.

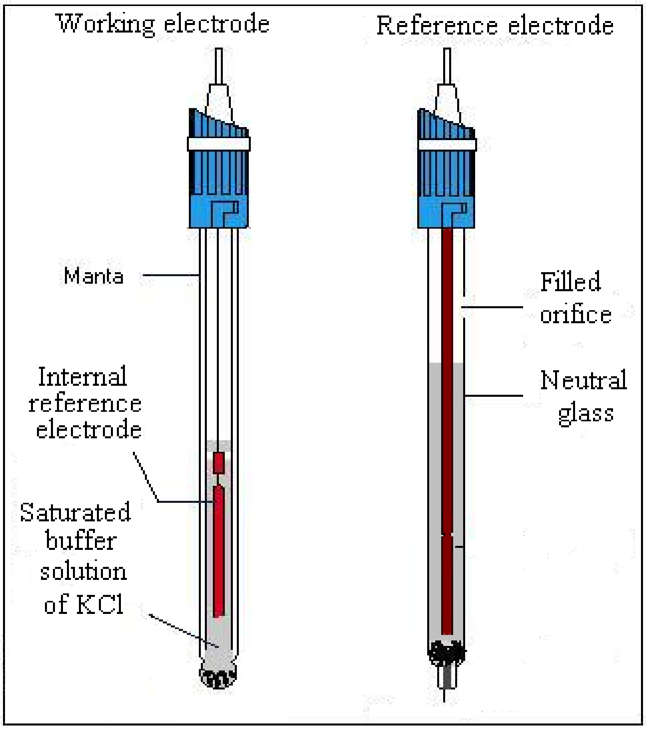

Fig. 3. Diagram of classic design for electrodes.

Inside the glass electrode there is a kali chloride buffer solution having practically constant concentration. At the interface between soda glass and solution inside electrode a difference of potential E_1 occurs being practically constant. To measure the E_x difference of potential an electrode is used made of calomel, AgCl, placed into the glass electrode. This electrode is manufactured of neutral glass.

The lower side is filled in with a mixture of mercury and calomel that through an asbestos buffer communicate electrically with solution ion the glass electrode. At upper side of calomel made electrode there is mercury that in contact with mercury and calomel solution generates a E_2 potential that is constant and recognized.

Reference Electrode is similar with the working one except the difference that it is made of neutral glass and consequently does not generate potentials E_x and E_1. The glass tube is filled with a solution of kali chloride generating the occurrence of E_4 difference of potential between the solution subject to analysis and the KCl solution from inside. This difference of potential is negligible.

3.2. The Flow Rate Measuring System

In the treating stations systems are used for flow rate measurement through open channels. The primary transducer of such flow meters is a local hydraulic resistance altering the variation in the level of liquid open surface in the measuring section. The variation of level is measured by a level transducer and the signal thus generated is processed by a secondary block with determination at outlet of the Q_r value of measured flow rate. The most largely spread flow meters are Parshall measurement channel flow meters featured by measuring channels with narrowing of water jet and variable height profile, figure 4. The primary transducer of such flow meters has got all surfaces plain and consequently is physically built much easier [6].

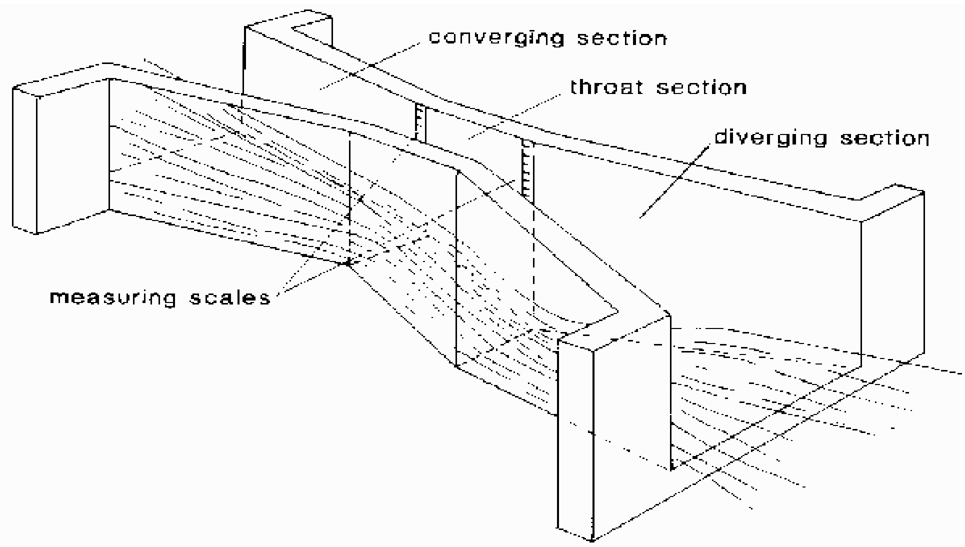

Fig. 4. The Parshall measuring channel.

Into non sunk regime primary transducers of Parshall measuring channel flow meters have the characteristic equation [6]:

$$Q_v = c_2 \cdot b \cdot H_{am}^{1,57 \times b^{0,026}} \ , \qquad [\mathrm{m^3/s}] \qquad (1)$$

Where the coefficient c_2 has expression:

$$c_2 = 0,372 \cdot 0,305^{-1,57} \cdot b^{0,026} . \qquad (2)$$

There are shown in figure 5 constructive data for Parshall measuring channel levels H_{am} and H_{av} are measured against the elevation of horizontal threshold in the channel convergent portion. Both the upstream level measurement H_{am} and downstream level measurement H_{av} may be straight carried out by means of level transducers based on the radar principle.

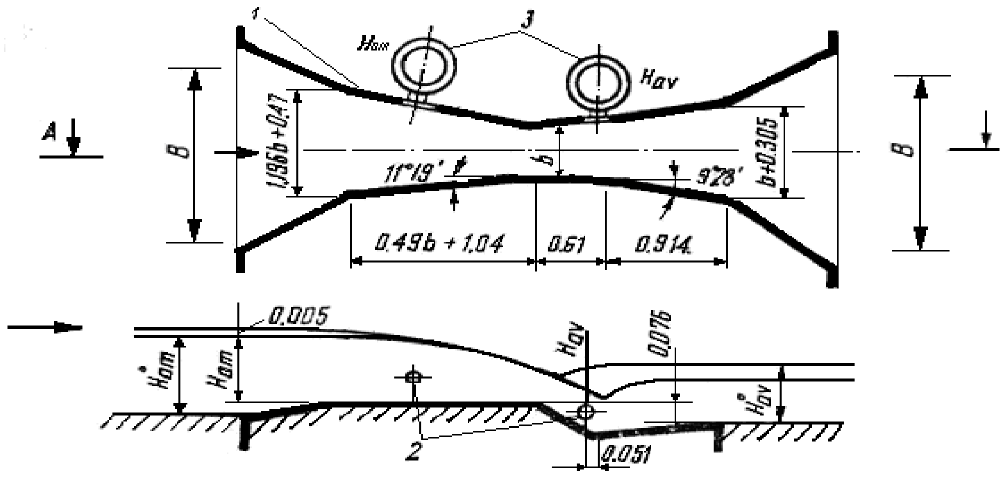

Fig. 5. Constructive data of the Parshall measuring channel

The Parshall measuring channel is used in measuring high variation flow rates having a good accuracy into both non-sunk regime and sunken regime with maximum flow rates reaching $15000\, m^3/h$ water.

3.3. The Level Measurement System

Level transducers based on radar principle are used for indirect measurement of flow rate into open channels. The most largely spread radar transducer is based on the principle of continuous modulation of the emitted frequency bearing the name Frequency Modulated Continuous Wave (FM-CW).

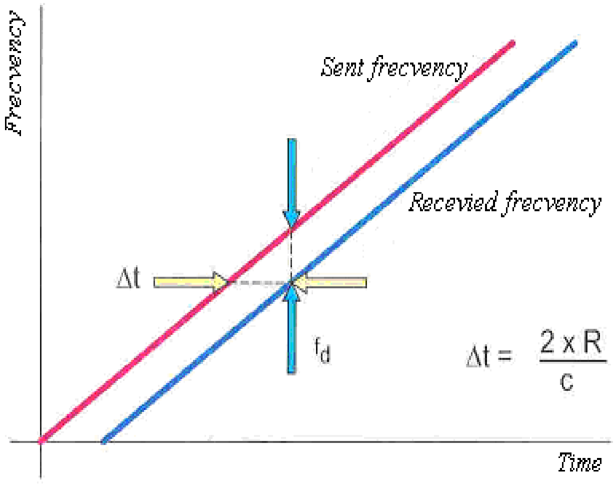

Fig. 6. FM-CW radar principle

The difference between the sent over frequency and frequency of the signal reflected is proportional with the distance from transducer to target, figure 6 [7].

Level transducers based on radar principle are not affected by action of sun, temperature, wind, rain, snow or frost and has got no piece coming in touch with the fluid whose level is measured.

4. Control systems of *pH*

For pH control utilisation is recommended of an automated system with combined action respectively after deviation and after disturbance. For software implementation of the component with action after disturbance process modelling is required and deduction of the controller equations.

The Process Modelling. The neutralizing reactor is considered as shown in figure 7. The input of reactor stands for the effluent featured by volume V_{ar} and pH_{in}. The neutralizing agent used through is the solution of $Ca(OH)_2$ having got concentration $c_{Ca(OH)_2} \leq 1{,}1 \cdot 10^{-2}$ mol/l.

Further to neutralizing reaction the volume of solution $V_{sol\,ies}$ is got with

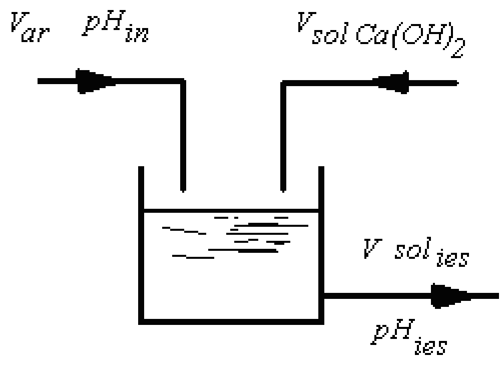

Fig. 7. *Structure of Neutralization Reactor.*

pH_{ies} required. As when getting out of the neutralizing reactor the treated water shall be alkali having got $pH \in [7{,}5 \ldots 8{,}5]$, then the neutralizer solution shall be in excess compared to the reaction stoichiometry.

The mathematical model of neutralization was developed and largely outlined in work [8]. Here are below the stages in mathematical modelling of the neutralization process:

a) The calculation of hydroxide ion concentration;
b) The calculation of the number of gram equivalents of neutralized acid;
c) The calculation of the number of gram equivalents of $Ca(OH)_2$ for neutralization;
d) The calculation of the number of gram equivalents of $Ca(OH)_2$ in excess;
e) The calculation of the volume of solution of $Ca\ (OH)_2$ used in process.

The Controlling Algorithm. The last stage of mathematical modelling of the process has a target in the model into stationary regime for the controller with action after disturbance. This can operate into two variants depending on the effluent input *p*H:

- effluent with $pH_{in} < 7$

$$V_{sol\,Ca(OH)_2} = V_{ar} \frac{10^{-pH_{in}} + 10^{-(14-pH_{ies})}}{2c - 10^{-(14-pH_{ies})}}; \tag{3}$$

- effluent with $pH_{in} > 7$

$$V_{sol\,Ca(OH)_2} = V_{ar} \frac{10^{-(14-pH_{ies})} - 10^{-(14-pH_{in})}}{2c - 10^{-(14-pH_{ies})}}. \tag{4}$$

5. Conclusions

The present work approaches certain aspects of the treatment of effluent resulted out of mining and oilfield industry. The structure of an effluent treating plant is flexible and can be adapted depending on the specific of the impurities effluents. The coordinate common to effluent treating plants originated in various activities run in these industries stands in the structure of treating plants residing in the existing of mechanical, physical-chemical and biological stages. In certain configurations mechanical and biological stages are combined under a joint action having a purpose to treat effluent which is achieved into biological filters, units with activated slime and treatment of slimes action achieved into septic tanks or slime digestion units.

Systems of measuring the parameters in the process of effluent treatment includes the system of measuring the *p*H, the system of measuring the effluent flow rate and the system of measuring the level and sensitive element of the flow rate transducer.

Neutralization of effluents and achievement of a solution with a required *p*H can be got within the physical-chemical stage inside chemical mixing reactors of high capacity and appreciable inertia. Quality improvement of the *p*H controlling system and mitigation of neutralizer consumption can be achieved by implementation of an advanced system of managing such reactor. For *p*H control the authors have proposed utilisation of an automated system with combined action respectively after deviation and after disturbance. A controlling algorithm was developed with action after disturbance specific to the neutralization process in treating plants.

Bibliography

[1] Fodor, D., *Influența industriei miniere asupra mediului*, Buletinul Agir, nr.3/2006, iulie-septembrie.
[2] Marinoiu, V., **Paraschiv, N**., *Automatizarea proceselor chimice,* Editura Tehnica, Bucuresti, 1992.
[3] *Documentul de referinta asupra Celor Mai Bune Tehnici Disponibile pentru Managementul Sterilului şi a Sedimentelor Reziduale rezultate din Activitățile Miniere*, Iulie 2004, p.379...382, www.anpm.ro
[4] Candea, **V**., *Epurarea apelor uzate*, Editura Oscar Print, Bucuresti, 2001.
[5] Luca, **C**., *pH-ul si aplicatiile lui*, Editura Tehnica, Bucuresti, 1973.
[6] Motiț, H.-M., Vasilescu-Ciocîrlea, A., *Debitmetrie industrială*, Editura Tehnică, Bucureşti, 1988.
[7] Devine, P., Griessbaum, K., Moakes, L., Brucker, E., *Radar Level Measurement – the user' guide, VEGA Control*, ISBN 0-9538920-0-X.
[8] Pătrăşcioiu, C., Vladimirescu, A., *The modeling and the simulation of the neutralization process in sewage plant*, Conferința Ştiințifică Internațională ECO-TREND 2007, editia a IV-a, Tg-Jiu, Romania.

WEAR OF EQUIPMENT IN THE TECHNOLOGIES FOR THE PREPARATION OF SOLID FUELS IN VIEW OF BURNING

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Abstract: Most of the energetically-used coals are accompanied by the non-combustible mass –for the burning process which will be energy consuming during grinding and sizing but also heat-consuming during burning in the heating chamber. The equipment in the grinding technological schemes physically wears out. The higher wear in the case of the Valea Jiului pit-coal can be explained by the higher ashes content and higher abrasiveness, as compared to brown-coal. The wear's effect can be diminished by choosing adequate alloys for the replacement parts.

The fossil fuels used for the burning in suspension within the heating chambers of the large burning installations – LBI, require an adequate granulometry which usually is not ensured by the fuel's producer. Therefore, each LBI has its own station for the preparation of fuel in view of burning, whose technological design is simpler or more complex, depending on the raw material's characteristics and on the burning conditions imposed by the burning installation.

The fossil solid fuels storing and handling processes are characterised by a natural granulometric degradation process that, for the burning in suspension, is an advantage if compared to the burning on grids.

The efficiency of burning solid fuel in suspension is conditioned by a series of factors, some depending on the coal's physical-chemical and mechanical characteristics, among which the granules' maximum dimensions and their density being critical, at lest in order to ensure their suspended state long enough for the complete burning of the fuel's mass and therefore for the reduction of the "non-burnt" percentage. This requirement, together with other factors which are not highlighted in the present paper, make the grinding process be very important while the grinding fineness control must be a current practice.

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The choice of the optimum grinding scheme is conditioned by the above factors but also by others which are going to be analysed below.

The coals' combustible mass usually has low-to-average hardness and a high degree of friability which favour the grinding operation. Most of the energetically-used coals are accompanied by the non-combustible mass – "ballast" – or "sterile" minerals for the burning process which will be energy consuming during grinding and sizing but also heat-consuming during burning in the heating chamber.

Besides the energy consumption, one must also note the additional wear effect caused throughout the burning preparation and post-burning equipment cycle, on the gas circulation and ashes elimination circuit.

In this context, we shall highlight some factors which intensify wear and solutions to reduce the technical, technological and economic effects.

Wear of the grinders' crushing elements

The equipment in the grinding technological schemes physically wear out; due to their characteristics and to the grinding process taking place, the wear is uneven and, as a consequence, any manufacturing company produces the parts that are the most exposed to wear from durable materials: Parts for the hammers, bolts and internal lining of grinders.

The choice of the lining materials takes into account the nature of the material being ground. In case of non-observance of the normal operation and maintenance conditions, as well as of the repair schedule can lead to breakdown wear which causes the equipment failure leading to taking it out of service.

The progressive malfunctioning usually occurs during the physical wear; it can be anticipated and followed until one decides the remedy by repairs. The sudden malfunctioning is not predictable because it has hidden causes. In order to minimise the possibility of occurrence of the various malfunctions, any grinding installation must be scheduled for preventive-planned maintenance, for technical inspections and repairs.

Increasing the frequency of inspections considerably reduces the costs of the operations required by the elimination of malfunctions and by accidental repairs and

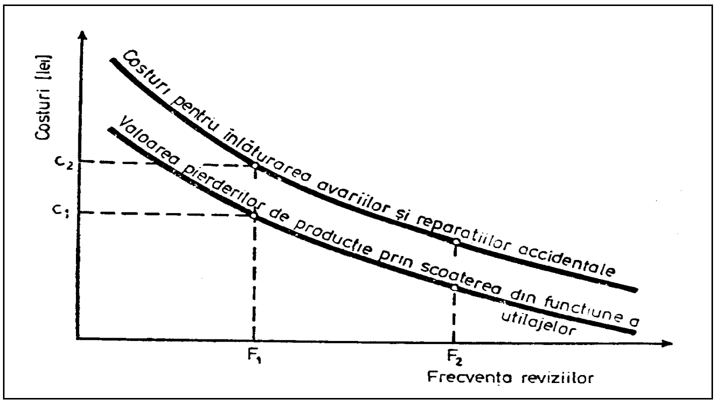

Fig. 1. Interdependence between inspection frequency and costs

also reduces the losses determined by taking certain equipment out of service, trend highlighted in Fig. no. 1.

The wear of the grinding elements is caused by the fuel being ground and depends on the nature of the wear elements' material, on the content and quality of the mineral material (ashes), on the produced dust's grinding fineness and on the grinder's condition. Figure 2 illustrates the influence of the coal ashes' content and of its quality on the wear of the grinder's crushing elements, for a certain fuel.

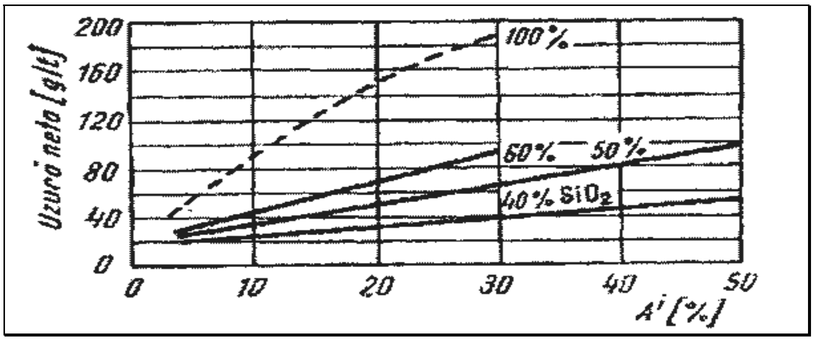

Fig. 2. The influence of the grinder's wear depending on the coal's ashes content

One should note an increase of the wear along with the increase of the fuel's ashes content and of the SiO_2 content, the abrasive element in the ashes. In case the grinder uses burning gases from the heating chamber as drying agent, there occurs a recirculation of a certain quantity of ashes together with the burning gases absorbed from the heating chamber, which intensifies the wear proportionally to the recirculation load. In case of grinding fuels with very high ashes content, the dust preparation recirculation scheme would not be beneficial from this point of view.

The grinding components' wear is also influenced by the dust's grinding fineness, as a consequence of the fact that a higher fineness is achieved by increasing the fuel recirculation rate between the separator and the grinder.

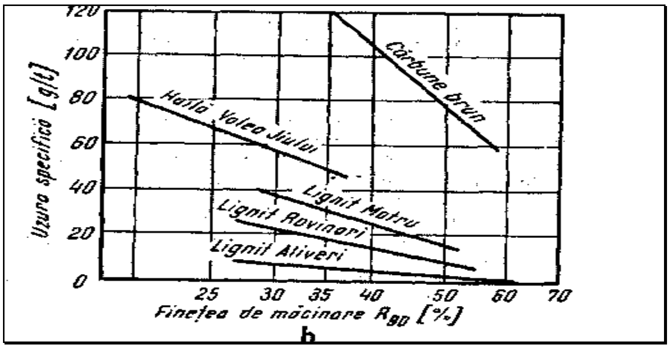

Fig. 3. Diagram of the grinding fineness' influence on wear

The higher wear in the case of the Valea Jiului pit-coal can be explained by the higher ashes content and higher abrasiveness, as compared to brown-coal.

The wear is also influenced by the grinder's wear degree or by the operation time since the initial start-up; wear causes a decrease in the grinder's flow-rate, as it can be seen in Fig. 4.

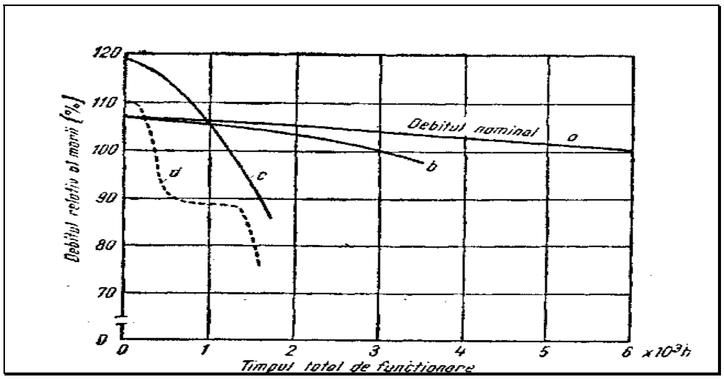

Fig. 4. The influence of the grinder's operation time on the grinder's flow-rate

The grinder's operation time also leads to a 0.090 mm decrease of the residue per sieve, meaning an improvement of the dust's grinding fineness as a consequence of the fact that, by decreasing the fuel flow-rate the fuel concentration in the drying agent decreases and, therefore, the characteristic curve of the dust network and, respectively, the grinder's operation point on its characteristic curve are modified.

Wear also greatly depends on the grinder's type. The fast, more flexible and easier to operate grinders have, as compared to the slow grinders, a higher metal consumption and, as a consequence, the wear of the grinding elements in the case of slow grinders is lower than the one of the fast grinders.

The abrasive effect of the various types of fuels manifests differently, depending on the fuel's A^{anh} ashes content and depending on the crushability coefficient expressed in Hardgrove units.

To be noted an increase of the wear as the ashes content increases and not as the crushability coefficient decreases. Also remarkable is the lower metal consumption in the case of roller grinders. The slow grinders are better suited for grinding abrasive fuels.

The wear of the grinding elements also depends on the quality of the materials these elements are made of.

When choosing a material for the grinding elements, technical-economic calculations must be carried out. From the trials for determining the wear on certain models of simple, fan grinders or suction hammer grinders and on a hammer grinder, it was noted that, during the brown-coal operation, the values of these wears are relatively close, obtained on the three types of tested grinders that belong to the impact grinders category. The friability difference between the petrographic components of the coal determined the inclusion of a sizing operation within the extraction process, the fraction over 300 mm or 200 mm which represents approx. 2-4% of the grinders' supply being removed. In this way, the wear of the grinding elements decreased as compared to the non-graded brown-coal, a difference in wear being observed even between the three tested types, 0-300 mm, 0-200 mm and 0-100 mm.

One can note the unfavourable influence of the iron and schist on wear, expressed in Fe_2O_3 or directly by the siderite percentage highlighted during the mineralogical analysis. Another element which directly determines the grinders' wear is the abrasive constituent quartz, finely dispersed throughout the schist mass.

The choice of the optimum granulometric interval from the wear point of view, takes into consideration the specific cost of the worn material (lei/ton) and the cost of the graded brown-coal under conditions of losing, by sizing, a part of the organic mass (lei/ton), these elements leading to the choice of the optimum type.

Observing the wear as the hammers were wearing out allowed the drawing of the specific wear curve (g/t) throughout the whole interval of hammers' wear, in general, up to 50% of its initial mass. Below you can find the variation curve (Fig. 4.9) of the specific cumulated wear, obtained for an alloy cast-iron hammer grinder with 10 t/h flow-rate, during the brown-coal grinding (the specific wear cumulated for a certain wear degree of the hammers takes into consideration the worn metal and the ground material since the initial start-up of the hammer grinder).

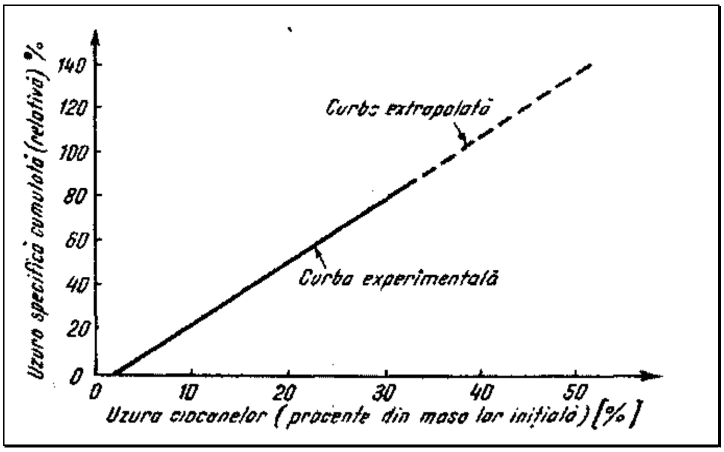

Fig. 5. Evolution of the specific wear for a hammer grinder

The wear variation represents a straight line and allows the usage of results and, therefore, the determination of the specific wear for the whole wear interval of the hammers.

The increase of the specific wear alongside the hammers' wear can be explained by the reduction of the grinder's self-ventilation which leads to the increase of the recirculation between the separator and the grinder and, as a consequence, to the greater wear of the grinding elements. Also, the increasingly larger spaces between the hammer's head and casing favours local recirculation which leads to an increase of the wear.

Conclusions

• The burning of coal in suspension is the safest method for the complete achievement of the oxidation reaction of the fuel mass, but the dynamic operation within the heating chamber requires the observance of a maximum dimension dependent upon the nature of the fuel;

• The presence of non-combustible minerals has negative effects concerning the grinding process and complicates the grinding scheme in order to achieve the particles' fineness, as well as a high degree of wear of the components coming into contact with the material subject to the granulometric degradation operation;

• The wear's effect can be diminished by choosing adequate alloys for the replacement parts, but this leads to additional costs which have to be technically and economically justified.

Bibliography

[1]. David, I., *Transportul poluanților în medii fluide (Transport of pollutants in fluid media)***,** U.P.T. Publishing House, Timişoara, 1996.

[2]. Mair, K., *Development of Action Plans for the Implementation of the LCP Directive, BAT, Procedures, Pilot Permits,* Bucureşti, 2005.

[3]. Ungureanu, C., *Combustibili.Instalațiide ardere. Cazane (Fuels. Burning installations. Boilers.)*, Politehnica Publishing House, Timişoara, 2006.

CONSIDERATION CONCERNING THE TRANSFER OF NEW TECHNOLOGIES FOR ENTERPRISES ACTIVATION IN REHABILITATED MINING AREAS AFTER CLOSURE OF PRODUCTIVE ACTIVITIES

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VIOREL GUȚĂ****

Abstract: For social – economical rehabilitation of mine closure affected areas, the acceleration of private sector development, in fact the foundation and development of IMM sector, through more secure and competitive new technologies introduction, represents the most real policy of ensure, medium and long term, the zonal development, with absorption of unemployed people, newly graduates, as well as people who wants to leave the mining sector.

Key words: reorganization, social-economical rehabilitation, new technologies, enterprises development.

1. Introduction

Transition between traditional mining industry and the industries which will constitute the base of future local and regional economies, will have to base on new technologies introduction, fundamental measure for new economical activities development and creation of places of employment [1, 4].

The promotion of technologies development and their use by enterprises it's an essential process to encourage and keep firms competitivity and rehabilitate industrial areas, particularly mining areas. In this field, first targets of local initiatives addressed

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to development and, implicit to places of employment creation are small and mid enterprises, namely IMM sector.

The promotion of new technologies can compromise the existent places of employment, but in a well adopted policy. Locally are putted the bases of some long term development objectives, considered as part of a more global strategy, addressed to local area economy structural problems.

On the other hand, technology transfer reclaims the practical communication network, making a connection between those who “own” the technology and those who will want to try new application, such as technology “cutting” from great enterprises to small and mid ones [6, 7].

A supplementary support, as finances and locals, will also be essential. Healthy local economies don’t invent necessarily new products and proceedings, but often impress them, as a key of area commercial success and development. The challenge actually consists of settling condition which will facilitate technological transfer process.

Within this paper, there are refers and appreciations to technological transfer concept, there are presented the objectives and way of transferring the technology to users and are defined innovative projects and innovation force as a zonal development source.

2. Technological transfer – definition, concept and objectives

Technology is the science/art of goods production (in Greek tehnos = art, handicraft, and logos = science).

In the same train of ideas, technology is the science of methods and means of goods production. It is essential if it wants the encouraging and keeping of competitivity. Its use will also influence work because of new products and proceedings development.

Form people who handle local development point of view, technology represent the putting in practice of an idea and scientific and mechanic proceeding inside an enterprise.

In a general context, technological development interconnects application and transfer of research results to social and economical environment, concerning processes, products and services.

As a component of area, region social-economical development strategy, technological transfer has as objectives [3, 4]:

- industrial development;
- research access to a competitive technology based industry;
- IMM-s development encouraging;
- industrial production reorganization and re-launching;
- entreprises re-technologies.

As functions, technological transfer has an intermediation (Broker) and catalyst role.

The intermediation function, between two or more social groups, it is accomplished through:

- information over offer and request;
- problems/themes selection;
- (managerial, technologic, financial, legal) assistance.

As a catalyst, technological transfer accomplishes the role of:

- stimulation;
- mediatization;
- organization forms.

3. Innovative projects as a rehabilitation source and zonal development

The promoting of an innovative idea has often, as support, an innovative project, which it's defined through some particularities, such:

- well defined purpose;
- precise objectives;
- allocated resources;
- its own rules set;
- dimensional time;
- settled activities.

The factors that influence the success of an innovative process are:

- orientation to market's request;
- project importance to society's objectives;
- fair evaluation and rigorously selection of the project;
- projects efficient manage and control;
- innovation receptivity;
- selection and training of a project component team.

Innovative projects can be promoted by some program administrator organization inside local research-development units, local authorities or different commercial units and private firms as partners and beneficiaries of the results.

One of local and regional authorities ideal will have to be the support of structures that can stimulate some new technologies development within affected areas.

Technological transfer centers, founded in our country too, are playing an important role in European countries, succeeding in introduction of new development technologies, principally, based on three project models [4]:

- some of the centers are supporting the development of the existent technology to obtain a dominant position in a certain economy segment. This model is applicable to already developed regions, which can profit by existent;
- others are identifying the main elements and services that economies have to develop, accomplished in cooperation with final users, IMM-s. This model necessitates o powerful capacity of IMM-s networks promotion, starting from their own concept over future and from local interests acknowledge;

▪ finally, other centers are starting a zonal approach of social necessities and requests, that is market's needs studying, to define the training, research and production systems.

The choice of one of the models depends first on strategic plan that all public and private factors, succeed in defining it in dynamic process of area future building.

On the other hand, enterprises development, as one of main consequences of a regional strategic plan consist of the fact that IMM-s can take over the administration of services centers for these.

On the base of re-launching of a business stays the force/power on innovation inside a society. In case of a product or service, on the base on re-launching stays the power of innovation of the organization that produces it. For re-launching, the organization/enterprise has to cover a inning/reorganization process, having as target its survival, or one of its segments, for future re-launching.

So reorganization represents the process that needs to assure the base for enterprise re-launch. It has two important stages, that are: first is "of cleaning", when takes part the elimination of "sand from gears", it is optimized the process and are created the conditions for business re-launch and benefit re-dimension, and the second one represents the creation of new products, market competitive (fig. 1).

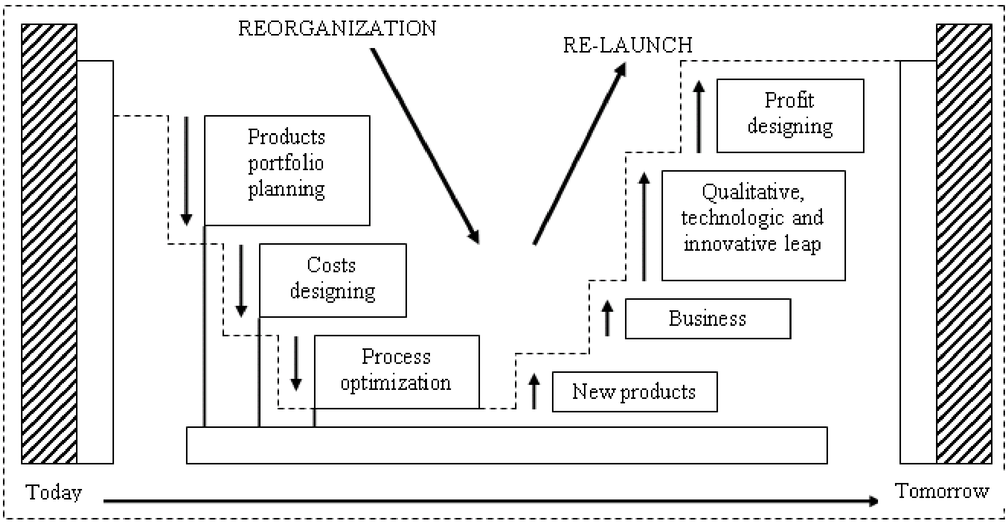

Fig. 1. Reorganization – premise for re-launch and durable development

The re-launch will be successful, if the innovation force of an enterprise and its general management will concentrate on their own competences and will make it penetrate new fields, on new markets and new services. This will be "the moment of truth", when there will ascertain if in spite of activity and personnel reducing will exist resources and motivation to succeed in new business, that are new obtained products and service will penetrate the market.

4. Conclusions

Beyond financial, qualitative and others obstacles, IMM-s from Romania are still facing specific barriers in new technologies adaptation, barriers principally created by lack of information concerning market requested products. The incognizance of industry technological changes possibilities potential, slow down the efficaciousness of competitivity and development.

Through a well intended and founded local policy it can be consolidated the areal and regional existent industrial basis, being possible the creation of new enterprises and the development of the old ones, through introduction and amelioration of afferent technologies.

Bibliography

[1]. **Androceanu, A.,** *Managementul schimbărilor – valorificarea potențialului creativ al resurselor umane*. Ed. ALL Educațional, București, 2000.

[2]. **Naum, N.,** *Inovarea şi transferul de tehnologie.* Inventică şi Economie, nr. 1, Bucureşti, 1997.

[3]. **Pițurescu, I.,** *Cercetarea, Dezvoltarea, Inovarea, Transferul Tehnologic – sprijin pentru Înființarea şi Dezvoltarea IMM-urilor*. Centrul de Conferințe Snagov, 28-29 Mai 1999, România.

[4]. **Pleşea, V.,** *Reabilitarea zonelor miniere după lichidarea activității productive.* Editura UNIVERSITAS, Petroşani, 2005.

[5]. **Robert, C.,** *The search for industry best practices that lead to superior performance*, ASQC Quality Press, 1989.

[6]. **Vida-Simiti, I.,** *Probleme actuale ale cercetării științifice, dezvoltării tehnologice şi inovării în perspectiva aderării la U.E.* Revista Politica Ştiinței şi Scientometrie, Ed. Media – mira Cluj Napoca, **vol. 1**, nr. 2, 2003.

[7]. *****,** *Managementul cunoaşterii, al proiectului Ştiințific şi al Inovării – Suport de instruire*. Ed. Sudura, Timişoara, 2003.

APPRECIATION ON NEW TECHNOLOGIES OF OIL RESIDUES TREATMENT AND RECYCLING THROUGH CHEMICAL PROCEEDINGS AND SEPARATION IN COMPOUNDS

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Abstract: Through oil industry developed activities in Romania, starting with extraction, but mostly refining and petrochemistry, beside main products, results a number of oil residues (wastes), which for over 75 years weren't processed anymore, or were partially processed, being stored in special areas close to generating economical agents. But as a result of new EU legislation, will have to be taken actions and solutions for oil residues treatment and recycling.

Key words: oil residues, ecological recycling, chemical treatment, centrifugal separation.

1. Introduction

Oil and petrochemical residues are a heavy source of environment pollution, those containing aromatic hydrocarbons (benzol – pyren, benzo-anthracene, benzo-dianthrance), which are injurious to men's health with cancerous effects, especially hetero-compounds with sulphur, azote and oxygen, which have major effects concerning pollution. Other waste products contain halogenated compounds, ethers, phenolic compounds etc., which not treated appropriate generate large soil pollution.

Also, refining and petrochemical process it's characterized through the presence of many wastes, such as acid tars, refinery sludge, deposition from oil tanks, inclusive those from catalytic processes, used catalysts, organ solvents, halogenated compounds, used sludge from biological cleaning plant of refinery waste waters.

In regard to extreme large palette of waste products from oil activity, as well as those resulted from antropic activity in general, EU politics regarding waste products

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management foresee the approach of three strategies, namely:

- elimination of source wastes production;
- encouragement of waste products recycling and re-use;
- incineration of waste products in case they can't be used or recycled.

Towards solving the problem of waste products treatment and recycling, within this paper are presented the technologies based on chemical process application and centrifugal separation in compounds.

2. Oil wastes chemical treatment technologies

The advantages of these proceedings consist of safety wastes elimination, for environment, health and security, natural resources conservation (through partial replacement of traditional staples with alternative ones) and reducing of gasses emissions that would be generated in case of those waste products storage and incineration.

These types of oil waste processing are principally without important environment impact, not-resulting any kind of residues, slag or ash.

For many O.E.C.D. member countries an interest option it's the one with zero percent residue in refinery, that reduce the unfavorable environment impact to minimum and efficiently capitalize the sub-products in refineries. The charts of future rock oil processing contain **the air distillation, vacuum distillation, propane deasphalting processes of residue by vacuum**.

From this type of combined plants, result electrical power, steam and hydrogen concomitant. This way, it's assured the energetic independency of refineries, with the possibility of electrical power, steam or hot water delivery, to other external consumers, and resulted after purification hydrogen can be used in other catalytic refining (hydro-desulfurizing, hydro-refining, hydro-treatment etc.).

The processes accomplish ecological clean fluxes, the conversion of carbon being 100% and over 99% of sulfur contained in alimentary products it's removed as elementary sulfur. The proportion of nitric oxides is minim, and metals (vanadium, nickel) can be reclaimed. From processes of asphalt aerating results synthesis gas that can take other manufacturing destinations (manufacture of methanol, ammonia), this way accomplishing the integration of refineries as synthesis industry units. The disadvantages of these types of technologies consist of extremely high cost of the investment.

The processing of oil residues through carbonization and oiliness reduction ("Carbon rejection" technology) represents another processing technology, that implies low costs, but the quality of products is below par, the flexibility of chart is reduced and the conversion degree is low. Because the problem of sulphur elimination from heavy and residual petroleum products it is not acceptable, this technology doesn't solve all the way the environment pollution problems.

The recovery and recycling of compounds from wastes have to be a constant preoccupation of responsible factors and are efficient ways of making important materials economy, doubled by an environment pollution. In western countries there were achieved remarkable results regarding industrial petroleum residues (wastes) recycling, considering the fact that an idle residue for an industry can be useful for another one.

While in Romania useful substances recovery and recycling are realized only 2 – 3% from yearly collected waste products, in European Union's countries it is realized 60 – 70%. The recovery and recycling of compounds from wastes are efficient ways of making important materials economy, doubled by an environment de-pollution.

3. Oil residues centrifugal separation technologies

A very important fraction of those residues have the conventional name of multi-stage mixtures and come from extracted or imported oil decantation, washing of oil or crude-oil tanks, infiltrations made in different parts of the technological process, residues from oil processing.

The existent quantities to this date are so big that became a national problem, even draw the attention of Environment Protection international forums.

The processing of these multi-stage mixtures, so them to become ecologic products, became very important and take the top of the table in waste products monitoring strategy.

This field is, global inclusively, something new, the research and practical accomplishments being relatively recent.

On the other, it is worthy of note that great difficulties are created by different composition of multi-stage mixtures, proper to each economical unit and even to place and way of storage.

Internationally, these difficulties have been solved from case to case, unexisting a general solution, generally valid. There were designed different capacities plants, according to existent stocks, as well as taking into account their proper composition, in a certain place. Still the designing possibilities are limited and not always preliminary data are identical with the ones in the field. In this system, the price of plants is very high, to its reducing it is recur to their individualization to certain given conditions.

Taking into account that multi-stage mixtures are threefold, namely solid component, oil and water, their processing in one step only presume firs a separation of solids from liquids into an enclosure, and then into another one it is continue the separation of several liquids into one. It is a matter of course that the other method presumes the simultaneous accomplishment of separation process of all phases at once. This way, M.G. ENGINEERING produces both type of plant, and ALFA LAVAL and NOXON produce one phase separation plants.

Regarding to separation process in two phases, it has advantages and disadvantages.

From advantages it shines: more simple processing plants and a better separation for each stage. From disadvantages, are enlisted the complexity of attachment plants, long technological process and high costs.

The second direction in which was acted is the designing and accomplishment of a plant that separates in one single processing three compounds: solid, oil, and water. This system has its advantages and disadvantages. From advantages are retaining small processing, low costs, and simple attachment plants. From disadvantages are mentioned the complexity of technological process and high qualified working force for designing and accomplishment of the separator.

In case of one stage centrifugal separation technology, the multi-stage mixture is introduced at a 3 – 4 bars pressure through an adduction pipe inside transporter, that swirls at 35 – 40 rot./min., at accelerator level that advances kinetic energy of mixture, modifying its direction, which goes through feeding orifices into decanting cylinder.

The centrifugal force causes the segregation of solid part first, on gravimetric principle, to the wall of decanting cylinder, which in proportion as the deposit thickens; it is transported by helical conveyor to ceiling outlet at one end of the cylinder. Essential in separation quality is the speeds difference of the two spinning elements, which will have optimal values to a certain type of mixture.

The liquids are settling only towards inside the cylinder, and while the solid is educed, they migrate to the other end of the cylinder and disposed through some centrifugal valves. So the separated compound, are collected in discharge tank and open exhausted.

The principle that underlies the designing and accomplishing basis of these plants is centrifuging to a very well calculated speed, according to many parameters (very important being the composition and characteristics of multi-stage mixture). The interior of the plant has as a main piece a conveyor cylinder that has its own speed, contrariwise to exterior one, calculated according to certain principles, that pushes the resulted solid compound toward disposal area. The other two multi-stage mixture processing products are selected and disposed with other devices help.

Accomplishment of such plant depend very much of special metallic materials from which are executed **the vital pieces**, external centrifugal cylinder, internal conveyor cylinder, disposal areas. Considering the high novelty level of these materials (in physical-chemical properties field that has to accomplish, as well as other characteristics such as: compactness, level of admitted faults etc.) it is imposing internally too the research, elaboration and practical achievement of such technologies.

The designing and accomplishment of such plant consist of an ample experience in centrifugal machines. In our country, the only producer of centrifugal machines with high performance is INCDT COMOTI Bucuresti that has very important accomplishment in this field.

4. Conclusions

Behind developed activities in oil industry, starting with extraction, but of all things refining and petrochemistry, beside main products, results a number of oil residues (wastes), which aren't processed anymore, but are stored in special areas close to generating industrial units. The oil sludge storages exist in areas with oil tradition inside the country. It is estimated that the accumulation of such oil residues summarize round 1.5 stere millions, being main method of industrial wastes disposal.

Oil wastes capitalization it is imposed by the fact that these pollute the environment, occupy important arable lands and represent an important waste of materials, growing, this way, refineries expenses. European Union set as standard, innovative techniques which emphasize capitalization and not disposal of wastes.

From all studied material results the conclusion that multi-stage mixtures processing it is not internationally fully solved, produced and commercialized plants having experimental character of service, permanent looking for their improvement.

General conclusion of elaborated research consist of feasible and opportune appreciation of the approach in Romania of some research types in complex chemical engineering and triphase centrifuging, which appeal to high technology discovers. Such high technological researches are in accordance with European and international normatives and qualitative comparable to similar European and/or American plants and investigation techniques.

Bibliography

[1]. Platon, V., Mazilescu, R., *Estimarea costurilor pentru strategia națională de gestiune a deşeurilor. Depozitarea controlată a deşeurilor - Sinteză*. IEN - ICIM Bucureşti, iunie 2002.

[2]. Trică, C., *Managementul mediului. Abordări conceptuale şi studii de caz.* Editura A.S.E., Bucureşti, 2004.

[3]. *,** *Legea nr. 426 din 18 iulie 2001 privind „Regimul deşeurilor"*, Monitorul Oficial al României, partea I, nr. 411 din 25 iulie 2001.

[4]. *,** *E.C. Delegation to Romania, TA for implementation of I.P.P.C. Directive,* 360039 -19 RP – 135aC Ediția 2, 17 decembrie 2004.

THE LANDSLIDES FROM ZONE OF THE VILLAGE SECIURI - NATURAL PHENOMENA OR PRODUCED BY ANTHROPIC CAUSES?

ILIE ROTUNJANU*
MARIA LAZĂR*

Abstract: In the beginning of May, year 2006, a big proportion landslide has affected the Sub Carpathian hill slopes near village Seciuri. The consequences of the landslide were extremely severe, this, affecting approximately 200 houses, many of them being completely destroyed as well as a series of technological installations belonging to S.M. Prigoria mining branch. In this document are analysed the natural conditions of the landslide affected area in correlation with natural and anthropic elements which are starting such phenomenon's and, based on the studies and observations performed, there are presented the causes of the landslide.

1. Introduction

Landslides are the most frequent and dangerous forms of ground degradation. They are making part of natural geomorphologic hazards category, with a high frequency in nature. According to statistics elaborated by NASA, they are estimated to situate on 4'Th place (fig. nr. 1).

Extreme climatic manifestations in 2004-2006, when rainfalls extended to February till September, in 2005 and continued also in February- May 2006, have led to floods production, which affected 29 districts, and to an amplification of landslides which extended over 10 districts and among these, Gorj and Vâlcea where the most affected. In a Ministry of the Environment and Sustainable Development report is estimated that the slopes consisting in inhomogeneic formations which contend alternations of clay, sabulous and sands, present an increased degree of instability described by shallow and medium depth landslides accompanied by mud flows. The increased rhythm of erosion and ravening processes(8 – 8,5 t/ha/year) as a result of weak consolidated rocks, torrents forming because of precipitations aggressiveness and the mobility of Getic Sub Carpathians tectonic structures, contributes also to landslide production.

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The Seciuri – Roşia de Amaradia area is making part of the areas with catastrophic landslide manifestations, being situated in Sub Carpathian hills of Gorj district where, increased ground surface morphologic modifications have been produced, also associated by severe material damages.

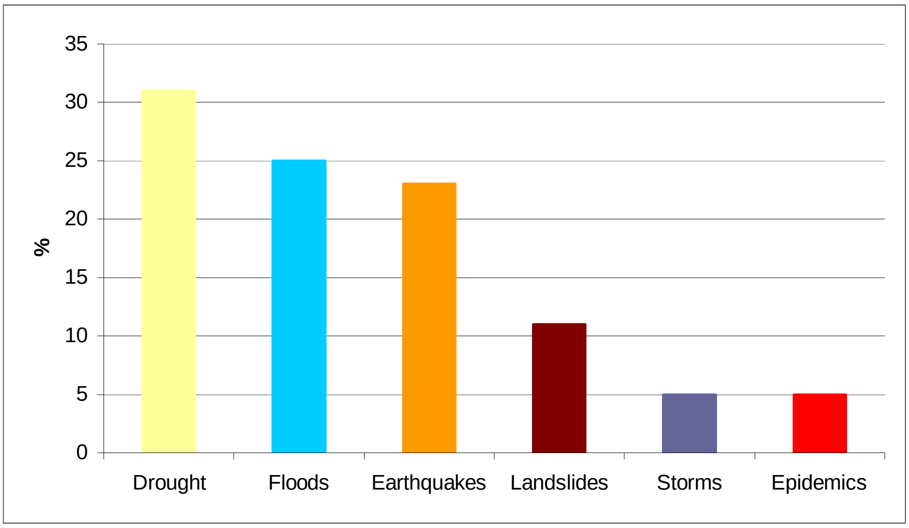

Fig. nr. 1 Natural hazard in Central and Eastern Europe

Establishing the causes which have started the landslide from Seciuri village area involves the following actions:

- investigating the speciality literature concerning the geology of the region and the historic of some specific phenomena of sub Carpathian area in Gorj district;
- consulting the geologic and geotechnical documentation provided by certain specialists;
- ground observations over the landslide affected areas and geotechnical charting;
- gathering documentation concerning the production of similar phenomena;
- explaining and describing the landslide phenomena and the causes which generate them in a scientific way.

2. Geology of the region and the historic of some specific phenomena of Sub Carpathian area in Gorj district.

The Sub Carpathian area and especially the Sub Carpathian hills of Gorj district are affected by numerous instability phenomena and mostly by landslides because of the construction of geologic formations prevailed by alternations of marl, clay and sands of Pliocene or quaternary age, morphological structures, hydrographical network, the presence of aquifer formations and the influence of hydro meteorological and climatic factors.

Landslides are found also in the limitrophe districts (Vâlcea şi Mehedinţi) of Gorj district and not only, the landslides from Vrancea, Vaslui, Iaşi, Suceava or Botoşani are historical, there being no anthropic causes related to mining activities.

The frequency of sliding phenomena is maxim in winter to spring transition periods, after snow melting and abundant precipitations manifestation, or in the autumn, when, draughty periods are followed by abundant rainfalls and the water has the possibility to penetrate into contraction fissures and openings from clay soils, diminishing their resistance characteristics.

According to Law nr. 575 from 22 October 2001 – annexe 7, the villages Alimpeşti, Bărbăteşti, Bustuchin, Căpreni, Cruşeţ, Dănciuleşti, Dăneşti, Licurici, Mătăsari, Roşia de Amaradia, Slivileşti and Stoina fom Gorj district, are mentioned as areas with highly natural risk of landslide. From a geomorphologic point of view they belong to sub Carpathian hills and they have a resembling geological structure, with hillock shapes generally oriented on north-south direction and delimitated by valleys with or without permanent water flows, but with torrents formation after abundant precipitations.

2. The local geomorphologic, structural, and hydro geologic conditions of Seciuri village

Village Seciuri is located longwise a hillock zone oriented on north-south direction, delimitated on east by Ferigilor spring and Valea Amaradiei and on west by Pârâului Cotului valley and it's effluents. The maximum and minimum heights of the area are about 500 m in north and 350 m at south. The longitudinal surface of the hillock zone inclines in the mentioned direction and it's generally parallel with the stratification surfaces of the Pliocene deposits composed of alternations of clay rocks and sandy rocks with frequent changes in the granulometric facies. The ranges of the two valleys (Ferigilor şi Cotului) are approximately parallel with the Roşia de Amaradia – Seciuri – Bustuchin road and coincide with the greatest incline line of the stratification levels.

From structural point of view, the alternation of argillaceous rocks with sabulous rocks and their outcropping in the northern part locality, as well as the layers outcropping on slopes with a slight tilt on the west side, facilitated the presence of phreatic and captive aquifer formations, where the one situated below local base of erosion presents underground waters with easy ascensional characters.

The supplying of the aquifers is achieved from the infiltration of the precipitations trough the zones of outcrop trough drainage and trough contact zones of the aquifer formations. The aquifer existence drove to formation of numerous springs and sloppy zones of waters on carinate surfaces (puddle from Crucile lui Iepure, puddle Puturoasa, puddle Mare, puddle of Mazilescu –all on the western part locality) and to construction of numerous drinking fountains with water to little depth (1 – 7 m) from which is supplied the brooklets from zone. The presence of these certifies the existence of supplying sources but also the possibilities of infiltration with modification of consistence state of argillaceous rocks.

The height difference between northern and southern zones of village Seciuri, which is almost 100 m and the existence of fine sabulous formations filled with water, is driving to the appearance of hydrodynamic forces which carry the soft, dusty or argillaceous sand trough the drainage zones of aquifer layers.

3. The rocks characterisation from geo mechanical and hydro geological point of view

The rocks from formation structure are, generally, argillaceous and sabulous rocks, with a fine aggregate grading, low consistence, medium compressibility, easy deformable, predisposed to liquefying and with low resistance characteristic ($\varphi = 4 - 16^o$ and $c = 0{,}03 - 0{,}3$ daN/cm^2 – for clay).

The sands from aquifer layers structure are mostly powdery or argillaceous, with a low capacity of water cession, but predisposed to suffusion phenomena in presence of hydrodynamic pressures caused by level differences from flow directions and the erosion of layer heads pursuant to erosion valley adjacencies.

4. Phenomena or processes which deform the structure of geologic formations and the ground surface

From view-point of the physical-mechanical process of deforming the formations structure and the terrain morphology, the zone Roşia de Amaradia – Seciuri – Bustuchin is an active zone in which took place frequent landslides with regressive or progressive character, depending on favoured factors, ground immersions and breakdowns. This production was due to ground morphology, nature of rocks, underground waters and surface waters and abundant precipitations from1998 – 1999; 2004 – 2005.

The aerophotogrametric registrations from 1979 and 1995 and the topographic lifts certify substantial morphology modifications in the sense of reducing the heights of the ground surfaces from northern part of village Seciuri and increasing those toward southern zone. Descending and lifting of grounds along locality Seciuri, expresses the tendency of dynamic equilibration of rocks but also the possibility of liquefying depth layers which have been favourable surfaces for rocks sliding. Those aerial-survey photographs materialise also some depression located zones which don't have an indispensably connection with general region morphology and rather show zones with non-uniform settle or immersion, caused probably by sand migration. The presence of the same sand downstream lead to the conclusion that they result from the existing aquifer layers in the structure of the geological formations in the zone.

5. Phenomena produced in the hearth of village Seciuri and the coal magisterial of quarry Ruget in May 2006

Phenomena produced in May 2006 are complex immersion and sliding phenomena which produced on the background of unbalances created in time, through phenomena inducted by natural favoured factors (Photo 1 and 2). These complex phenomena are justified trough the presence of at least 5-6 sliding directions and trough the existence of more immerging (breakdown) zones with vertical movements up to 5-7 m without the presence of sliding debris.

The various inclination of the damaged constructions, the breakdown directions of some houses as well as maintaining stable zones in the affected hearth of the village, completes this complex scenario of landslide production (Photo 3 and 4).

Photo 1

Photo 2

Photo 3

Photo 4

In case which only sliding phenomena have been manifesting, mostly caused by mining anthropic factor, it should have been existing a primarily direction of sliding and in the lower part of the slid zone the debris resulted from the slid zone should materialize.

6. The causes of the landslide from Seciuri

From analysis of the phenomena of slide and the factors which produce these, are detached the next causes:

6.1. Natural causes

❍ ***Morphologic configuration***- the analysed zone is making part of the category of sub Carpathian hills with medium heights, N-S oriented , with slopes inclinations up to 30^0, intensely fragmented by a strong transversal hydrographical network. Both the inclinations and the slope exposition but mostly the high degree of zone fragmentation, represents helpful elements in landslide producing.

❍ ***Stratigraphy*** – the litologic formations belong to Pliocene and quaternary and are represented by alternations of clay and sand with frequent facies changes, sensitive rocks which in the presence of water suffer a substantial worsen of mechanical resistance characteristics and have a labile behaviour which favours landslide production.

❍ ***Geological structure*** – geologic formations in the zone are stratified and the stratification is approximately parallel with the slopes direction which lowers from north to south, fact which favours the appearance of sliding surfaces.

❍ ***Ground surface*** – is affected on extended zones by phenomena of degradation and erosion in abaft the act of atmospheric factors (precipitations and wind) and hydro graphic network. The ravines formed in abaft the processes of pluvial and aeolian erosion facilitate the penetration of a large quantity of water from precipitations in subsoil. These kinds of zones are present in the interest area, being often found along the Ferigilor and Cotului valleys.

❍ ***Hydrological factors*** – as it shown already, the zone is fragmented by numerous valleys wandered through of watercourses which generate an increased process of erosion of riverbed respectively to slopes toe, which led, on one side, to those undermining and, on the other side, to the increasing of the hydraulic gradient.

❍ ***Hydro geological factors*** – among these, the most important is the permeability of rock formations, which condition the type of circulation of underground and above-ground waters. Is mentioned as the way of circulation of underground waters is connected with the size and distribution of hydrodynamic pressure, pressure which are often the primary causes of sliding phenomena. In the analysed area are existing alternations of aquifer formations with waterproof formations, which create, on one side, the appearance of streams and swamps on the ground surface (through natural drainage of aquifer formations) and on the other side, favourably conditions of blocking the water circulation (because of the presence of waterproof layers of clay) and increasing the pressure of the water from pores.

❍ ***Climatic factors***

- ***The abundant precipitations of long duration*** – represents, in the majority of cases, the primary cause in a landslide production, in abaft the processes of water infiltration and the processes generated by water presence in the mass of rocks. They have a determinate role in the activation of slides especially in zones characterised by a climate with alternations of dry periods with intense precipitation periods. A great number of specialists consider that the abundant precipitations represent a key factor in activation of landslides. Among these are Alder and Hong, who, in 2006 conceived a dependence model between the quantity, the intensity of precipitations and the slide production, model based on observations and satellite measurements in real time (fig. nr. 2) in which is shown the increase of observed slides with the increase of precipitations duration.

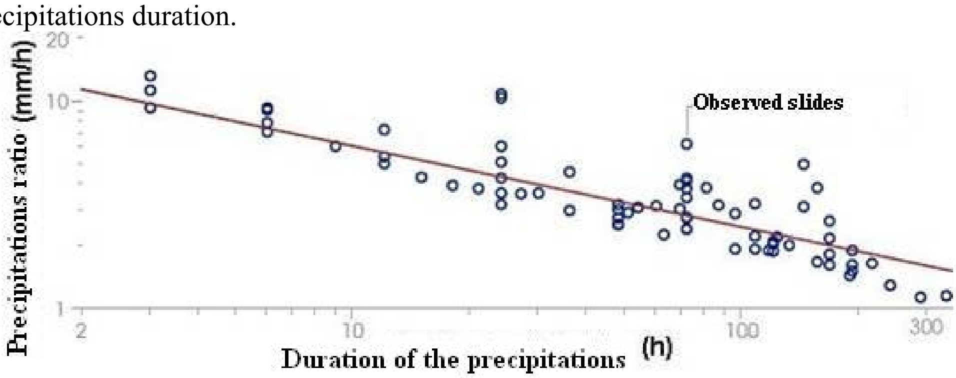

Fig. nr. 2 Dependency of the phenomena of slide ratio and duration of the precipitations

Because of this, flow variations appear in the superficial draining network, with the increasing of corrosion action, with the rising of free water level due to the infiltrations, with side effects mostly when the hydrostatic level is close to the ground surface. The presence of water in the rocks pores has side effects over the slope stability through an increasing of the bulk density of the massif, through the embitterment of the rocks resistance characteristics and through the increasing of water pressure in pores. After analysing the pluviometric regime of years 2005 and 2006 it's been found the entire year 2005 was characterised of abundant precipitations which felt as much as under the shape of snow (January and February) but also like abundant and prolonged rainfalls (in March-June period, with a top period in April and May). The year 2006 begun with massif snowfalls (in the zone of Oltenia were registered large quantities up to 15 l/m^2 in 12 hours) followed by abundant rains in March- May interval. Corresponding to the National Hydrology Institute, in March 2006 the quantity of precipitations was two times bigger than what is normal for that period of the year which means around 100 l/m^2. Is known the fact that the modifications of the water found in the rock pores don't depend exclusively of one single rain effect and that the past meteorological processes have an appreciable influence in the evolution of this phenomena. In these conditions, the quantity of water infiltrated in subsoil has increased considerably, determining substantial modifications in the structure and the behaviour of the sabulous and argillaceous rocks. The increasing of the piezometric pressure and the hydraulic gradient has determined a significant increase in the afflux and the speed of the underground water, which led to suffusion phenomena in the sand layers. Underground cavities are created through the entrapment of the sands by the water, which favour the initiation of the sliding process through a series of ground breakdowns. The consistency state of the saboulos or powdery clays has modified, reaching to a critical level, which permitted those to liquefy and immerge, this causing landslides oriented after the fallen zones. Because of the production of these precipitations is mentioned that in April-May period numerous landslides, similar to the one near Seciuri, took place, affecting localities and infrastructure elements found at large distances to any mining activity.

- ***Snowmelting*** – has contributed to increasing the water quantity cumulated in the rock pores by melting the quantities of snow felled in the beginning of year 2006 and the infiltration of water from the underground.

- ***Frost-defrost phenomena*** – have contributed, especially to damaging and reducing the mechanic resistance of the rocks.

6.2. Anthropic causes

❍ ***Placing the constructions on slopes*** led to excavations and supplementary overloads created by the extension of social constructions which have multiplied as a result of social development and the existing of mining activities for exploiting the lignite in the zone, the execution of ground works on slopes without ballasting the lands for crops and orchards. Creating water sources on people’s proprieties, with an impact in water drainage, has contributed to an extension of land erosion.

❍ ***The deforests*** – have a great impact in producing of the landslides as a result of the arboreal vegetation which contributes to ground arming clearance, the water ratio of infiltrations reduction, the consumption of ground water reduction. On the range of villages Seciuri and Roşia de Amaradia, in the past decades, took place, on a large scale, numerous deforests of the slopes and land use modifications.

❍ ***The in-zone exploitation of hydrocarbons deposits*** – may be a hypothetic cause concerning some ram and immersion phenomena. Although we are not in possession of data regarding the exploiting level and the extracted volume, is obviously the exploitation of liquefied and gaseous hydrocarbons has contributed to the modification of the three-phased (solid-liquid-gas) system in the zones where hydrocarbons are located and eventually to undermine the geological structures.

It is estimated that all this causes have contributed to major unbalances production which affected the hearth of village Seciuri. The influence of the mining activities from the area cannot be unconsidered since they are taking place at long distances and some excavations made in the northern part of the locality have contributed to diminishing the geological loads not in adding an extra charge. In favour of excluding the influence of the mining activities in the area over the breakdowns and the landslides from village Seciuri, plead the presence of landslides from other localities situated in the zone of Sub Carpathian hills, which have similar geological and hydro- geological structures.

7. Conclusions

The landslides from the zone of village Seciuri from Gorj district are the result of cumulative effects due to the natural factors which produced unbalances in the geological structure through erosion phenomena on the slopes and at their base, suffusions, rocks liquefying and ground breakdowns/immersions. The result of these phenomena has materialised in the appearance on slopes of numerous immersion riverbeds with vertical breakdowns which finally determined the unbalancing of the whole area through landslides oriented on different directions. Today, the slopes of the village Seciuri zone are fragmented by numerous cracks and their existence proves that the zone is still active and new landslides are possible to happen when all the favouring factors will combine.

ÖKOLOGISCHE SANIERUNG DER TAGEBAURESTLÖCHER

MARIA LAZAR*

Zusammenfassung: Nach der Gewinnung der Rohstoffen im Tagebaubetrieb entstehen sogenannten Restlöcher, die unterschiedliche Hohlformen haben. Im Prinzip, um solche Bergbaufolgen ökologisch wiederzustellen, gibt es zur Verfügung zwei Hauptrichtungen, und zwar: die entstandene Restlöcher mit Abraum zu verfüllen und danach die resultierende Flächen zu rekultivieren, oder die entstandene Restlöcher mit Wasser zu fluten und die Restseen entsprechend den lokalen Notwendigkeiten zu benutzen. In letzten Jahren, fast in allen Länder, die eine wichtige Tätigkeit im Hinblick auf Restlöchersanierung haben, ist die zweite Variante mehr angewandt, weil sie außer der Flutung der Restlöcher auch der Ausgleich des defizitären Wasserhaushalt und die Lösung des Wasserqualitätsproblem bedeutet.

1. Folgenutzungen der Restseen

Die Restseen, die in Tagebaurestlöcher gebildet werden, können mehrere Folgenutzungen übernehmen. Sie können als Wasserspeicher, Fischerei, Erholungsgebiet oder für Naturschutz dienen, aber auch andere Nutzungen übernehmen. Die große und kleine Wasserflächen, die in Bergbaufolgelandschaften entstanden werden, sollen nicht immer ganz natürlich wirken. Die sind künstlich entstanden und dürfen also auch geometrischen Formen haben.

Landschaftssee

Landschaftssee haben die Zielsetzung, einen Ausgleich für den Verlust an natürlichen Feuchtgebieten zu erreichen. Voraussetzung dafür ist ein Abbaubetrieb oder eine nachträgliche Geländeausformung, die eine abwechslungsreiche Uferlinie mit Steil- oder Flachböschungen sowie seichte Unterwasserbereiche mit Verladungszonen zurückläßt.

Auf diese Weise können sich verschiedene Biotope entwickeln, wobei die natürliche Sukzession ohne menschliche Einflußnahme zu überlassen ist. Die ganze Entwicklung braucht allerdings Zeit und muß störungsfrei verlaufen.

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Bei der Entscheidung für diese Folgenutzung müssen verschiedene standörtliche Bedingungen berücksichtigen werden, aber auch die Nachbarschaftseinflüsse. Auch bei Landschaftsseen können bestimmte Formen der Erholungsnutzung eine große Bedeutung haben. Eine große

Foto 1 Tagebaurestloch

Foto 2 Landschaftssee

Bedeutung dabei hat es, inwieweit die angestrebte Schutzfunktion die Formen der Erholung (Wandern, Spaziergang oder Naturbeobachtung) ermöglicht. Solche Seen können der stillen Erholung dienen, wenn sie mit einem entsprechenden landschaftsverträglichen Wegesystem ausgestattet sind, die Naturerlebnisse am Gewässer, seinen Ufer- und Feuchtarealen sowie seinem terrestrischen Nahbereich gestatten. Das Befahren von Landschaftsseen, die als ökologische Regenerationsräume dienen muß nicht gestatten werden wegen der Störungen auf die Tierwelt und auf die Pflanzen im Uferbereich. Eine Kombination zwischen Landschaftsseen und Seen für Freizeit ist nur dann möglich, wenn der Schutz des Landschaftssee gewährleistet werden kann.

Angelgewässer

Die Seen, die in Tagebaurestlöcher entstanden sind, weisen in der Entstehungsphase, wenn sie keinen oberirdischen Zufluß und keinen nähr- und schadstoffbelasteten Grundwasserzufluß haben, eine sehr niedrige Produktivität auf. Die Biomasseproduktion und die Artenvielfalt ist am Anfang gering. In diesem Stand, sind sie aus ökologischem Sicht relativ labile Gewässer, die auf Maßnahmen empfindlich reagieren können, mit denen in die sich entwickelnde Biozönose eingegriffen wird.

An die morphologische Gestaltung der Restseen sind einige Anforderungen gestellt, darunter abwechselnde Uferlinie mit Falchböschungen und seichten Unterwasserbereiche als Laichsschongebiete und Ruhezonen. Die geignete Gestaltung ist auf jedem Fall eine Aufgabe der Bergbauunternehmen, sowie die Erstbepflanzung und die Anlage von Pufferzonen. Die Angelnseen stellen eigentlich keine großen Ansprüche an die Flächenausstattung. Auf größeren Restseen kann das Angeln nur zusammen mit der Beruffischerei ausgeübt werden. Die Fischarten hängen von der Wasserqualität, insbesondere vom Trophiergrad ab.

Wasserwirtschaftliche Nutzung

Die Freilegung des Grundwassers bedeutet einerseits einen Eingriff in den Wasserhaushalt der Region und andererseits bietet sie die Möglichkeit, wasserwirtschaftliche Anforderungen zu erfüllen. Diese Möglichkeit hängt in der ersten Linien von folgenden Kriterien ab:

- Wasserfläche und –tiefe;
- Wasserspiegelschwankungen;
- Umgebungseinflüssen;
- Limnischen (physikalischen, hydrochemischen und biologischen) Eigenschaften des Wassers.

Trinkwassergewinnung – dafür eignen sich nur ausreichend große oligotrophe, toxikologisch einwandfreie Seen, mit mittlere Härtegraden. Außerdem ist das Seevolumen und der Zufluß häufig einen begrenzenden Faktor. In diesem Fall, für die Wasserversorgung ist einen richtigen Schutz des entstehenden Sees notwendig und zwar schon während des Abbaus müssen die mechanischen und chemischen Verunreinigen verhindert werden.

Brauchwasserspeicher – die Restseen können sowohl als Betriebswasserseen für Verarbeitungsindustrie oder für sonstige industrielle und gewerbliche Zwecke als auch als Brauchwasserssen für landwirtschaftliche Bewässerung gedient werden. Um den Spitzenbedarf zu decken, sind oftmals Überleitungen aus Fließgewässern erforderlich und aus diesem Grund ist auf ein ausreichendes Speichervolumen zu achten. Dabei muß die Qualität des Zuleitungswasser und des infiltrierenden Grundwasser berücksichtigen zu werden.

Hochwasserrückhaltebecken – sind dann sinnvoll, wenn hierdurch ein Ausgleich für die häufig verlorengegangene natürliche Wasserrückhaltung in ehemaligen Auen von regulierten Flüssen geschaffen werden kann. Dabei muß die gesamte Speicherkapazität im richtigen Verhältnis zu den erwarteten Hochwasserabflußmengen stehen.

Fluß und/oder Abwasserreinigung – stelle eine weitere Möglichkeit für eine wasserwirtschaftliche Folgenutzung dar. Zusätzlich zu der Funktion der Abwasserreinigung bietet eine solche Folgenutzung auch Lebensraum (Feuchtbiotope) für viele bedrohte Tier- und Pflanzenarten.

Wassersport- und Freizeitnutzung

Durch den Sanierungsverlauf werden natürliche Prozesse initiiert, die die Eignung der Tagebaurestseen bezüglich einer Badenutzung entscheidend bestimmen. Bei Erholungs- und Freizeitseen sind in Abhängigkeit von den konkreten Bedingungen mehrere Variante möglich: Baden, Wassersport, Baden und Wassersport, alle Varianten in intensiver und extensiver Form möglich. Für alle Nutzungsformen bestehen Nachfrage und Erwartungen seitens der Regionbewölkerung.

Foto 3 Angeln- und Erholungssee

Die Eignung der Tagebauseen für die Erholungsnutzung, insbesondere für die Badenutzung, ist vorrangig von der Wasserbeschaffenheit abhängig. Die Prognose der Wasserbeschaffenheit in den Tagebauseen erfordert neben der Bilanzierung der Wassermengenflüsse und der hydromechanischen Bewertung des Wassers und des Bodenmaterials auch Kenntnisse der hydrogeologischen Situation, der Reaktions- und Herkunftsräume und der Morphometrie der Hohlform.

Die Erholungsaktivitäten unterscheiden sich nach dem stattfindenden Kontakt zur Wasserfläche auf folgende Weise:

❍ Aktivitäten auf dem Wasser (Rudern, Paddeln, Kanu- und Wasserskifahren, Segelsurfen, Segeln oder Eissport);

❍ Aktivitäten im Wasser (Baden, Schwimmen, Tauchen);

❍ Aktivitäten im Uferbereich (intensive Nutzung – Strandbereiche, Liegewiesen, Lager- oder Campingplätze und extensive Nutzung durch stille Erholung – Fuß- oder Radwanderungen, Naturbeobachtung).

Foto 4 Schwimmende Insel auf Restsee

Die Zulassung von Sportbooten mit Verbrennungsmotoren muß in der Regel verboten werden. Um die verschiedene Wassersportzwecken möglich zu sein, ist eine gute Verkehrsanbindung erforderlich, die aufgrund der infrastrukturellen Ausstattung des Abbaubetriebes gegeben ist (Bootslager, Werkstatt, Plätze für Bootspflegearbeiten, Sanitär-, Umkleide- und Aufenthaltsräume). Im Hinblick auf die Wasserqualität, die muß ähnlich wie für Badewasser sein, da sehr oft die beide Nutzungen kombiniert werden.

Als wichtigste Kriterien zur Nutzung als Badesee sind die biologisch-chemischen Wasserparametern zu berücksichtigen. Während ein Landschafts- oder Naturschutzsee auch sauere bis extremsauere PH-Verhältnisse aufweisen kann, sollen die Bade- und Speicherseen PH-Werte im neutralen Bereich haben und damit diese Form der Nutzung ohne Risiko gewährleisten zu können. Bezüglich der Phosphate sollten die mittleren Winter-Gesamt-P-Gehalte nicht über 20 µg/l liegen, während im Sommer in der Badesaison es bis zu 50 µg/l toleriert werden können.

Die Badestrandlänge sollte maximal bis ein Drittel des Seeumfangs betragen. Die Badestrände müssen als Flachufer hergestellt werden, mit einer Neigung von 1:15 bis 1:6 bis zu einer Wassertiefe von 2 m, wobei der Seeboden in diesem Bereich aus Grobsand oder Feinkies bestehen soll. Der Übergang von Grün- zu Wasserflächen ist am zweckmäßigsten ebenfalls durch einen 4 – 5 m breiten Grobsand- oder Kiesstreifen zu trennen, um nährstoffreiche Einschwemmungen weitgehend zu verhindern. Auch in diesem Fall ist die Herstellung der Landflächen in der Nähe für Liegewiesen, Ver- und Entsorgungseinrichtungen sowie Parkplätze.

Eine gute Idee im Hinblick auf die Vorbereitung der Seen für Erholung und Freizeit ist von der schwimmenden Insel dargestellt. Schwimmende Insel sind keine neue Erfindungen. Viele alte Agrarkulturen nutzten die schwimmende Insel als Anbauflächen sowie zur Erweiterung ihres Lebens- und Wirtschaftsraumes. Die natürliche schwimmende Insel sind bewegliche komplexe aus lebenden Sumpf- oder Landpflanzengemeinschaften, die durch Unterspülung entstanden und durch den Eigenauftrieb der Biomasse schwimmfähig sind oder sich auf Treibholz gebildet haben. Solche natürliche schwimmede Insel sind Ausgangspunkt für Konzepte zu künstlichen schwimmenden Insel. Schwimmende Insel auf den zukünftigen Tagebauseen bieten die Möglichkeit der Entlastung der sensiblen Uferzone.

Mehrere konkrete Projekte wurden auf diesem Gebiet in Deutschland entwickelt, darunter:

- schwimmende Gärteninsel;
- schwimmende Plattformelemente für Schwimmbad;
- künstliche Insel, die das Thema im Sinne von Skulpturen aufnehmen und weniger dem Aufenthalt des Menschen dienen sollen;
- abstrakt figurativen Skulptur Insel als Kunstobjekt;
- kleine Insel die mit Polaroid – Technologie automatisch Fotodokumente von der Wasseroberfläche liefert.

Fischereiwirtschaft

Als Nutzungskriterien dafür dienen Größe, Tiefe und Form des Sees, Bodenbeschafenheiten, Böschungswinkel und Uferbewuchs. Der Temperaturgang ist von der Gewässertiefe abhängig. Als wichtigste Faktoren für Fischereiwirtschaft, die Temperatur und der Sauerstoffgehalt sind von dem Grad der Grundwasserdurchströmung abhängig. Neben einer allgemein einzuhaltenden Böschungsneigung von 1:2 bis 1:3 ist ein gewisser Anteil an vegetationsreichen Flachufern (möglich in geschützten Buchten) für Gelegebildung, Laichmöglichkeiten und als Kinderstube für Jungfische erforderlich.

2. Flutung der Restlöcher

Für die Durchführung der Flutung der Tagebauenrestlöcher stehen zur Verfügung zwei Möglichkeiten:

- Eigenwasserflutung (Grundwasserinfiltrationen, Niederschläge);
- Fremdwasserflutung.

Die Flutungskonzepte im allgemeine ist Fremdwasserflutung, für die eine große Bedeutung die Wasserquelle hat. Der Defizitausgleich im Umfeld des fremdgefluteten Restlochs erfolgt nach Erreichen der Zielwasserstände im Restsee durch weitere Seeinfiltration und Grundwasserneubildung im Trichterbereich.

Das Wasser die für die Flutung der Restlöcher erforderlich ist, wird in der Regel von der näheren Fließgewässer entnommen und durch Überleitungen oder Gräben nach Restlöcher transportiert.

2.1. Gefahrengruppen für die öffentliche Sicherheit während der Flutung der Restlöcher

Während der Flutung der Tagebaurestlöcher können folgende Gefahren eintreten:

- Gefahr geotechnischer Böschungs- und Geländebrüche sowohl im gewachsenen Böschungsbereich, als auch im Kippenbereich;
- Gefahr der Formierung schwefelsaueren Restseen;
- Verschleppungsgefahr der Folgenutzung und damit gebunden die Auslösung hoher Folgekosten.

Um solche Gefahren verhindert oder zumindest minimiert werden zu können, ergeben sich die folgende Forderungen der Gefahrenabwehr durch Fremdwasserflutung:

- Mindestgeschwindigkeiten des Wasserspiegelanstieges als Maßnahme zur Minderung des Gefahrenrisiko. Unter solchen Risiko können Fließ-und Verformungsgefährdung der an Böschungen anstehenden Schichten, Windwellenerosion und Starkniederschlagserosion von oberhalb der Uferlinie gelegenen Böschungsflächen erwähnt werden.
- Böschungs-, Ausschüttung- und Stützkippengestaltung und der Erhalt bereits gestalteter Böschungen.
- Verhinderung des Eigenwasseraufgangs in den Restlöchern.

2.2. Gefahrenabwehr zur Gewährleistung öffentlicher Sicherheit

❍ *Gefahr geotechnischer Brüche*

Die erforderliche Böschungssanierung muß Flachböschungen im Bereich der Zielwasserstände der Restseen und Steilböschungen im übrigen Bereich schaffen. Steilböschungen sind weder starkniederschlags- noch wellenerosionsicher. Bruchsicherheit der Böschungssysteme wird oftmals erst erreicht, wenn sich die Seewasserspiegel den Zielzuständen nähern und Grundwasser den Restseen nur noch mit geringem Gradienten zugeht.

Die gewachsene Böschungen können auch beim Seewasseranstieg durch wellen-, niederschlage- und fließerosionsgefährdet sein. Deswegen erscheint es als nötig, eine Mindestgeschwindigkeit des Wasseranstieges zu behalten. Eine weitere

Gefahr dabei ist die Setzungsfließgefahr im Kippenbereich, die auch oft erst nach Erreichen des Zielwasserstände im Restsee endet.

Solche Gefahren sowohl im Kippenbereich als auch im gewachsenen Umfeld der Tagebaurestlöcher sind bis am Ende der Flutung kaum zu vermeiden. Durch die Festsetzung von Sperrbereichen wird dieser Gefährdung gewöhnlich zuerst begegnet.

Vor der Flutung des Restloches, können unterschiedliche Verfahren für Stabilisierung der Kippenböschungen angewandt werden, wie dinamische Stabilisierung durch Sprengungen (Abb. 1), Verdichtung oder Stützmauern.

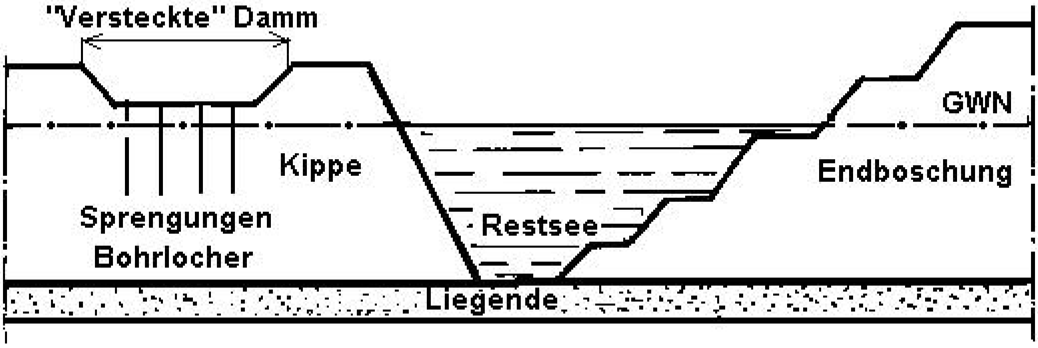

Abb. 1 Stabilisierungsverfahren durch Sprengungen

❍ *Versaurungsgefahren*

Wenn das Wasser sehr geringe PH-Werte besitzt, um eine Versaurung zu vermeiden, ist eine Zumischung sehr großer Mengen von Fremdwasser nötig, bis es Neutralwerte annimmt.

Schwefelsauere Seen sind lebensfeindliche Elemente der Landschaft. Ein solches Wasser ist auch beton- und metallagresiv. Die Infiltrationen aus schwefelsaueren Seen kann die Grundwasserqualität und damit insbesondere Trinkwasserversorgung gefährden.

Nur durch Fremdwasserflutung ist die Formierung schwefelsauerer Seen vermeidbar. Am Ende der Restlochflutung muß, in der Regel, ein Mindest-PH-Wert von ca. 4,5 erreicht werden, um die Herausbildung komplexer biologischer Prozesse zu ermöglichen.

❍ *Verschleppungsgefahren der Folgenutzung*

Die Folgenutzung von Bergbauregionen sind nur dann möglich, wenn die Sanierung schon abgeschlossen ist. Das heißt, die Endwasserstände im Grundwasser und in den Restseen und auch stabile Böschungssysteme erstellt worden sind.

Wenn die Flutung eine lange Zeit dauern muß, sowohl die Restseen, als auch ihres Umfeld können nur später für die Folgenutzung verfügbar sein und damit ist die ganze Entwicklung der Region verschleppt.

Um die Flutung schneller zu verlaufen, steht zur Verfügung eine zügige Fremdwasserflutung, die die Voraussetzungen für die planmäßige Entwicklung schaffen kann. Sonst kann die Zeit bis zum Erreichen des Endwasserstandes und Wasserneutralisierung mehr als hundert Jahre sein.

Ein wichtiger Vorteil der schnellen Fremdwasserflutung ist die Verminderung der Gefahr hoher Folgekosten. Je zügiger die Restlochflutung mit qualitativ geeignetem Fremdwasser durchgeführt wird, desto geringer werden die Böschungsschäden während der Flutung durch Starkniederschlags- und Wellenerosion sein und desto bessere Restseewasserqualität wird beim Erreichen der Endwasserstände eintreten.

Jeder Fehler der zügigen Fremdwasserflutung, insbesondere jede zeitliche Verzögerung, bewirkt ein Vielfaches an Folgekosten bei der Nachsorge und gefährdet die Sanierungsziele und damit die Folgenutzung der Bergbaufolgelandschaft.

❍ *Rückfallgefahr*

Die Gefahrenabwehr muß auch der Rückfallgefahr durch Nachsorge begegnen. Die Anforderungen im Hinblick auf die Nachhaltigkeit der wasserwirtschaftlichen Sanierung schließt Forderungen nach ökologischer Tragfähigkeit und wirtschaftlicher Sinnhaftigkeit ein.

3. Mindestziele für die ökologische Sanierung der Restlöcher

Die Mindestziele für die Wiedernutzbarmachung sind heute allgemein akzeptiert und dabei soll die Fremdwasserflutung einen wirksamen Einfluß haben. Zu den Mindestziele der Sanierung der Tagebaurestlöcher gehören:

❍ Die Zufuhr des Fremdwasser muß einen Wasserspiegelanstieg gewährleisten, so daß bei Lage der Uferlinie im Steilböschungsbereich eine Mindestgeschwindigkeit aufzuweisen. Damit ist das Risiko des Erosions-, Bruch- und Fließverformungen der Böschungen und des Umfeldes bedeutend begrenzt.

❍ Am Ende der Flutung muß der Restsee einen Mindest-PH-Wert von 4,5-6 aufweisen, um die Entwicklung des biologischen Lebens im See möglich zu sein. Bei Verfehlung dieses Mindestziels ist eine komplexe biologische Lebenstätigkeit im See kaum vorstellbar und die Gewässernutzung wäre praktisch unmöglich.

4. Überwachung der wasserhaushaltigen Sanierung

Die Wiederherstellung eines landschaftsgerechten, renaturierten und langfristig stabilen Wasserhaushalt in der Bergbaufolgelandschaft bedingt durch die untrennbare Verkopplung der Teilsysteme die Sanierung des Boden-, Grundwasser- und Oberflächengewässerhaushalts gleichermaßen. Die Tagebaurestseen gilt es dabei als wichtige wasserwirtschaftliche Elemente in dar renaturierte Vorflut- und Grundwassersystem der Bergbaufolgelandschaft einzufügen.

Die Überwachung der sich formierenden Wasserbeschaffenheit in den Bergbaufolgelandschaften muß sich deshalb sowohl auf die gespeicherten und strömenden Wassermengen, als auch auf die gespeicherten und transportierten Stoffmengen beziehen.

Der Sanierungsprozeß der wasserwirtschaftlichen Verhältnisse mit all seinen Steuerungsmaßnahmen bedarf der sachgerechten Überwachung, die es sorgfältig zu planen, technisch abzusichern, aufgabenbezogen durchzuführen und angemessen auszuwerten gilt. Die Festsetzung einer Richtlinie für die Überwachung der sanierung der wasserwirtschaftlichen Verhältnisse erscheint hierbei unerläßlich.

Die Überwachung der wasserhaushaltlichen Sanierung in der Bergbaufolgelandschaft sollte einen Sonderbereich der Umweltüberwachung bilden, der sich örtlich, zeitlich, eigentums- und verantwortungsrechtlich sowie finanziel von der ländergetragenen Umweltüberwachung abgrenzt.

BIBLIOGRAFIE

[1]. Drebenstedt, C., *Planungsgrundlagen der Wiedernutzbarmachung. In Braunkohletagebau und Rekultivierung*, Springer Verlag Berlin, 1998 – pg. 487-512.

[2]. Lazăr, M., *Braunkohlentagebauen und Bergbaufolgelandschaften. Forschungsprojekt*. Freiberg, 2001.

[3]. Pflug, W., *Braunkohlentagebau und Rekultivierung*. Springer Verlag Berlin, 1998.

SOLLUTIONS CONCERNING THE REDUCTION OF THE RESULTED SO_2 CONCENTRATIONS FROM THE SOLID FUEL'S COMBUSTION AT S.E. PAROSENI UNDER THE ADMISSIBLE VALUES

DANIELA IONELA CIOLEA*

Abstract: The reduction of the noxes from the existent sources through measures taken at S.E. Paroseni and presented in detail in the paper, have lead to the azoth oxides and dust reduction under the admissible limits, but, they have not solved the sulfur dioxide's reduction problem, for which is necessary the set up of a desulphurization installation for the combustion gases evacuated in the atmosphere.

For S.E. Paroseni the wet procedure with limestone, in order to reduce the SO_2, is good, but not the only one, as we can conclude from what's been presented in the paper.

Key words: big burning installations, atmospheric pollution, noxes' reduction, solutions for desulphurization.

1.Introduction

S.E. Paroşeni supplies electrical and thermal energy, functions on coal as basic fuels and in on the big burning installations' list (IMA 1 and IMA 2). IMA no.1 has a functioning right of maximum 20 000 during 01.01.2008 - 31.12.2015, and for IMA no.2 a period of transition of 3 years has been demanded, beginning with January 1, 2008 to December 31, 2010, in that time the desulphurization installation will be designed and built on the field in which the old boilers that compose IMA1 currently reside.

Through the air dispersion of SO_2 and NO_x and from the atmospheric oxidation of these highly watersoluble gases, appreciable quantities of hard acids appear (sulfuric and nitric acid) which produce a certain degree of acid precipitations (rain and fog), which fall on the soil as *acid rains* and determine negative effects on all of the natural

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and artificial environment's factors. The CO_2 emissions lead to the atmosphere's warming and produces *the greenhouse effect*.

The reduction of the emissions from the big burning installations is accomplished through different methods, but mainly the measures considered are divided in two categories, respectively primary measures and secondary measurements.

2. The current legislation concerning the atmospheric noxes regime

The current legislation concerning the atmospheric noxes regime is accomplished through two environment directives belonging to the European Union which concern the big burning installations from the electric and thermal energy production sector:

- *The directive concerning the big burning centrals* ***(LCP, 2001/80/CE)****, transposed in* HG no. 541/2003 (completed and modified by HG 322/2005) concerning the establishment of some measures for the limitation of some pollutants that come from big burning installations' emissions in the air. The transpose of the directive 2001/80/CE (LCP) into the national legislation is made in order for Romania to achieve some environment performances according to the European Union politic to improve air's quality;
- *The directive concerning the prevention and control of the industrial pollution* ***(IPPC, 96/61/CE),*** transposed in Law no. 84/2006 for the approval of OUG no. 152/2005 concerning the integrated prevention and control of the pollution (abrogates and replaces OUG no. 34/2002). The directive 96/61/CE (IPPC) is the only directive focused on the industrial sector and it refers to the air as well as to the water and waste.

The limit emission values for the big burning installations are presented in table 1:

Table no. 1. Limit emission values for the big burning installations

Fuel's type	**Emissions**	**Thermal nominal capacity P [MW]**	**Limit emission value [mg/m^3]**
Solid fuels **O_2 of reference: 6%**	SO_2[1)]	$50 \le P < 100$	2000
		$100 \le P < 500$	Linear drop from 2000 to 400
		$P \ge 500$	400
	NO_x as NO_2[2)]	$50 \le P < 500$	600
		$P \ge 500$	200[2)]
	Dust[3)]	$P < 500$	100
		$P \ge 500$	50[3)]

Notes: [1)] *the derogations for SO_2 based on fuel's characteristic properties*
[2)] *derogations are possible depending on the annual functioning time*
[3)] *derogations are possible for some of the fuel's properties*

The limit emission values applied at S.E. Paroseni are given in table 2:

Table no. 2. Limit emission values applied at IMA2- S.E. Paroseni (P_t=587 MWt)

Thermal power	**Pollutant substance**	**Medium measured value mg/m^3_N**	**LEV mg/m^3_N**
IMA 2 P_t=587 MWt (solid fuel combustion burning point)	SO_2	2200	400 1)
	NO_x	150	500 1)
			200 2)
	PM	35	50

Notes: *1) beginning on 31.12.2010*
2) beginning on 01.01.2016

3. The emissions and concentrations of the sulfur dioxide at S.E. Paroseni

The SO_2 emissions and concentrations evacuated in the atmosphere through the smoke chimneys at S.E. Paroseni are given in table 3, one can notice that the SO_2 surpasses greatly the limit admissible values.

Table no. 3. Pollutant's emissions and concentrations through the smoke chimneys at S.E. Paroseni

Year	**IMA - S.E. Paroşeni**		**Functioning hours**	**Emissions** [t/year] **SO_2**	**Concentrations** [mg/m^3_N] **SO_2**
2004	IMA 1		11 577	8 800	4 900
	IMA 2*		84	25	2 300
2005	IMA 1		12 019	8 436	4 242,35
	IMA 2*		134	45	4 226,99
2006	IMA 1		11 812	8 404	4 055,62
	IMA 2*		30	10,26	2 856,51
2007 sem.I	IMA 1		4 322	2 600,06	3 448,64
	IMA 2	CAF	156	55,84	3 309,13
		gr.4	1 917	2 542,44	2 900
CMA [mg/ m^3_N]					**400** 1)

Note: ** only CAF, group no. 4 was stopped for modernization;*
1) beginning on 31.12.2010

4. Solutions concerning the desulphurization at S.E. Paroseni

The personal experimental researches presented in detail in chapter 7 in [1], have been effectuated on two installations: an experimental laboratory installation for different wet desulphurization technologies, in which the oxygen peroxide (H_2O_2) has been used as reagent and a pilot combustion in liquefied layer installation for coal, using some reagents for gases' desulphurization, such as: lime, sodium hydroxide, limestone, ammoniac.

The solution which offers the best results for gase' desulphurization on the experimental laboratory installation, is the use of a pulverizing liquid on the basis of oxygened water, with a concentration of 1,5 mg/ml.

The results obtained through limestone's introduction into the burning point are not as efficient as in the other used reagents. The solution is however simple and cheap, fact that can demand it as the desulphurization solution for IMA 1 from S.E. Paroseni.

The procedure that gives the best desulphurization results on the pilot combustion in liquefied layer installation is the wash of the combustion gases into the reactor with an alkaline solution of sodium hydroxide with 5 % NaOH.

For IMA 2 from S.E. Paroseni the wet procedure with limestone, in order to reduce the SO_2, is good, but not the only one, as we can conclude from what's been presented in the paper.

It's imperious that until 31.12.2010 at S.E. Paroseni the desulphurization installation is implemented, because nowadays at S.E. Paroseni the sulfur dioxide's emissions are ten times higher than the European standards.

S.E. Paroseni will be in accordance with the current legislation if the desulphurization installation is implemented at the thermal central until December 31, 2010.

Bibliography

[1] Ciolea Daniela Ionela, *Study for the reduction of the atmospheric noxes relieved through solid fuels' combustion in the thermoelectrical centrals, applied at C.E.T. Paroseni, University of Petrosani, 2007*

[2] Ciolea Daniela Ionela - *Contract CEEX-MD,* No. 5936/18.09.2006

[3] Ionel Ioana, Ungureanu C., Bisorca D., *Thermalenergetics and environment*, Treaty, Revised edition, Polytechnic Publishing, Timişoara, 2006

[4] Ungureanu C., Panoiu N., Zubcu V., Ionel I., *Fuels. Combustion installations. Boilers*, Polytechnic Publishing, Timişoara, 2006.

PROTECTION OF ENVIRONMENT BY COAL DESULPHURATION

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Abstract: Coals have a sulphur content between 2,2 ÷ 3,3 %, sometimes even higher. In coal, beside some other elements, sulphur represents an unwanted element, because by coal burning in steam power plants results an assembly of agents, one more noxious than the other, which leads to a mechanical and chemical pollution of environment.

Considering the noxious effect of sulphurous gases over the flora and fauna, in the paper a special accent is placed on reducing the sulphur content from coals through different methods like: desulphuration by flotation, magnetic desulphuration, granulometric and bacterial desulphuration.

Keywords: granulometric desulphuration, magnetic desulphuration, bacterial desulphuration.

1. Theoretical part

Coal is a macromolecular compound with a very complex structure that contains some regular elements: C, H, O, N, S.

The element sulphur can be found inside coals under the following forms:

- sulphate sulphur;
- sulphide sulphur (pyritic or marcasitic);
- organic sulphur.

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□ The percentage of sulphate sulphur is minor in the sulphur balance of coal; it hardly ever exceeds 0,2%. The occurrence of sulphate sulphur can be explained by the oxidation of pyrite with the oxygen in the air or water, thus leading to the formation of ferrous sulphate ($FeSO_4$). The sulphate sulphur can also occur under the form of $CaSO_4$, being transported by the percolating waters.

□ Sulphide sulphur occurs as pyrite and marcasite. The pyritic sulphur can occur in coals under different forms and in different amounts, from microscopic particles, finely disseminated into the mass of coal up to large grains of several millimeters (fig. 1, 2).

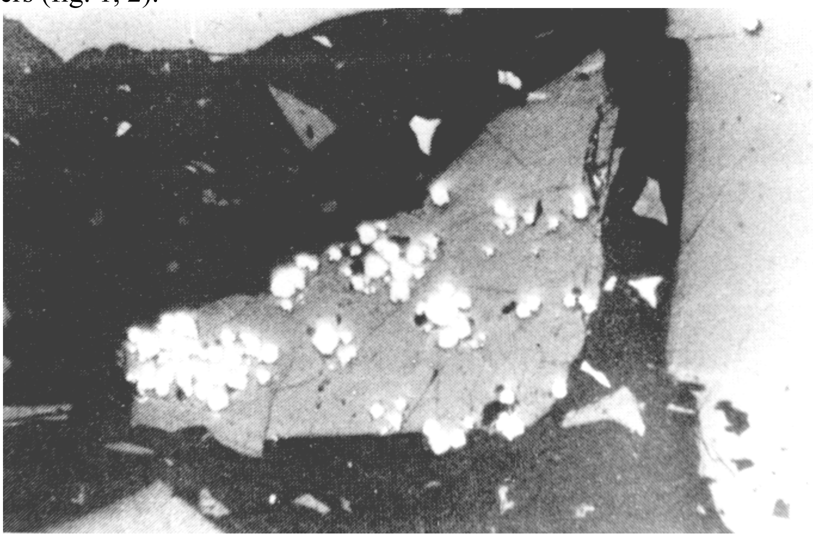

Fig. 1 – Pyrite that is finely disseminated into the coal mass

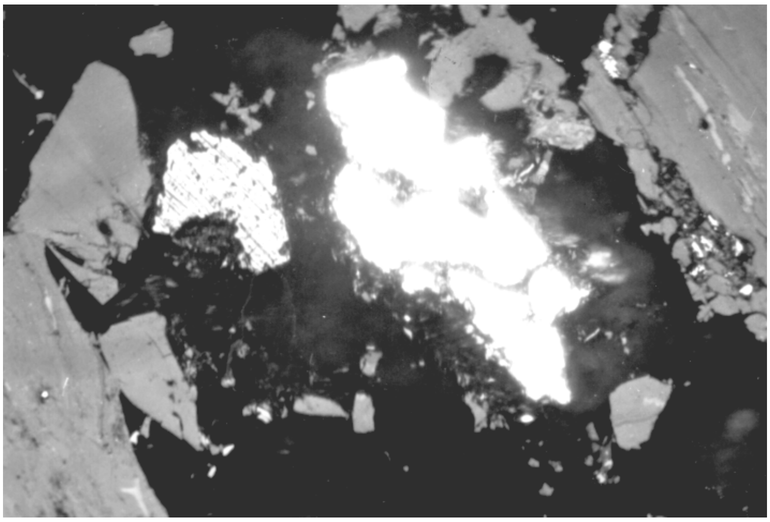

Fig. 2 – Pyrite under the form of large grains

The large majority of pyrite in the bituminous coals of the Jiu Valley is finely disseminated into the mass of coal having the grain size under 0,1 – 0,25 mm.

□ Organic sulphur can occur in coals under three forms:

- Sulphur as – SH or H – S – S – H with a concentration of 2% which turn into the HSO_3 group by oxidation;
- Sulphur as C = S which is being eliminated as SO_2 as a result of oxidation;
- Sulphur as an indefinite form, very resistant to active chemical reactants.

Fig. 3 shows these forms under which sulphur may occur.

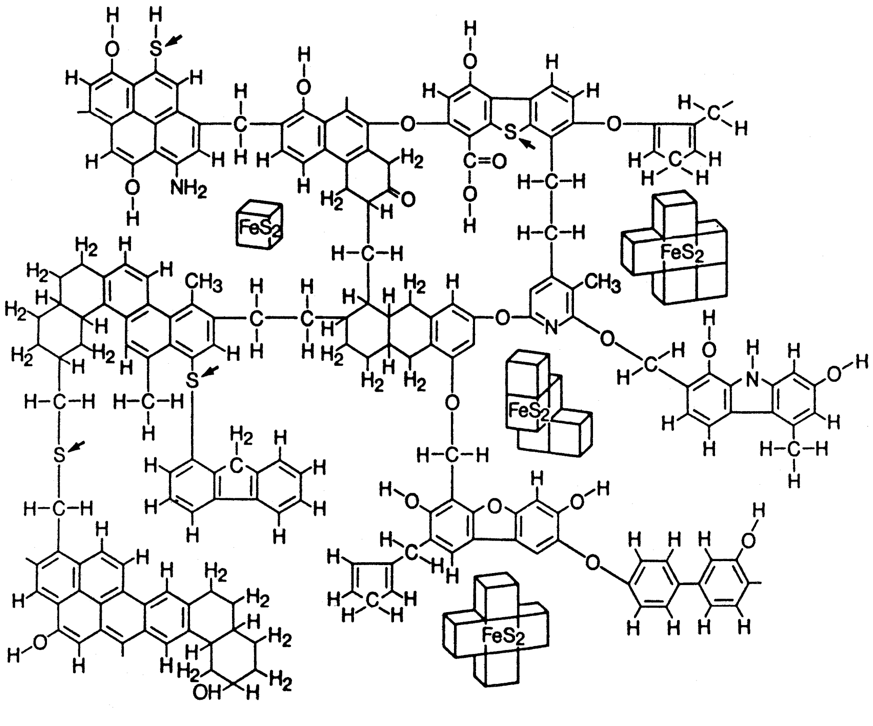

Fig. 3 - Coal chemical structure

Together with some other elements, sulphur is an unwanted component element of coals because when these coals are being burned by thermal power stations, there results a pack of noxious agents that lead to a mechanical and a chemical pollution of the surrounding environment.

a) mechanical pollution due to the powders emitted by the chimneys;

b) chemical pollution due to the action of chemical substances that results from coal burning.

The chemical substances that result from the burning of coals have a complex impact over all the parameters (air, water, soil) of environment neighboring these polluting sources. The atmospheric pollution with SO_2 is quite damaging for the human body. A concentration of 20 ppm SO_2 shall produce cough and it proves to be irritating for the eyes. SO_2 also affect the trees; it shall break up on the humid leaves and it shall give birth to sulphurous acid (H_2SO_3) which turns to sulphuric (H_2SO_4) acid by the process of oxidation. The latter one is the destructive agent. This process occurs especially during the winter time and this is the reason why coniferous trees suffer the most and their leaves turn spotted.

As coal burning gives off chemical substances which are very harmful for both flora and fauna, a refining of coal is recommended before their burning, particularly to diminish the sulphur content.

This operation can be carried out either by classical means (gravitational wash, the use of hydrocyclones with heavy mediums, flotation, a.s.o.) or by chemical or biological methods.

2. Experimental part

Considering the high content of sulphur in coals and the harmful effect of gases that result from the coal burning, especially of sulphurous anhydride (SO_2) over the flora and fauna, this paper intends to present different methods for diminishing the sulphur content in coal before this one is subjected to the burning process.

a) <u>Coal desulphuration by flotation</u>

Flotation involves a physical and chemical process that relies on the difference between the superficial properties of the surfaces of coal particles and the surfaces belonging to the sterile. This method is valid for the fine grain sizes and there has been obtained a diminution of the pyritic sulphur content of up to 30% for the grain size range – 0,074 mm.

Concentration tests have been carried out on the Humphreys spiral at different processing capacities and different grain sizes.

The results of the concentration tests for the grain size range 0 – 1,41 mm are shown in the table 1.

Table 1. **The results of the concentration tests**

Grain size range and products	Elementary concentration (%)				Cumulated concentration (%)			
	Weight extraction	Ash	Pyritic sulphur	Total sulphur	Weight extraction	Ash	Pyritic sulphur	Total sulphur
1,41-0,074	91,2							
Concentrated	84,6	2,3	0,37	0,93	84,6	2,3	0,37	0,93
Mixed	7,3	3,7	0,80	1,38	91,9	2,4	0,40	0,97
Sterile	8,1	38,2	19,92	20,21	100,0	5,3	1,99	2,53
0,074-0	8,8							
Concentrated	78,1	12,2	2,09	2,72	78,1	12,2	2,09	2,72
Mixed	9,6	13,9	2,93	3,64	87,7	12,4	2,18	2,82
Sterile	12,3	24,0	10,0	10,63	100,0	13,8	3,14	3,78
Intake 0-1,41mm	100,0							
Concentrated	84,0	3,1	0,51	1,08	84,0	3,1	0,51	1,08
Mixed	7,5	4,8	1,04	1,64	91,5	3,2	0,55	1,13
Sterile	8,5	36,4	18,66	18,99	100,0	6,0	2,09	2,64

The results shown in the table 1 correspond to a concentration of 35% of the solid phase in the intake.

b) Magnetic desulphuration of coal

In order to clean the small size grain coal there is also being used the magnetic separation.

This method relies on the existing differences between the magnetic properties of coals and the ones of the related materials (table 2).

Table 2. **Magnetic sensitivity of coals and of the impurities in the related minerals**

Constituent	Chemical formula	Magnetic sensitivity. 10^6 (u.e.m.)
Organic substance (coal)		(-0,4) ÷ (-0,8)
Pyrite	FeS_2	4,53 – 1,20
Siderite	$FeCO_3$	331,45
Limonite	$2Fe_2O_3 \cdot 7H_2O$	57
Ferrous sulphate	$FeSO_4$	74
Ferric sulphate	$Fe_2(SO_4)_3$	57,2
Limestone	$CaCO_3$	3,8
Clay	-	20
Shale	-	39 - 45
Sandstone	-	15 - 20
Calcium sulphate	$CaSO_4$	- 0,36
Aluminium sulphate	$Al_2(SO_4)_3$	- 0,48
Magnesium sulphate	$MgSO_4$	(-0,9) ÷ (-1,3)

As everybody can notice, a large part of the mineral impurities incorporated by coal are paramagnetic and it could be possible to remove them by magnetic separation that follows the grinding process through which they are being released.

In order to get a desulphuration as efficient as possible, the magnetic properties of the pyrite incorporated by coal should be intensified by different methods.

One of these methods consists in a selective wetting of the component parts of coal with the help of a water - based ferrofluid with a high magnetic sensitivity.

There has been used a water - based ferrofluid; the component wetted by the ferrofluid and thus considered as the magnetic product is the mineral part in this situation (pyrite, clays, quartz). The magnetic sensitivity of coals shall not be affected; consequently they shall form the non - magnetic fraction. There was used a HGMS separator to separate the “magnetized” component.

The use of this desulphuration method decreased the concentration of the mineral components from 17% to 5% and the sulphur from a raw hard coal from 1,9% to 0,7%. Consequently, the amount of SO_2 discharged into the atmosphere after burning the “clean” coal diminished with more than three times compared to the amount of SO_2 discharged into the atmosphere after burning the raw coal.

c) Bacterial desulphuration of coals

Hard coal is predominant inside the Jiu Valley coalfield. It is being characterized by a high diversity of the content in total sulphur and of the ratio between the mineral and organic sulphur.

For the case of Vulcan, Lonea, Uricani mines, the ratio between the mineral sulphur and the organic sulphur is almost the equal. Usually, there is being considered that the ration between the mineral sulphur and the organic sulphur is 1/1 in the Jiu Valley coalfield.

With respect to the content in sulphur, the Jiu Valley coals display values within the range 2,2 – 2,6% sulphur for Aninoasa, Petrila, Lonea coalfields and 2,4 – 3,3% sulphur for the western part of the Jiu Valley (i.e. Lupeni, Uricani, Barbateni).

As pyrite is finely disseminated inside the organic mass of the coal, the methods for its mechanical processing don't give good results in what concerns the diminution of sulphur content.

This is the reason why the sulphur content of coal should be diminished with the help of the microbiological methods.

The first stage of the researches has engaged a microbiological and chemical analysis of the water sampled from Lupeni mine. The results have highlighted the existence of the bacteria belonging to the type Thiobacillus with the following predominant species: T. thiooxidans, T. thioparus, T. neapolitanus, T. ferrooxidans, T. denitrificans, and T. novellus.

The coal that was used during that experiment came from Lupeni mine and had a content of total sulphur of 2,23%.

As a result, the following conclusions have been drawn:

- Due to the high carbonates content, the coal extracted at Lupeni mine does not provide optimum conditions (average culture pH is liable to become neutral) for developing the bacteria that belong to the type Thyobacillus and the sulphur is being removed from this coal only in a proportion between 5 and 25%;
- The rate of success for a bacterial desulphuration of coal shall depend on the composition, the structure and the distribution manner of the sterile matter inside the coal mass, especially the basic one. The reaction between the sterile found inside the coal mass, which can attach the sulphuric acid, and the sulphuric acid that represents the result of the bacterial activity shall lead to the formation of alkaline sulphates that cannot be aggressed by bacteria;
- The power for a bacterial desulphuration shall decrease gradually with the increase of the coal grain size;
- For being able to carry on with this type of desulphuration, it is necessary to create a culture media for these bacteria with a pH = 2,5 by adding HCl;
- The length of this desulphuration process is of 6 days minimum;
- The biological desulphuration can remove around 20% of the total sulphur and around 60% of the sulphurs content can be confined under the form of sulphates;
- The desorption of the desulphuration products can be made by washing with warm water.

Also, a group of Czech and Romanian experts carried out desulphuration testing of the hard coal at Lupeni mine (the Jiu Valley coalfield). They used a 5 liter airlift bioreactor for the bacterial leaching.

The mineralogy of the hard coal involves pyrite and clayish minerals, especially carbargilite.

Pyrite exhibits a spheroid shape and is being located in the coal grains (fig. 4) and in the mass of minerals (fig. 5).

As a result of bacterial leaching with Thiobacillus ferooxidans, process that extended along a month period, the content of total sulphur diminished from 4,81% to 1,79%, reaching a desulphuration level of 62,79%; the pyritic sulphur was reduced the most (92,96%).

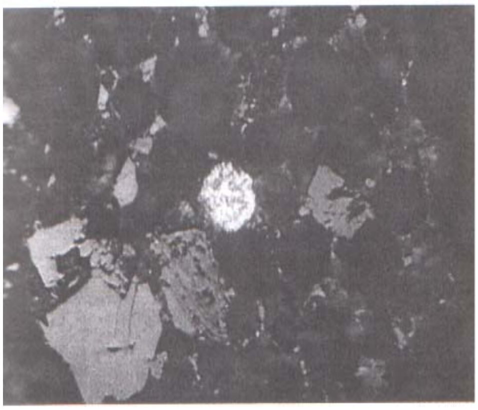

Fig.4. Pyrite in coal grain

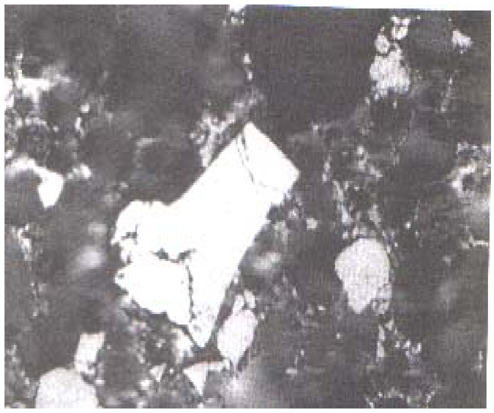

Fig.5. Pyrite in mass of minerals

Tables 3 and 4 show the results of the bacterial leaching.

Table 3. **The results of the bacterial leaching of the hard coal at Lupeni mine**

Leaching time (days)	**Fe^{2+} (mg/l)**	**Total Sulfur (%)**	**Nr.of bacteria in 1ml of solution**
initial	-	4,81	-
7	335,10	-	25.10^8
14	167,50	-	160.10^9
21	117,25	-	160.10^9
28	75,30	1,79	160.10^9

Table 4. **The decrease of the sulphur content of the hard coal at Lupeni mine following the bacterial leaching**

Sulphur content	Before leaching	After leaching	Desulphuration degree
Total sulphur	4,81	1,79	62,79
Pyrite sulphur	0,71	0,05	92,96
Organic sulphur	4,03	1,59	60,55
Sulfate sulphur	0,15	0,07	53,33

Conclusions

- Desulphuration by flotation can be applied on the fine coal grains, thus reducing the content of the pyritic sulphur up to 90% for the grain size range of +0,074 mm;
- Magnetic desulphuration can be applied on the small grain coals; the concentration of the mineral components reduces from 17% to 5% and of sulphur from 1,9% to 0,7%.
- The biological desulphuration can remove around 20% of the total sulphur;
- The bacterial leaching with Thiobacillus ferooxidans shall diminish the content of total sulphur from 4,81% to 1,79%, reaching a desulphuration level of 62,79%; the pyritic sulphur was reduced the most (92,96%).

References:

[1]. Zarnea, G., *Tratat de Microbiologie Generală*, ED.Academiei, vol. II, p.289-301, 1984.

[2]. Fečko, P., *BIOTECHNOLOGY- technologies of 21 century* Institute of Environmental Engineering Mining University of Ostrava ,Czech Republic, 2007.

[3]. Fečko, P., *Bacterial Desulphurization of Coal from Lupeni in Romania*, Proceedings of the 7-th International Mineral Processing Symposium, Istambul, 1998, pg.361-366.

[4]. Fečko, P., *Bacterial desulphurization of Coal from mine Novaky*, 7-th Balcan Conference on Mineral Processing, Vatra Dornei, 1997, pg. 36-41.

[5]. Deurbrouck, A.W, Jacobson, P.S., *Coal Cleaning, State of the Art*; *Coal utilization* Symposium- SO2 Emission Control, National Coal Conference, Louisville, 1974.

[6]. Abel, W.T. – *Removing Pyrite from Coal dry-Separation Methods*, Bureau of Mines, USA, 1973.

[7]. Keller, D.V., Smith, C.D., *Demonstration Plant Test Results of the OTISCA Process Heavy Liquid Beneficiation of Coal* – Annual SME-AIME Conference, Atlanta, 1977.

[8]. Murrai, H.H., *High Intensity Magnetic Cleaning of Bituminous Coal*, Second Symposium on Coal Preparation, Loisville, Kentucky, 1976.

[9]. Belly, R.T., Brock, T.D., *Ecology of iron-oxidizing bacteria in pyritic materials associated with coal*. Journal of Bacteriology, 117 (2), p.726-732, 1974.

THE JIU VALLEY MINES EXPERIENCE ACQUIRED IN ECOLOGICAL REMEDIATION OF INACTIVE MINING WASTE DUMPS SITUATED ON HIGH ALTITUDE WITH WATER ACCUMULATION

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Abstract: The paper presents the Jiu Valley mines experience acquired in ecological reclamation of inactive mining waste dumps situated on high altitude with water accumulation.

Key words: reclamation, waste dump, collector channel, versants, raven

C.N.H.S.A Petrosani recognizes that the technological process used in coal extraction and preparation affects the environment. For decreasing these effects C.N.H.S.A Petrosani promotes the environment politics durable development and allocates for this purpose financial resources for endowments and trainings, documentations on environment problems.

Specific to Jiu Valley carboniferous basin is the synclinal shape of ore and the relief which impose the mining waste depositing through funicular on high altitude versants, which sometime water courses and lead to water accumulations with high potential energy.

In this situation are inactive mining waste dump 2 west, Ileana new branch, 1 East and 2 East Ileana, Victoria mining waste dump and the inactive branch I-II from Lupeni perimeter, Put 7 West mining waste dump, mining waste dumps Dalja and Piscu mining waste dump from Aninoasa perimeter.

Conforming with the national strategy for mining restructuring in Jiu Valley were closed some mines including some mining waste dump became inactive, for which were provided by Government Decisions financial sources regarding ecological reconstruction.

After no 493/2000 Government Decision appeared, in bid base organized by Economy and Trade Ministry, the reclamation works for Ileana mine were assign to

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some construction firm, which, on the technical project executed by ICPM SA Petrosani, had cu execute specific works for underground and on the surface in 11 month.

Reclamation works for inactive mining waste dump 2 west and Ileana new branch prefigured guard channels made from prefabricated concrete flags for the main valley (which drained the waters in a main collector channel made from triple concrete flags), mining waste dump embankment, and versants forestation by planting acacia trees and grass on the low bent areas. In the project, the main collector from 1 West mining waste dump was prefigure on the Renghii‘s stream old course, in the mining waste rocks.

The initial project didn’t prefigure solutions for the appropriate areas of Ileana’s mine perimeter and solution for taking over the rain fall in Renghi stream and in West Jiu’s drain channels.

The two waste dumps had been constructed for 30 years, with a 18.35 ha total surface and had been inactive for 14 years. The space between the two waste dumps was occupied by a water accumulation with a 400 000 m^3 volume (photo 1).

Photo 1. The water formed between two waste dumps.

For reducing the breakage risk of waste dump body, by increasing the water level, in the period when the waste dumps were active, were prefigure 2 drainage tubs, an inferior one made from steel Ø 1400 mm (over this tube there is a wound tube at 6 m above made of reinforce concrete de Ø 1400 mm). The second drainage tube was constructed in case that the first one it is plugged with mining waste. During time it observed that the inferior metallic tube is partially plugged and it was supplementary mounted a pump station which it suppose to take the water surpluses after the waste dumps are abandoned. This system was out of hand by steeling metallic tubs and by the inexistence of maintaining funds.

Reclamation works started in April first 2002 by making the guard channels with flags in the marginal areas of mining waste dumps. When the constructer took over the area he observed that even the water level was over the metallic tubes quote through this pass a very small water debit (photo 2).

Photo 2

Seeing that the metallic tube was partially plugged and the pumps station didn't exist anymore, the only solution for maintaining the water level in the lake was the execution of some open trenches on the established alignment, which had to be deepened concomitant with lake drying (photo 3).

Photo 3. Works in the waste dump

Opening trenches works were made in 5 August 2002 when the lake water level was under the metallic pipe quote.

The period between 10-18 august 2002 was a rainfall one and dues to the increasing of the water level from the lake with 2 m over the metallic tube. The executed trenches hearth was with 2 m over the metallic tube and had a protection role.

In 18 August 2002, because of the pressure of the high water volume, the metallic tube ceded and permitted the water evacuation with a high debit, which carried wood and mining waste material and plugged the discharge channel in West Jiu. (Photo 4) The accident flooded 76 establishments (photo 5).

Photo 4. Consequence of 2002 accident

Photo 5. The flooded establishments

For preventing similar phenomena were taking the following measurements:

- Setting some DOAGA boards for dispersing water energy and putting some material on gap's course
- Executing a barrage in the water accumulation area and at the gap's limit where was introduced a concrete tub PREMO Ø 1400 mm (Photo 6)
- Putting the concrete tubes in trenches starting with the outlet area
- Making some network at the versant base on Renghii stream

- Maintaining functional the discharge channel in West Jiu.

Photo 6. Concrete tubs introduced at gap's limit

- Maintaining the water level from the lake at a quote under metallic tube level (photo 7)
- Moving the main collector channel position with 70 m to West, where are natural rocks at higher altitude
- Making the main collector channel in open system with concrete flags
- The deviation of the channel from the inhabited area on a shorter track

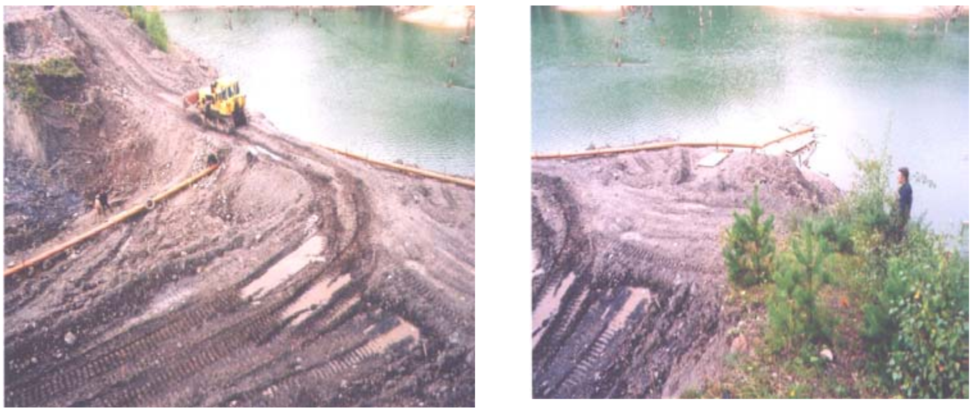

Photo 7. Works for maintaining the water level from the lake

These works were executed until June 2003 (photo 8) and in this way were evacuated 400.000 m^3 of water. In parallel were executed filling works for the lake drying.

The main collector channel of 2 west waste dump was made in cascade with 9 stairs for decreasing water energy produced by the quote differences.

In normal precipitation condition these works were capable to take over the water debit from precipitation and lake, but during 26-27 July 2004 were recorded massive precipitations (over 170 l/m^2 in 10 hours).

After this meteorological phenomenon were damaged 9 cascades of the main collector channel, were destroyed the guard and collector channels especially in the intersection areas. Downstream it was formed a mew raven on the waste dump.

The downstream establishments were again affected but in this case the main cause was related with the waste dump reclamation works.

Photo 8. The finished guard channel

For finishing the reclamation works were made the following measurements:

- Urgent retrieval of all works affected by calamity conforming with the designs solutions
- Executing supplementary works imposed by the new situation and which weren't contained in the initial project
- Extending the actual project for Ileana mine with the purpose of solving the situation: regularizing the Renghii stream, cleaning the channels from the lived area, increasing the channels, increasing the ruttier bridge

For regularizing the Renghii stream was emitted a Government Decision which provides founds allotment for solving the problems and works. At the moment there weren't made all the documentations necessary for starting the works.

On these experiences regarding mining waste dumps from the high altitude with water accumulations, we have to take into account some aspects:

- The main collectors which pass the waste dumps must be putted in natural rocks conforming to the geotechnical study, because the material form the waste dump doesn't resist to the water erosive action.
- It isn't indicate to put the main channels on the old water course
- It isn't indicate to construct the collecting channel in a closed system in waste dumps from the diving areas
- In a unevenness area it isn't indicate to use concrete flags; it is indicate to use reinforced concrete

- When are designed the cascades for decreasing the energy must be provided a water system
- It is necessary analyzing the full track for water evacuation until emissary. The project must have hydro technical constructions for silt retaining, correlation of channel sections, increasing channel areas where exists over shedding potential , cleaning the water routes
- The project must have cleonaje construction on waste dump's versants, adequate slope which eliminate erosion and the loss of stability
- The construction systems for silt retaining must be verified in time for maintaining them in a functional stage

I consider that the CNH experience will be very useful for design firms, firms which execute reclamation works, for avoiding some undesired events and increasing the quality and durability of reclamation works.

BIBLIOGRAPHY

[1]. Atkins, The National Agency of Mineral Resources – Lupeni Mine Waste Dumps Remediation study – 2005.
[2]. Petrosani University – Stability studies of UP Lupeni dumps – 1996.
[3]. ICPM Petrosani - Technical project for closing Ileana Dump – 1998.

DEPOLLUTION OF SOIL AND UNDERGROUND WATER CONTAMINATED WITH OIL PRODUCTS, BY MEANS OF IN SITU BIO – DEGRADATION METHOD

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DIANA MARCHIŞ***

Abstract: The present paper refers to a practical experience regarding the depollution of a certain soil and of the underground fresh water from the yard of an oil storage house by means of bio-degradation in situ. In this sense, after establishing the level of pollution with TPH, of the affected perimeter and of the underground fresh water volume, a decontamination technology was elaborated. This technology consists in: drilling 5 holes (shafts) for the hydraulic blockage; excavating the soil within the contaminated area down to the depth corresponding to the underground fresh water level roof, deeply impregnated with oil products, in order to achieve the aeration of the soil and to bring to surface the contaminated water seam; treating with nutriments the water pumped out from the shafts and dispersing this water onto the whole contaminated area using aspersion.

Key words: *depollution, soil, water, bio-degradation, aeration, nutrients, hydroaerator.*

1. Soil contamination

Investigations performed in 1997 (stage I) and 1998 (stage II) emphasized the contamination of soil with oil products within the analyzed perimeter, estimated at a total area of approx. 1500 m^2 and a total volume of 4700 m^3 of soil. In this way, in the former storage yard of oil products there were found values of TPH (total of oil hydrocarbons) up to 25800 mg/kg (SMR 9 – 3 m).

The investigations were restarted in 2003 by the University of Petroşani, and there was estimated a volume of soil of 3637 m^3 respectively an area of approx. 2536 m^2, and the contents of TPH were included in the limits 0 – 60530 mg/kg.

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The TPH contents from previous campaigns were related to western standards, as those from Holland and Germany, where for the maximum admissible content of TPH, those admit the value of 5000 mg/kg of soil, and in the last campaign these were compared to the Government Decision 756/1997 – **Provisions regarding the evaluation of environment pollution** – for less sensitive usable lands, here being included all existent industrial and commercial facilities, as well as the land areas provided for such utilizations in the future. The maximum admissible contents are presented in table 1, which is an extract from the annex to the Government Decision 756/1997.

In all presented bellow, all the results of analyses will be compared with these CMA (Maximum Admissible Contents), respectively for alert limits and less sensible usage types, that is maximum 1000 mg/kg.

Table 1. The maximum admissible contents of TPH oil hydrocarbon

Pollution tracks	Normal values	Alert values Usage types		Intervention values Usage types	
		Sensible	Less sensible	Sensible	Less sensible
Total TPH oil hydrocarbon mg/kg	< 100	200	1000	500	2000

2. Underground water pollution

The locations afferent to the sampling of the underground water from the yard are SMW – 2, SMW – 3, and SMW – 12. These bore holes reach the underground water-bed and they have the depth of 9.5, 8.5 and respectively 8 m.

Because in Romania there are no laws referring strictly to underground waters' quality conditions, the values obtained from the analysis of the water samples were compared with the Dutch norms and with the Government Decision 756/1997 regarding the alert and intervention values.

The TPH contents and their evolution are presented in tables 2 and 3.

In the following, there will be made comparisons to other normative documents regarding the surface waters, because it is estimated that the underground waters have to be pumped and treated until they comply the admissible limits provided by NTPA 001, NTPS 002 and respectively STAS 4706 – 88.

Table 2. The TPH contents and their evolution

Bore hole	Thickness of oil product layer (cm)					
	19.10.1999	20.04.2000	01.01.2001	08.07.2001	14.11.2002	24.11.2003
SMW 2	13	1	15	6.5	5.5	2
SMW 3	27	70	12	13	8	5

SMW – 12 underground water monitoring bore hole.

Table 3. The TPH contents and their evolution

Substance	U/M	Date					
		29.08.1998	14.10.1999	20.04.2000	01.07.2001	14.11.2002	24.11.2003
TPH	$gx10^{-6}/l$	100	100	340	300	27000	180

Analysis of data provided by the Environment Protection Department from SC ELECTROLUX SA shows that the ground water is highly affected by the infiltration of oil products, very urgent decontamination actions being required.

3. Possibilities of depolluting the underground waters

Bibliographic and field studies have shown that the most appropriate method for purifing the waters from the water bed within the studied area is the hydraulic blockage, which consists in drilling certain shafts or bore holes, pumping the water from these areas in order to achieve a depression area, aerating the water with a hydroaerator, separating the phases (oil products) within an existing settlement tank and finally irrigating the contaminated soil with treated water that was saturated with oxygen and nutriments.

3.1. Hydraulic blockage

The hydraulic blockage in the migration of the pollutants is provisionally used, in emergency regime, especially for crisis situations, when the pollutants have reached the underground water and they threaten to move on the direction of underground water flow, towards highly important points, as there are the drinking water sources or surface waters.

This method can be used very easily, without significant cost, if there are known the hydro – geological and hydro – dynamic characteristics of contaminated environment. Another condition required for the usage of this method consists in the possibility of pumping the underground water into an invulnerable place (the waste water network in vicinity, water purification tanks of the plant, etc.).

Pollutants' migration stoppage with hydraulic blockage is achieved by executing certain shafts or bore holes for pumping the water, having connection bellow the level of the contaminated area, followed by the evacuation of the water to the surface.

Around the pumping shaft, called blockage shaft, a depression cone is obtained at the level of the water bed; onto the cone axis it is oriented the surrounding water, this fact is blocking the natural flow of the underground water onto the neighboring stream, respectively river Somes.

Despite the fact that the underground water connection is located in depth, bellow the impregnation corpus, its contamination is possible to occur by diffusion. As a result, it is required the purification of the polluted water at the surface. The most delicate problem consists in establishing of minimum pumping flow used for blocking the natural flow of underground water under the conditions of a reduced dispersion.

An important increase in the efficiency of the hydraulic blockage is obtained by re-introducing the treated water in the water bed using a shaft located up stream of the pumping shaft. There is also the possibility of re-introducing the treated water into the water bed with shafts or bore holes adequate to this purpose. Sometimes, it is recommended the hydraulic blockage of the pollutants by injecting the water in certain bore holes located up stream, in our case the existing SMWs. The simplicity and easy applicability, as well as the reduced cost of the hydraulic blockage represent the main advantages of this method. The success chances of this method are higher in the case of a reduced mobility of the pollutants due to the location of the water bed in a fine sand seam, the average size being of approx. 0.3 mm.

The hydrocarbons accumulated at the upper part of the water bed, at the base of the backwards depression cone, are selectively evacuated with a special pump located above the water pump. Usually, the water pump operates permanently in order to keep the depression cone and to attract the hydrocarbons, and the hydrocarbons pump is active only in the presence of a consistent hydrocarbons layer.

The hydroaerator, according to its construction and operating method, is included in the category of the "Fluid jet pumps", which in industrial practice are usually called **ejectors,** due to the fact that they adsorb a fluid from a certain network or from atmosphere.

As opposed to all fluid jet pumps types, the hydroaerator has the particular characteristic that all the internal physical phenomena take place in a centrifugal field, as a result of their tangential feed with the main fluid – the water pumped out from shafts.

The air quantity adsorbed from the atmosphere is directly induced by the growth in water velocity; the possibility to obtain the highest possible values of the water velocity being achieved not only by decreasing the flowing section, but also by changing the flow direction of fluid layers. In the points where there are changes of direction, the Coanda effect occurs and its consequence makes possible the execution of the process of aspiration of the atmospheric air.

4. Depollution of soil

4.1. Soil washing

This is a physical or physico-chemical method, used for removing the residual phase of the pollutant immobilized in the soil matrix.

The principle of washing consists in separating the soil pollutants and their transfer into a liquid or gas phase, under the action of water and mechanical energy. This method is completed with other methods regarding depollution as: stripping, flotation or bio–degradation.

Because only the biodegradation methods can be used for the depollution of soils and underground waters contaminated with hydrocarbons, next only these methods will be presented.

The methods of biodecontamination by means of biodegradation are based on the presence in the underground environment of some microorganisms capable to degrade most of the carbonated organic pollutants and some of the anorganic pollutants.

The biodegradation is a natural phenomenon, because the soil, the underground and the underground water represent the life environment for most of the microorganisms (bacteria, fungi) which have a biodegrading action on the organic pollutants. The predominant microorganisms are bacteria (Pseudomonas, Bacillus, Arthrobacter and Flavobacterium) and fungi (Trichoderma, Penicillinum and Aspergillus). **One gram of normal soil contains 10^6-10^8 microorganisms and in one mililitre of unpolluted underground water there are approx. 10^4 microorganisms.**

The development of these microorganisms is achieved with energy and vital elements consumption. The main source of energy is obtained from the carbon oxidation reaction. This reaction involves besides carbon, an oxydant and the nutritive substances called **nutriments** (nitrogen, phosphorous, organic substances) which participate to the proteic synthesis. In oxidative conditions (aerobic) the oxidant is the oxygen, and in anaerobic conditions its place is taken by nitrates, sulfates, methane etc. The reaction type is redox, which means that the carbon atoms lose electrons.

The biodegardation process develops due to a chain reaction, in which the carbon compounds are transformed by means of successive degradation in less and less complex molecules until water and CO_2 are obtained. The product obtained after biotransformation are called **metabolites.**

The most important factors that influence the biodecontamination process of soils and underground waters are: the biodegradability of the pollutants; the type of the used microorganisms; the selection of the oxidant and of the nutritive substances; the properties of the environment chosen for depollution.

The biodegradability of the pollutants is expressed by their capacity to degrade under the action of microorganisms.

The ***autochthonous microflora*** of the polluted area represents in the most of cases the base of microorganisms needed for decontamination.

In the case of bio-degradation of oil hydrocarbons there are used natural species existent in soil: Arthrobacter, Achromobacter, Novocardia, Pseudomonas and Flavobacterium, etc.

In the process of biological purification of waste water and within the process of decontamination in situ of the soils polluted with oil products, there is a wide range of microorganisms representing a biocenosis that is diversified into trophic levels.

Being fed exclusively with organic matter of autochthonous origin, these ecosystems are characterized by the lack of chlorophyll plants, which represent the "producers". The circulation of matter is obtained only within a "little" trophic cycle, consisting in certain rings: decomposers (bacteria and fungi), bacteria eaters (represented especially by Protozoas), certain predators and saprofages (Rotifera, warms, nematods, insects, etc.).

In general, **within the biological decontamination processes the established ratio between carbon, nitrogen and phosphorus is 100: 10: 1.** As for the mineral nutriments, the selection is less complicated, because it is well known the fact that the phosphorous and nitrogen forms are the most assimilated nutriments by all the microorganisms. For nitrogen it was selected the ammonium nitrate and for phosphorous it was selected the nitrogen tri-phosphate. The tensioactive agents represent another group of organic substances that are used to increase the solubility of low solubility pollutants, in this category being included the biodegradable froth detergents.

The biodegradation in situ assumes the utilization of bio-decontamination operations performed directly in the polluted environment (soil, underground, underground water), aiming for simultaneous depollution of soil and underground water. Biological treatment in situ is highly recommended in the case of important extensions of pollution both in depth and laterally. At the same time this method proves to be adequate for depollution of soil, underground and underground water located bellow certain buildings, as it is in the studied cases. The quantity of nutriments and oxygen administrated in underground environment by means of water is calculated depending on the carbon quantity immobilized in pollutants and depending on the flow rate and duration of injection.

4.2. Depollution of underground water

The underground water, estimated to a volume of 4500 m^3, is located in discontinuous underground water layers, separated by shale intercalations (Prefesability study regarding water supply of Satu Mare city, provided by Environment Department from SC Electrolux SA).

The average thickness of aquifer horizon is 3.5 – 4 m, and the depth from the surface to the roof plan of this horizon is 4.5 – 5 m.

The average feeding flow of aquifer horizon is estimated to 2.5 m^3/h, having flowing direction in NW – SE direction, respectively onto the Somes River, the hydraulic gradient being of 0,005 n/m with a declivity flowing of $5^0/_{00}$.

The structure of the aquifer horizon is characterized by a good disposal of water, its permeability being estimated to 1.05 x 10^2 – 7.74 x 10^2 m^3/day, and hydraulic conductivity (k) is between 150 – 282 m/day.

In order to perform hydraulic blockage and to remove the water from aquifer horizon, respectively to reduce the hydrostatic level, there are used 5 bore holes onto an alignment that is perpendicular onto the water flowing direction, at different distances between them and a similar number of submersible pumps placed in these bore holes. The depth of the bore holes is of 10 m, in order to provide the infiltration in impermeable rocks from the floor onto minimum 1 m.

The bore holes are piped with plastic pipes (dia. 300 mm), that are perforated on a height equal to the thickness of the aquifer horizon. In order to avoid the ascendant blockage of filtrated tube, this is closed at the bottom part, and around the part with slots, it is provided with concentric gravel layer "pea gravel".

The evacuation of the water and oil products from filters is made with submersible pumps by means of the pumping column that is connected with the collecting pipe, and further on to the separation tanks existing in the yard, and by means of a hydroaerator that provides a good oxygenation of water and the emulsion of nutriments. The total operating rage is 12.5 m, covering the entire width of the affected perimeter.

4.3. Soil extraction and loosening in order to be depolluted

Based on the analysis regarding pollution level of the soil performed on samples took from 18 bore holes (contract no. 417/2003) it was elaborated the conclusion that the volume of polluted soil is 3637 m^3 afferent to an area of 2536 m^2.

Depollution of soil performed by an adequate treatment (biodegradation in situ) involves its extraction, loosening and, if it is necessary, its storage.

Soil extraction and loosening was made with a shovel excavator of 1.1 m^3 in 2 different stages:

- the turning and loosening of the soil in order to aerate and bring to the surface of the layer in the aquifer roof contaminated with oil products;

- the manual selection of bituminous parts and the storage of these separately onto plastic sheets in order to evacuate them in authorized storage houses.

To every shovel bucket of soil it was added an adequate quantity of solid phase nutriments.

The technological process of hydraulic blocking, pumping, aeration, washing and bio-decontamination is presented in figure 1 and includes the following main operations:

- hydraulic blockage by drilling 5 bore holes with depth of 10 m and dia. of 300 mm, in this way being created a depression cone for collecting the waters located in aquifer;

- water pumping with submersible pumps continuously or selectively and separation of phases in a separation tank existing in the yard, by means of a hydroaerator assuring water oxygenation;

- adding some nutriments in the water mechanical and biological purified and irrigating the contaminated area;

- loosening of contaminated soil by excavation and manual selection of bituminous fractions or fractions badly contaminated and the separately storage of these. In order to monitor the results of decontamination, there are periodically taken water samples from SMW2 and SMW12 and from the depression bore holes 1 – 5, respectively soil samples from the surface and from underground. Final results of these analyses are synthesized in figure 2 and 3 and table 4.

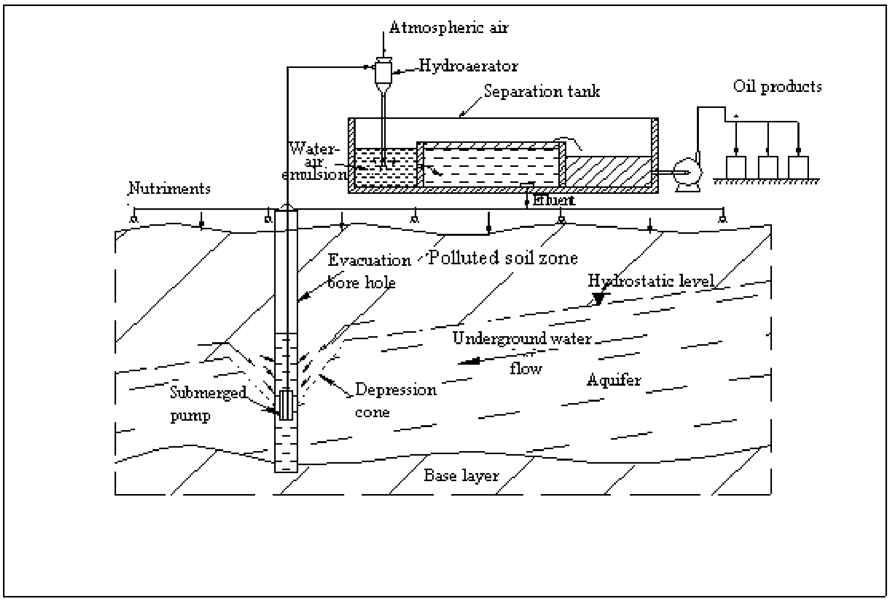

Figure 1. Technological process of hydraulic blockage, pumping, aeration, washing, and bio – decontamination

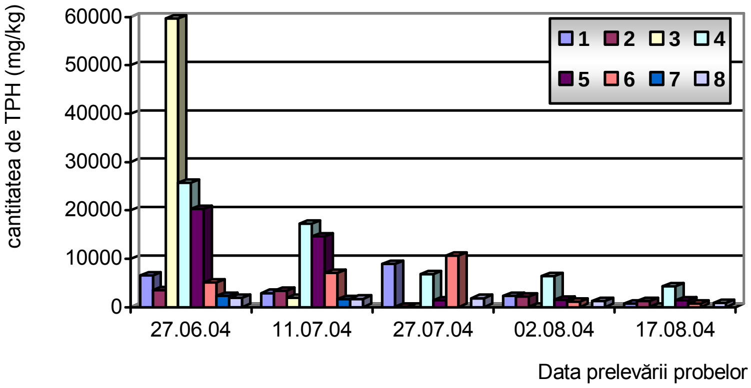

Figure 2. Variation of TPH quantity in different surface samples taken at different dates

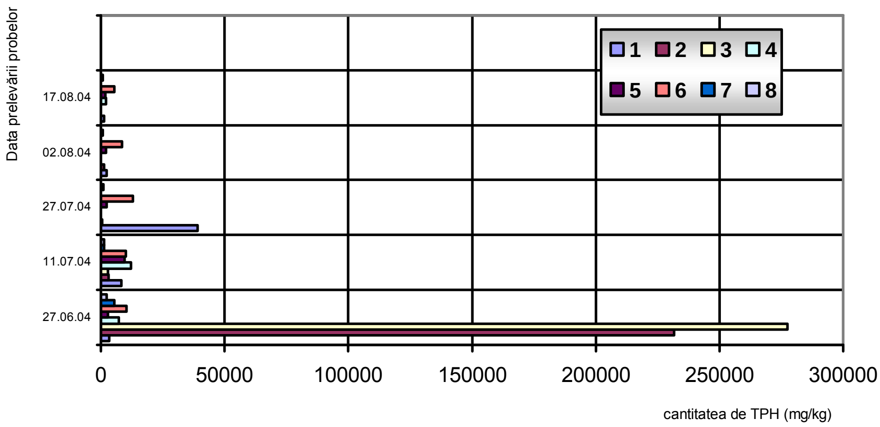

Figure 3. Variation of TPH quantity in different underground samples taken at different dates

Table 4. Evolution of soil quality from the point of view of TPH in successively sampling campaigns.

No. of bore holes	Analysis date /TPH content mg/dm³					CMA for TPH mg/dm³			
	27.06.04	11.07.04	27.07.04	02.08.04	17.08.04	Drinkable water standard	Romanian standard	Dutch standard	German standard
1	0,00	2,1	0,8	1,6	1,1	0,01	1,0	0,6	2,0
2	110	4,1	1,6	0,8	0,5	0,01	1,0	0,6	2,0
3	230	2,7	2,4	0,0	0,5	0,01	1,0	0,6	2,0
4	140	5,5	2,2	2,2	1,7	0,01	1,0	0,6	2,0
5	10	3,5	2,2	1,4	1,1	0,01	1,0	0,6	2,0
Average	98	3,58	1,84	1,2	0,98	0,01	1,0	0,6	2,0

In Romania, there is no separate normative for estimating the underground water quality; there are used the following existing normative: STAS 1342/1991, for drinking water, STAS 9450/1988 for water used for irrigating the crops and STAS 4706/1988 for surface water.

Unfortunately, the standards mentioned above do not include maximum admissible values for oil product concentrations (oil hydrocarbons) in water. As consequence, according to the provisions of the art. 18 from Decision no. 756/1997 of M.A.P.P.M., it was decided to establish the depollution objective for underground water to a value equal to C_{water} = 0.01 mg/l, value that corresponds to the maximum admissible concentration of oil products in drinking water used in European Union. Comparing to these normative the Dutch standard stipulates 0.6 mg/l and the German one 2.0 mg/l.

Depollution of water from ammonium and phosphate ions, as well as the content of detergents, included on purpose as nutritive substances will be made also by means of this aeration process, as soon as the estimated parameter regarding the soil and underground water are reached.

References

[1]. Neag Ghe. - *Depollution of soil and water*.
[2]. Sârbu R – *Hypobaric flotation installation*, Patent OSIM no. 119992/15. 01. 1998
[3]. Sârbu R., Badulescu C., Traista E., - *Treatment of soil and underground water contaminated with oil products*, Research contract no. 90/2003
[4]. *Provisions regarding evaluation of environment pollution*, Decision no. 756/1998

ELECTRICITY GENERATION BY COAL-FIRED VERSUS REDUCING GREENHOUSE GASES EMISSIONS

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Abstract: Longer-term global economic growth cannot be achieved without adequate and affordable energy supplies, which will require continuing significant contributions from fossil fuels, including coal. Coal provides the fuel for 39% of electricity production globally, and will continue to make an important contribution to energy security because of its widespread geographic distribution, and the extent of available resources relative to anticipated energy needs. At the present time, however, some market and policy frameworks discourage the investments that will be required to assure the capability of coal to serve as an environmentally sound cost-effective contributor to global energy needs in coming decades.

Numerous governments are now calling for very significant cuts in greenhouse gas emissions in the longer term (some of the order of 50% by 2050, and others on a carbon intensity basis), but action will be ineffective in the absence of participation of numerous countries that are major greenhouse gas emitters.

Keywords: climate change, environment, policy, strategies.

1. Power generation from coal

Since 1 May 2004, the European Union has had 25 member States with some 455 million inhabitants. Primary energy consumption in the EU-25 amounts to approximately 2.5 bn tonnes of coal equivalent (tce) or one-sixth of the 15 bn tce global energy consumption.

The EU-25 is heavily dependent on energy imports (>50% of energy requirements). The EU estimates that this will have grown to 62% by 2020, with gas consumption and imports rising dramatically in the medium term and consequent significant increases in electricity prices.

Coal holds an important place in the EU-25 energy supply mix, accounting for 32 % of power supply. Coal is indispensable to primary steel production and other

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energy-intensive industries. Being the only significant indigenous energy source, it also guarantees a certain degree of independence in energy supply.

The EU-25 has some 675 GW of electricity generating capacity, expected to generate about 3 000 TWh of electricity in 2004. Of this, 30% is based on nuclear

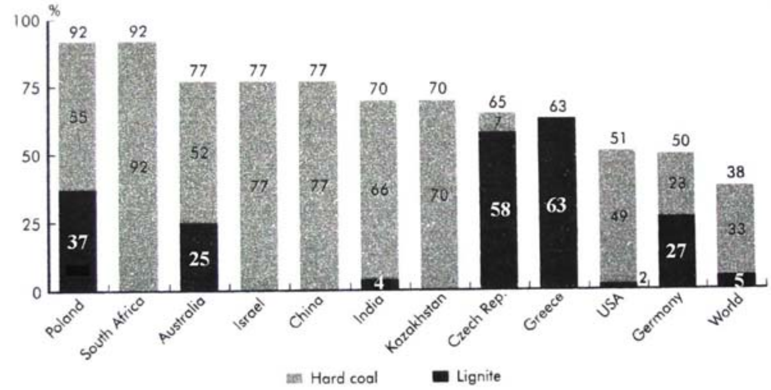

Figure 1. Share of coal in power generation, 2002 [3].

energy, 30% on coal, 19% on gas, 5% on oil and 16% on renewable energies. In the latter case, most of the total is generated by hydropower (some 12 percentage points). The EU-25 countries account for 19% of worldwide power consumption.

The consumption of electrical energy is expected to increase to an even greater extent. World electricity demand is projected to grow at an annual rate of 2.5%, nearly doubling from 16.1 trillion kilowatt-hour (tn kWh) in 2002 to 31.7 tn kWh in 2030. Strong growth in electricity consumption is expected in countries of the developing world, where electricity demand increases by an average of 3.5% per year. The global power sector will need 4 800 GW of new capacity between now and 2030 to meet the projected rise in electricity demand and to replace ageing infrastructure. The total installed capacity is expected to increase from 3 500 GW to more than 8 000 GW. The exact mix of fuel input to this new generating capacity will depend on a number of factors including fuel diversity, indigenous and international availability, cost and environmental acceptability; and will vary between different regions of the world. Gas and renewable energy sources will play increasing roles, particularly in the industrialised nations. However, coal's wide availability, supply security and competitiveness are recognised in the projections. They show coal retaining a very important position in fuelling this electricity generating capacity.

Currently, two-thirds of the coal consumed worldwide is used for electricity generation. In many large countries in the developed world as well as in the developing nations, coal occupies top slot as energy source in power generation. In almost every region, power generation accounts for most of the projected growth in coal consumption of some 1.5%/a. Coal-fired power plants provided 39% of global electricity needs in 2002. This share will fall only slightly, to 38% in 2030 (Figure 2).

The use of geologic formations for CO_2 sequestration is being investigated in many nations. Depleted gas fields, non-minable coal seams, if possible with simultaneous coal bed methane production, and saline aquifers, all offer CO_2 sequestration options. Options for CO_2 sequestration in deep-sea sediments are also being explored. Considerable research and development effort is still required to clarify and confirm these options.

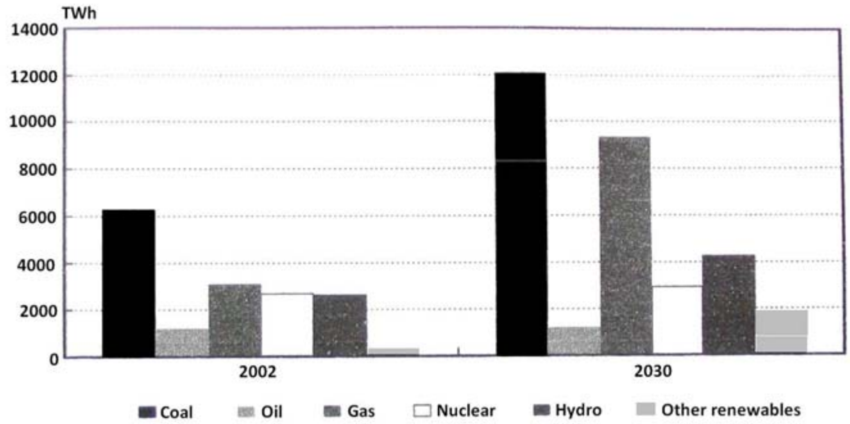

Figure 2. World electricity generation by energy sources [4].

The use of these newer technologies will be highly location-specific and driven by government policy in terms of the extent of GHG emissions reduction in the longer term. Regions with strong endowments of fossils fuels, existing pipeline infrastructure, and well-mapped geological structures, are expected to be able to offer lower-cost development options, and to provide a lead in demonstration of these technologies. As costs reduce over time and the imperative for comprehensive action is taken up, the deployment of these near-zero emission technologies can be expected to widen.

Hard coal and lignite combustion efficiencies will continue to improve through the use of coal drying and higher power plant steam cycle temperatures, as illustrated below.

Coal-fired generating capacity of about 1 000 GW is installed worldwide. Almost two-thirds of the international coal-fired power plant portfolios are older than 20 years and have an efficiency of 29%. These power plants emit some 3.9 bn t CO_2 per year.

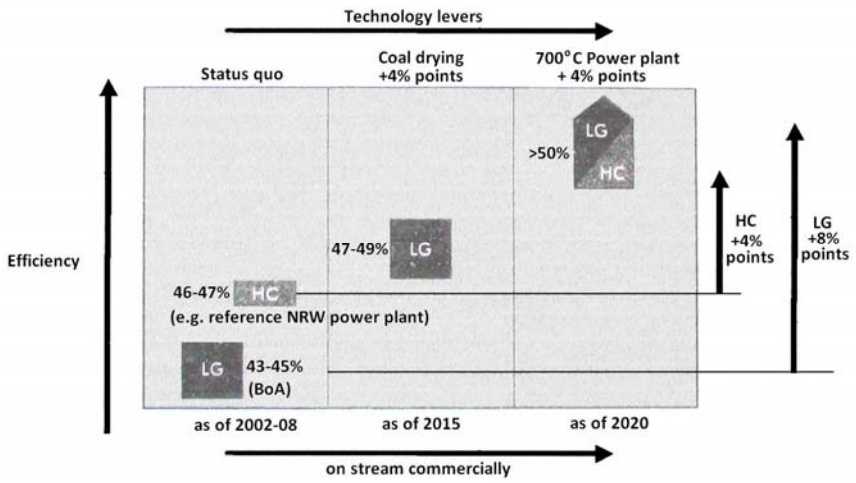

Figure 3. Development horizons of lignite and hard coal-fired power plant (LG = lignite; HC = hard coal).

If the normal life of these plants is assumed to be 40 years, and they are replaced when they reach this age with modern, ultra-supercritical plant with efficiencies typically around 45%, the total greenhouse gas (GHG) emissions from this 1 000 GW of capacity will be reduced by 1.4 bn tonnes CO_2 per year, reflecting a 36% reduction in GHG emissions.

This corresponds to some 6% of the 23.4 bn t of global energy-related CO_2 emissions which are reported by the IEA for 2002 and is more than the targeted reductions under the Kyoto Protocol in 2008-2012. This is an important contribution, albeit it is recognised that even greater reductions are required.

2. Preventive climate protection

Fossil fuels will continue to be part of the energy mix for many decades to come. In developing countries, the prime driver is to increase the economic well-being of the population and, where possible, to use indigenous energy resources. In more mature economies, the focus is increasingly on environmental improvement and global climate issues. In both cases coal-fired electricity generation will be an important part of the picture, giving the world access to a cost-efficient supply of energy and having the technological potential to make a significant contribution to reducing CO_2 emissions over the short and longer term.

In Europe and the USA, uncertainties around the future direction of environmental and global climate policies have stalled investment in coal-fired electricity generating plant, except where the use of indigenous resources has been an important consideration. Commercial markets and financial institutions have not had the confidence to invest in newer technologies, which would reduce CO_2 emissions but which have long payback periods. Instead, investment has tended to favour gas-fired electricity generating capacity with its shorter and less risky payback horizon. However, gas alone will not be able to fill the demand for new generating capacity, particularly in developing countries, and excessive reliance upon it will drive prices

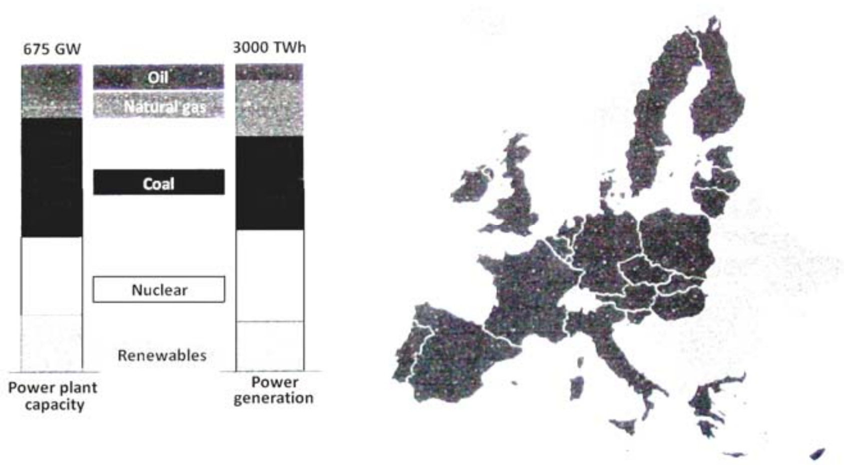

Figure 5. Power generation structures, in EU-25, 2004 [1].

higher and decrease energy security.

Climate protection issues and the Kyoto Protocol of 12 December 1997 have profoundly affected European energy policy. The European Union signed the Protocol and has also ratified it. In accordance with the Protocol, the EU-15 has undertaken to reduce emissions of the six chief greenhouse gases by a total of 8% in the period from 1990 to 2008/12. In 1998, as part of the concluded burden-sharing agreement, this undertaking was divided very unevenly among the member States. Eight of the 10 States that acceded to the EU on 1 May 2004 have also given an undertaking to lower their GHG emissions in line with the Kyoto Protocol. The reduction commitments amount to 6% for two and 8% for six of these states, each relative to the base period.

EU Directive 2001/77/EC, 27 September 2001, aims to raise the share of electricity produced from renewable energy sources in the Community's total power consumption to 22.1% by the year 2010.

Renewable energy is defined [5] as energy that is converted from resources that are used at a rate no faster than that at which they are replenished: ”on a time-scale of human relevance, they will not be exhausted, unlike the effectively limited stocks of fossil fuels (coal, oil, gas), which have been laid down over geological time and are not being renewed at the rate at which they have been consumed since the Industrial Revolution.”

The following renewable energy resource options [2] could have a significant role:

- Solar energy, converted into other useful forms through:
  - solar photovoltaic technology: electricity generation;
  - solar thermal for heating: water, space, cooking, process heat;
  - solar thermal electric technologies: using heat from solar energy to drive 'heat engines' that can drive electricity generators or provide mechanical power;
  - sunlight: itself a critical source of lighting and space heating in homes and workplaces (solar energy is also the primary driver for all the other energy sources listed below – except geothermal and tidal)
- Wind energy: electricity generation on both small- and large-scale, water pumping and, more rarely, other mechanical power applications;
- Hydro-power: the size of hydropower plants ranges from as little as 50 W to several gigawatts);
- Ocean wave and tidal power: wave power in particular is receiving more interest at present;
- Biomass:
  - electricity generation: typically through conventional combustion in boilers to drive steam turbines; other options include gasification;
  - household energy fuels: used for cooking, space heating;
  - biofuels: used either directly (e.g. biodiesel), or as an additive in transport and other liquid fuels;
- Landfill gas: methane gas produced at landfill sites from organic material (this is included here consistent with government practice, but should not be taken to indicate that current levels of waste production or management methods are sustainable);
- Geothermal energy: where the heat in the earth is used to drive heat-engines.

There are a number of other 'future' technologies, such as direct photosynthesis linked production of electricity, which may play a role in the longer term. Although these could be relevant by 2050, they have not been reviewed for this study.

The theoretical potential for renewable energy is enormous, many times greater than current or projected demand. However, although renewable energy resources are continuously replenished, there are limits as to how much can be extracted at any one time, or during the course of a year. These limits typically relate to the area of land or sea that can be used to harness the resource, the intensity of the resource and the timing of resource availability.

In addition to the trade in emission allowances, the Kyoto Protocol provides for Joint Implementation (JI) and a Clean Development Mechanism (CDM) as further mechanisms to help meet given commitments. JI enables an offset of emissions reductions obtained by projects between two industrialised nations. Here, one industrialised country entity participates in a project (*e.g.* to increase the efficiency of a power plant) in another State that has a duty to limit emissions under the Protocol. The emissions reductions obtained are credited to the country in which the project was launched and may be transferred to the investor. The CDM concerns projects in which investors from industrialised countries lower GHG emissions in developing countries. Suitable underlying conditions permitting, JI and CDM can offer a cost-effective alternative to expensive emissions reduction measures taken at home.

In 2004, the EU Parliament and the Council issued a supplementary directive to the emissions-trading directive, giving companies investing in appropriate projects tradable allowances for the reductions in CO_2 emissions achieved by such projects. As a result, this will increase the diversity of low-cost compliance options within the Community scheme leading to a reduction of the overall costs of compliance with the Kyoto Protocol while improving the liquidity of the Community market in greenhouse gas emission allowances. This Directive 2004/101/EG (JI/CDM directive) was adopted with legally binding effect, irrespective of the entry into force of the Kyoto Protocol.

The directive amending the directive establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms, took effect on 13 November 2004.

This allows European industry, at an early stage, to use the option of project-based schemes to lower the cost burden generated by reducing GHGs. In this way, an adverse impact on growth and jobs in EU countries could be contained, while making a contribution towards technology transfer.

The EU's trade in allowances is a plant-based system at company level. It affects power producers (combustion installations >20 MWth, refineries, coking plants), the iron and steel sector, the mineralprocessing industry (cement, glass, ceramics) and pulp, paper and cardboard makers. Throughout the EU, for example, some 12,000 plants in total will be affected. The transport, households and trade/crafts/services are exempt from emissions trading. Of the six Kyoto Protocol greenhouse gases, only carbon dioxide (CO_2) is included in the first trading period from 2005 to 2007.

In order to trade CO_2 emission allowances, initial allocations must be made. The directive imposed a duty on member States to publish national allocation plans (NAPs) by 31 March 2004 and to submit these to the EU Commission and to the other member States. Each NAP must state the total emission allowances that a member State proposes to issue in the three-year period 2005 to 2007 and how these allowances are to be distributed between the affected plants. The directive prescribes that member States must issue at least 95% of emission allowances free of charge for the period 2005 to 2007 and at least 90% for the period 2008 to 2012.

Conclusions

The development of near-zero emission technologies for coal may be centred in developed nations, which have the means and political will to apply resources to the development of these technologies. However, most new coal-fired generating capacity will be installed in developing countries. National and international policies supportive of advanced coal technologies and zero-emission technology transfer to developing nations is essential, including recognition of such projects in the Joint Implementation and Clean Development Mechanism accounting frameworks under the Kyoto Protocol.

Governments also should seek to agree on the domestic and international incentives and rules that might encourage the application of modern technology to improve efficiency when older power stations are being refurbished. In particular, these activities should also qualify for government support and be admissible under the Joint Implementation and Clean Development Mechanism rules.

More fundamentally, governments should seek to balance the social, economic and environmental needs of society by maintaining the energy security, including continued coal use, needed to support growth. Government policies need to provide long-term strategic solutions for achieving sustainable energy use and economic growth. In this context, government support for the demonstration of first-of-a-kind technologies may be appropriate, allowing these to compete on even terms with mature, commercialised technologies and thereby accelerating their deployment.

The co-ordination of technology development efforts by energy market regulators and participants is also important – lack of co-ordination, rivalry and duplication among research and development programmes will waste resources and delay new technologies.

References

[1]. European Commission, *European energy and transport trends to 2030.* Eurelectric, Brussels, 2004.

[2]. International Energy Agency, *Renewables for power generation: status and prospects.* IEA, Paris, 2003.

[3]. International Energy Agency, *Electricity Information.* IEA, Washington, DC, 2004.

[4]. International Energy Agency, *World Energy Outlook 2004.* IEA, Washington, DC, 2004.

[5]. Sorenson, B., *Renewable energy.* Academic Press, 1979.

ENVIRONMENTAL POLLUTION INTERACT WITH THE INNOVATION AND DIFFUSION OF NEW TECHNOLOGIES

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ILIE ONICA**

Abstract: Theory and empirical evidence suggest that the rate and direction of technological advance is influenced by market and regulatory incentives, and can be cost-effectively harnessed through the use of economic-incentive based policy. In the presence of weak or nonexistent environmental policies, investments in the development and diffusion of new environmentally beneficial technologies are very likely to be less than would be socially desirable. While environmental technology policy is fraught with difficulties, a long-term view suggests a strategy of experimenting with policy approaches and systematically evaluating their success.

Key words: diffusion rates, environnement, technology innovation, pollution.

1.Fundamental concepts in the economics of technological change

The literature pertaining to the economics of technological change is large and diverse. Major sub-areas (with references to surveys related to those areas) include: the theory of incentives for research and development [1]; the measurement of innovative inputs and outputs [3]; analysis and measurement of externalities resulting from the research process [6]; the measurement and analysis of productivity growth [3]; diffusion of new technology [2]; the effect of market structure on innovation [10]; market failures related to innovation and appropriate policy responses [7]; the economic effects of publicly funded research; the economic effects of the patent system; and the role of technological change in endogenous macroeconomic growth.

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The modern theory of the process of technological change can be traced to the ideas of Josef Schumpeter [8], who saw innovation as the hallmark of the modern capitalist system. Entrepreneurs, enticed by the vision of the temporary market power that a successful new product or process could offer, continually introduce such products. They may enjoy excess profits for some period of time, until they are displaced by subsequent successful innovators, in a continuing process that Schumpeter called "creative destruction."

Schumpeter distinguished three steps or stages in the process by which a new, superior technology permeates the marketplace. *Invention* constitutes the first development of a scientifically or technically new product or process. Inventions may be patented, though many are not. Either way, most inventions never actually develop into an *innovation*, which is accomplished only when the new product or process is commercialized, that is, made available on the market. A firm can innovate without ever inventing, if it identifies a previously existing technical idea that was never commercialized, and brings a product or process based on that idea to market. The invention and innovation stages are carried out primarily in private firms through a process that is broadly characterized as "research and development" (R&D). Finally, a successful innovation gradually comes to be widely available for use in relevant applications through adoption by firms or individuals, a process labeled *diffusion*. The cumulative economic or environmental impact of new technology results from all three of these stages, which we refer to collectively as the process of technological change.

The measurement of the rate and direction of technological change rests fundamentally on the concept of the transformation function:

$$T(Y, I, t) \leq 0 \tag{1}$$

where Y represents a vector of outputs, I represents a vector of inputs, and t is time. Equation (1) describes a production possibility frontier, that is, a set of combinations of inputs and outputs that are technically feasible at a point in time. Technological change is represented by movement of this frontier that makes it possible over time to use given input vectors to produce output vectors that were not previously feasible.

In most applications, separability and aggregation assumptions are made that make it possible to represent the economy's production technology with a production function:

$$Y = f(K, L, E; t) \tag{2}$$

where Y is now a scalar measure of aggregate output (for example, gross domestic product), and the list of inputs on the right-hand side of the production function can be made arbitrarily long.

For illustrative purposes, we conceive of output as being made from a single composite of capital goods, K, a single composite of labor inputs, L, and a single composite of environmental inputs, E (for example, waste assimilation). Again, technological change means that the relationship between these inputs and possible output levels changes over time.

Logarithmic differentiation of Equation (2) with respect to time yields

$$y_t = A_t + \beta_{L_t} l_t + \beta_{K_t} k_t + \beta_{E_t} e_t \quad (3)$$

in which lower case letters represent the percentage growth rates of the corresponding upper case variable; the β 's represent the corresponding logarithmic partial derivatives from Equation (2); and the t indicate that all quantities and parameters may change over time. The term A_t corresponds to "neutral" technological change, in the sense that it represents the rate of growth of output if the growth rates of all inputs were zero. But the possibility that the β 's can change over time allows for "biased" technological change, that is, changes over time in *relative* productivity of the various inputs.

Equations (2) and (3) are most easily interpreted in the case of process innovation, in which firms figure out more efficient ways to make existing products, allowing output to grow at a rate faster than inputs are growing. In principle, these equations also apply to product innovation. *Y* is a composite or aggregate output measure, in which the distinct outputs of the economy are each weighted by their relative value, as measured by their market price. Improved products will typically sell at a price premium, relative to lower quality products, meaning that their introduction will increase measured output even if the physical quantity of the new goods does not exceed the physical quantity of the old goods they replaced.

On its face, Equation (3) says nothing about the *source* of the productivity improvement associated with the neutral technological change term, A_t. If, however, all inputs and outputs are properly measured, and inputs (including R&D) yield only normal investment returns, then all endogenous contributions to output should be captured by returns to inputs, and there should be no "residual" difference between the weighted growth rates of inputs and the growth rate of output. The observation that the residual has been typically positive is therefore interpreted as evidence of some source of exogenous technological change. In many contexts, it is difficult to distinguish the effects of innovation and diffusion. We observe improvements in productivity (or other measures of performance) but do not have the underlying information necessary to separate such improvements into movements of the production frontier and movements of existing firms towards the frontier. A related issue, and one that is often significant for environment-related technological change, is that innovation can be undertaken either by the manufacturers or the users of industrial equipment.

In the former case, the innovation must typically be *embodied* in new capital goods, and must then diffuse through the population of users via the purchase of these goods, in order to affect productivity or environmental performance. In the latter case, the innovation may take the form of changes in practices that are implemented with existing equipment. Alternatively, firms may develop new equipment for their own use, which they then may or may not undertake to sell to other firms. The fact that the locus of activity generating environment-related technological change can be supplying firms, using firms, or both, has important consequences for modeling the interaction of technological change and environmental policy.

2. Key analytical issues

2.1. Fundamentals of environmental economics

Economic analysis of environmental policy is based on the idea that the potentially harmful consequences of economic activities on the environment constitute an „externality", an economically significant effect of an activity, the consequences of which are borne (at least in part) by a party or parties other than the party that controls the externality producing activity. A factory that pollutes the air, water, or land imposes a cost on society. The firm that owns the factory has an economic incentive to use only as much labor or steel as it can productively employ, because those inputs are costly to the firm. The cost to society of having some of its labor and steel used up in a given factory is „internalized" by the firm, because it has to pay for those inputs. But the firm does not have an economic incentive to minimize the „external" costs of pollution.

When technology enters the equation, the terms of the tradeoff between the marginal cost of pollution control and its marginal social benefit are altered. In particular, technology innovations – such as new pollution control equipment, cleaner production methods, or new substitutes for environmentally harmful products – typically reduce the marginal cost of achieving a given unit of pollution reduction. This means that a specified level of environmental cleanup can be achieved at lower total cost to society, and it also means that a lower total level of pollution can be attained more efficiently than would be expected if the cost of cleanup were higher. Thus, in this simple static picture, technology improvements can be good for the environment and good for the firm that must meet environmental mandates.

2.2. Fundamentals of the economics of technology

In this simple analytic scenario, the technology innovation results in greater overall social benefit because the cost of reducing pollution has decreased and environmental health has improved. If this were the end of this static story, than the only effect would be to convert the analysis of environmental policy from a static cost/benefit tradeoff to a dynamic one. Policies to reduce pollution have two effects, however – they reduce pollution today, and they also typically change the incentives that firms face with regard to investing resources in developing new technology for the future. In particular, when firms face an incentive to reduce their emissions, this simultaneously creates an incentive for them to find ways to reduce pollution at lower cost. The fact that the development of such technology will, over time, change the pollution benefit/cost calculus means that choosing efficient environmental policy requires an analysis of this dynamic interaction. The simple static model does not take into account the fact that new technology is itself not free.

To reach the point where pollution is being reduced or some other benefit is realized, two things must happen, both of which require the investment of resources. The first step–innovation–involves scientific or engineering research to establish a new technical idea and to develop that idea into a commercial product or process. The second step – adoption (or diffusion) – is the process by which a new product or process gradually replaces older technology throughout many firms and applications. Adoption is also costly, because firms must learn about new technology, purchase new equipment, and adapt it to their particular circumstances.

Both innovation and diffusion of new technology are characterized by additional market failures related to incomplete information. While all investment is characterized by uncertainty, the uncertainty associated with the returns to investment in innovation is often particularly large. Further, information about the prospects for success of given technology research investments is asymmetric, in the sense that the developer of the technology is in a better position to assess its potential than outsiders. A firm attempting to raise investment capital to fund the development of new technology will therefore find such investors skeptical about promised returns, and likely to demand a premium for investment that carries such risks. This likely imperfection in the market for capital for funding technology development exacerbates the „spillover" problem and therefore contributes to our expectation that the invisible hand encourages too little research and development.

With respect to technology adoption and diffusion, we have already noted that imperfect information can slow the diffusion of new technology. First, information has important „public good" attributes: once created it can be used by many people at little or no additional cost. It may be difficult or impossible for an individual or firm that invests in information creation to prevent others who do not pay for the information from using it. It is well known that such public goods will tend to be underprovided by ordinary market activity. Incomplete information can also foster principal–agent problems, as when a builder or landlord chooses the level of investment in energy efficiency in a building, but the energy bills are paid by a later purchaser or a tenant. If the purchaser has incomplete information about the magnitude of the resulting energy savings, the builder or landlord may not be able to recover the cost of such investments, and hence might not undertake them. These market failures with respect to adoption of new technology are part of the explanation for the apparent „paradox" of underinvestment in energy-saving technologies that appear cost-effective but are not widely utilized [5].

2. Diffusion of green technology

The explanation for the apparent slowness of the technology diffusion process has been a subject of research in a variety of disciplines. Two main forces have been emphasized. First, potential technology adopters are heterogeneous, so that a technology that is generally superior will not be equally superior for all potential users, and may remain inferior to existing technology for some users for an extended period of time after its introduction. Second, adopting a new technology is a risky undertaking, requiring considerable information, both about the generic attributes of the new technology and about the details of its use in the particular application being considered. It takes time for information to diffuse sufficiently, and the diffusion of the technology is limited by this process of diffusion of information.

In the literature unrelated to environmental technology, both theory and empirical evidence are clear that technology diffusion rates depend on the strength of economic incentives for technology adoption. Both of the models discussed above predict that the present value of benefits from adoption and the initial adoption cost enter into decisions affecting the diffusion rate. In the probit model, this net present value comparison determines the location of the adoption threshold that determines what fraction of potential adopters will adopt at a moment in time. In the epidemic model, this net present value comparison determines the magnitude of the "contagiousness" parameter, which in turn determines the speed at which the technology spreads from adopters to previous non-adopters.

While the induced innovation literature focuses on the potential for environmental policy to bring forth new technology through innovation, there is also a widely-held view that significant reductions in environmental impacts could be achieved through more widespread diffusion of *existing* economically-attractive technologies, particularly ones that increase energy efficiency and thereby reduce emissions associated with fossil fuel combustion. For example, the report of the Interlaboratory Working Group [4] compiled a comprehensive analysis of existing technologies that reportedly could reduce energy use and hence CO2 emissions at low or even negative net cost to users. The observation that energy-efficient technologies that are costeffective at current prices are diffusing only slowly dates back to the 1970s, having been identified as a "paradox" at least as far back as Shama [9].

First, what is the theoretical and empirical potential for "induced diffusion" of lower-emissions technologies? Specifically, how do environmental policy instruments that implicitly or explicitly increase the economic incentive to reduce emissions affect the diffusion rate of these technologies?

A second and related question is the degree to which historical diffusion rates have been limited by market failures in the energy and equipment markets themselves. To the extent that diffusion has been and is limited by market failures, it is less clear that policies that operate by increasing the economic incentive to adopt such technology will be effective. On the other hand, if such market failures are important, then policies focused directly on correction of such market failures provide, at least in principle, opportunities for policy interventions that are social-welfare increasing, even without regard to any environmental benefit.

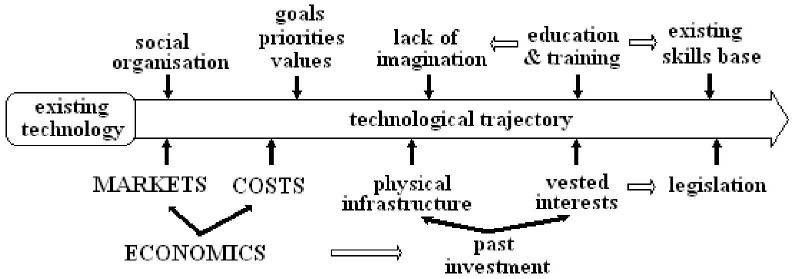

Figure 1. Factors that constrain the direction of a technological trajectory.

As a result, technological development tends to follow certain directions, or trajectories, that are determined by the engineering profession and others (see Figure 2). Ideas are developed if they fit the paradigm; otherwise, they tend to be ignored by the mainstream engineers, the bulk of the profession. An example is the development of sewerage engineering. The range of ways of treating sewage is limited by a sewage treatment paradigm that assumes that sewage will be delivered in pipes to centralised locations near waterways. Treatment is classified into three stages – primary, secondary and tertiary, which build upon one another. The first stage is to remove some of the solids from the sewage; the second stage is to decompose the sewage; and the third stage either removes more solids or decomposes the sewage further. Any new technology will only be thought of or developed if it can fit within this system.

Generally, technological change is gradual and occurs within technological paradigms. Radical technological innovation is often opposed by firms because of the social changes that may need to accompany it – for example, changes to the work and skills of employees, to the way production is organised, and to the relationships between a firm and its clients and suppliers.

Conclusions

When it comes to green technology, two mutually reinforcing sets of market failures are at work – which decrease the likelihood that the rate of investment in the development and diffusion of such technology would occur at the socially optimal level. The solutions fall into two categories of approaches. One approach is to foster the development and diffusion of new technology by designing environmental policies to increase the perceived market payoff and maximize flexibility in compliance. The other approach is to implement policies aimed directly at encouraging the development and diffusion of environmentally friendly technologies. Theory suggests and empirical research confirms that innovation and technology diffusion do respond to the incentives of the market, and that properly designed regulation can create such incentives.

The empirical evidence to date is generally consistent with theoretical findings that market-based instruments for environmental protection are likely to have significantly greater, positive impacts over time than command-and-control approaches on the invention, innovation, and diffusion of desirable, environmentally-friendly technologies. Further, empirical studies suggest that the response of technological change to relevant price changes can be surprisingly swift in terms of patenting activity and introduction of new model offerings – on the order of five years or less. Substantial diffusion can sometimes take considerably longer, depending on the rate of retirement of previously installed equipment. The longevity of much equipment reinforces the importance of taking a longer-term view toward improvements – on the order of decades. Existing empirical studies have also produced some results that may not be consistent with theoretical expectations, such as the finding from two independent analyses that the diffusion of energy-efficiency technologies is more sensitive to variation in adoption-cost than to commensurate energy price changes. Further theoretical and/or empirical work may resolve this apparent anomaly.

Sustainable development relies on technological change to achieve its aims but will governments take the tough steps that are required to force radical technological innovation rather than the technological fixes that have been evident to date? Such measures would require a long-term view and a preparedness to bear short-term economic costs while industry readjusts.

Even if people put their faith in the ability of human ingenuity in the form of technology to be able to preserve their lifestyles and ensure an ever increasing level of consumption for everyone, they cannot ignore the necessity to redesign our technological systems rather than continue to apply technological fixes that are seldom satisfactory in the long term. Technological optimism does not escape the need for fundamental social change and a shift in priorities. That was the mistake many in the Appropriate Technology Movement made. It takes more than the existence of appropriate or clean technologies to ensure their widespread adoption.

References

[1]. Geroski, P.A., *Markets for technology: Knowledge, innovation and appropriability,* in P. Stoneman, ed., Handbook of the economics of innovation and technological change, Oxford, Blackwell Publishers, 1995.

[2]. Geroski, P.A., *Models of technology diffusion,* Research policy, **29**, 2000.

[3]. Griliches, Z., *R&D and productivity, the econometric evidence,* University of Chicago Press, Chicago, 1998.

[4]. Interlaboratory Working Group, *Scenarios of carbon reductions: potential impacts of energy technologies by 2010 and beyond,* Office of Energy Efficiency and Renewable Technologies, U.S. Department of Energy, Washington, 1997.

[5]. Jaffe, A.B., Stavins, R.N., *The energy paradox and the diffusion of conservation technology,* Resource and Energy Economics, **16**, 1994.

[6]. Jaffe, A.B., *The importance of "spillovers" in the policy missions of the advanced technology program,* Journal of technology transfer, Summer 1998.

[7]. Martin, S., Scott, J., *The nature of innovation market failure and the design of public support for private innovation,* Research Policy, **29**, 2000.

[8]. Schumpeter, J., *Capitalism, socialism and democracy*, Harper, New York, 1942.

[9]. Shama, A., *Energy conservation in U.S. buildings, solving the high potential/low adoption paradox from a behavioral perspective,* Energy Policy, **11**, 1983.

[10]. Sutton, J., *Technology and market structure.* The MIT Press, Cambridge, 1998.

CRITICAL PARTICLE SIZE IN SPONTANEOUS COMBUSTION OF COAL STOCKPILES

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Abstract: Coal is one of the carbonaceous materials which, under certain conditions, can combust spontaneously as a result of its oxidation with atmospheric oxygen. Coal oxidation is an irreversible exothermic reaction and its rate increases with temperature. In mines or in storage, the deficiency of the heat dissipation capacity of the coal bulk with respect to its heat generation capacity can result in heat accumulation which subsequently leads to higher oxidation rates due to higher temperatures. This process, if not averted with appropriate action, results in the spontaneous combustion of the coal. Spontaneous combustion may occur in a coal stockpile when the heat generated within the pile cannot be dissipated at near ambient temperature.

Key words: coal, particle size, spontaneous combustion, stockpiles.

1. Introduction

Spontaneous combustion of coals is the result of the complex phenomena associated with the atmospheric oxidation of coals. This low temperature reaction may occur in mines, during mining or postmining stages whenever the coal is exposed to oxygen. It is an exothermic reaction and its rate increases with temperature [1]. If the heat generated by coal oxidation is not dissipated at the same rate, heat is accumulated in the mine/seam, or the pile, and the temperature increases. With higher temperatures the rate of the reaction and, therefore, the rate of heat generation increases. In such cases, when the ignition temperature of the coal is reached, the coal autoignites.

Whether or not the ambient oxidation of a coal results in autoignition and spontaneous combustion, depends on the relative rates of heat generation and heat dissipation in the given location.

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2. Analytical expression for the ignition

Exists a critical particle size Ra_r below which ignition occurs. An analytical expression for the ignition point may be obtained using a simplification that is frequently used in the thermal explosion theory. The simplification assumes that on the extinguished (low-temperature) branch the reactant consumption is very low and $Y \approx 1$. Moreover, it is assumed that the dimensionless temperature rise is very small ($\theta - 1 << 1$), so that the Arrhenius temperature dependence can be replaced by the positive exponential approximation

$$\exp\left[\gamma\left(1-\frac{1}{\theta}\right)\right] \approx e^{w} \tag{1}$$

where

$$w = \gamma(\theta - 1) \tag{2}$$

where θ is the dimensionless temperature, Y is the oxygen fraction divided by ambient value. The dimensionless activation energy γ is a measure of the sensitivity of the reaction (heat generation) rate to changes in the temperature.

Using these assumptions, the steady state equation for the lumped thermal model simplifies to

$$\Delta = \left(2w + Ra_r^* w^2\right)\exp(-w) \equiv f_1(w) \tag{3}$$

where

$$\Delta = \gamma \cdot \beta \cdot Da_r, \qquad Ra_r^* = \frac{Ra_r}{\gamma} \tag{4}$$

β is the dimensionless adiabatic temperature rise.
At the ignition point, $f_1(w)$ has an extremum. This occurs at

$$w_i = 1 - \frac{1}{Ra_r^*} + \sqrt{1 + \frac{1}{\left(Ra_r^*\right)^2}} \tag{5}$$

$$\Delta_i = 2\left[Ra_r^* + \sqrt{1+\left(Ra_r^*\right)^2}\right] \cdot \exp\left[-1 + \frac{1}{Ra_r^*} - \sqrt{1 + \frac{1}{\left(Ra_r^*\right)^2}}\right] \tag{6}$$

For sufficiently small values of the rayleigh number Ra_r^*, the ignition point approaches the *conduction asymptote*

$$w_i = 1 \qquad \Delta_i = 2e^{-1} = 0.736 \tag{7}$$

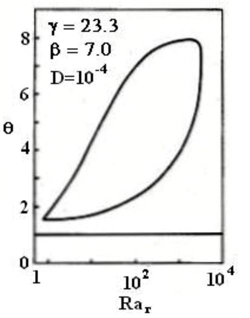

Figure 1. Locus of ignition points.

on which conduction is the main mechanism of heat removal, while for sufficiently large values of Ra_r^* it approaches the *convection asymptote*

$$w_i = 2 \qquad \Delta / Ra_r^* = 4e^{-2} = 0.541 \tag{8}$$

on which natural convection is the main mechanism of heat loss. The ignition points, computed by Eq. (6), are plotted in figure 1, clearly showing the two asymptotes. The transition from the conduction asymptote to the convection asymptote occurs at Ra_r^* of order unity.

In practice one may wish to change the coal particle size in order to avoid spontaneous ignition. Thus, it is essential to know the dependence of the bed temperature on the particle size. This dependence is usually presented as a bifurcation diagram of dimensionless temperature θ vs. a dimensionless particle size. Since both Da_r and Ra_r vary with the particle size, by defining

$$D = Da_r \sqrt{Ra_r} = k(T_a) \cdot M \cdot \rho_a \cdot L \left(\frac{\varepsilon^3 \cdot g \cdot c_p^3}{150\mu \cdot h^3} \right)^{0.5} \tag{9}$$

3. Heat and mass transfer

Governing equations for heat and mass transfer through the system must account for the different thermophysical properties in each domain as well as the chemical reaction occurring in the coal stockpile. In the open fluid domain these equations take the non-dimensional forms

$$v \cdot \nabla T = \frac{1}{Pr_0} \nabla^2 T \tag{10}$$

$$v \cdot \nabla C = \frac{1}{Sc_0} \nabla^2 C \tag{11}$$

Within the coal stockpile

$$v \cdot \nabla T = \frac{1}{\mathrm{Pr}_p} \nabla^2 T + \beta \cdot Da \cdot C \cdot \exp\left(\gamma \frac{T}{1+T} \right) \tag{12}$$

$$v \cdot \nabla C = \frac{1}{Sc_p} \nabla^2 C - Da \cdot C \cdot \exp\left(\gamma \frac{T}{1+T} \right) \tag{13}$$

In the above equations v is the dimensionless velocity, T is the dimensionless temperature, C is the dimensionless oxygen concentration, β is the Prater number (adiabatic temperature rise) and γ is the Arrhenius number. The dimensionless Prandtl number *Pr* and Schmidt number *Sc* take different values in the open air and porous coal pile domains, as indicated by subscripts "o" and "p" respectively.

Along the centerline and top of the open domain no-flux conditions are set for heat and mass transfer. Along the ground the temperature is set to its ambient value and a no-flux condition is applied for oxygen transfer. Along the outer edge of the computational domain the temperature and concentration fields are set to ambient values.

The flow in the open domain is governed by the steady state, Navier-Stokes equations, written here in dimensionless stress divergence form for an incompressible fluid with the Boussinesq approximation:

$$v \cdot \nabla v = \nabla \cdot \sigma_o + \frac{Ra}{\beta \cdot Pr_p} T e_z \tag{14}$$

$$\nabla \cdot v = 0 \tag{15}$$

where Ra is the dimensionless Rayleigh number and e_z is a unit vector oriented upwards against the direction of the gravitational force vector. The total stress tensor for a Newtonian fluid in the open fluid region, σ_o in equation (14), is given in dimensionless terms by

$$\sigma_o = -P \cdot I + \left(\nabla v + \nabla v^T \right) \tag{16}$$

where P is the dimensionless dynamic pressure, I is the identity tensor and superscript T denotes the transpose operation.

The Navier-Stokes equations require the application of two distinct boundary conditions along all surfaces in this two-dimensional geometry. At the porous/open fluid interface we require continuity of normal stress [2]:

$$n \cdot n \cdot \sigma_o = n \cdot n \cdot \sigma_p \tag{17}$$

where σ denotes the total stress tensor for the fluid in each domain. The second boundary condition is a specification of the shear stress at the interface, $t \cdot n \cdot \sigma_o$, and depends on our choice of the flow equation in the porous region.

To complete the specification of boundary conditions for the Navier-Stokes equations and the open fluid domain, the following choices are made. Stress-free boundary conditions are imposed along the outer and upper surfaces of the computational domain. No-slip conditions are specified along the ground surface outside the coal pile and axisymmetry is enforced along the centreline in the open region.

4. Low temperature coal oxidation

The reaction takes place between the oxygen-reactive sites in the coal material and molecular oxygen in the surrounding atmosphere under ambient conditions. The products are CO, CO_2 and H_2O and oxygen-containing functional groups in the coal material. The chemical mechanisms generally proposed for coal oxidation include the following sequence of free radical reactions [3]:

$$RH + O_2 \rightarrow R^- + HOO^- \tag{18}$$

$$R^- + O_2 \rightarrow ROO^- \tag{19}$$

$$ROO^- + RH \rightarrow ROOR + H^- \tag{20}$$

$$ROO^- + RH \rightarrow ROOH + R^- \tag{21}$$

$$ROOR \rightarrow 2RO^- \tag{22}$$

$$ROOH \rightarrow RO^- + {}^-OH \tag{23}$$

$$HOO^- + H^- \rightarrow HOOH \tag{24}$$

$$HOOH \rightarrow 2HO^- \tag{25}$$

$$RO^- \rightarrow products \tag{26}$$

$$HO^- \rightarrow products \tag{27}$$

$$\mathrm{coal} + \mathrm{O_2} \rightarrow \mathrm{oxidized\ coal} + \mathrm{CO} + \mathrm{CO_2} + \mathrm{H_2O}$$

Since coal consists of various types of organic structures with different reactivities towards oxygen, new types of reactions emerge as the temperature increases. Decarboxylation reactions gain significance around 80ºC generating additional heat due to their exothermic nature.

Self-heating (spontaneous heating) and autoignition (selfignition or spontaneous ignition) are the precursors of spontaneous combustion. All coals self-heat to some extent, both in mines and storage; but only if the conditions are favourable they may autoignite.

Figure 2 illustrates the change in the self-heating rates of five coal samples. Below 80ºC, the rate of self-heating hardly changes, but at arround 80ºC a rapid increase is observed.

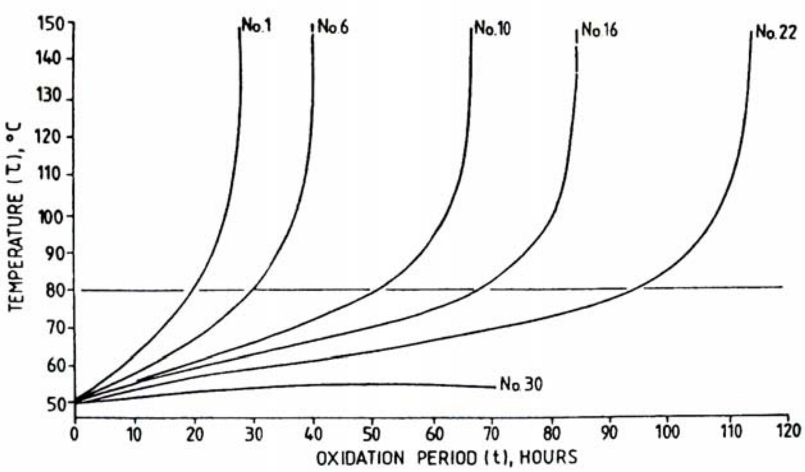

Figure 2. Typical self-heating curves of coal.

Conclusions

Coal may combust spontaneously in mines or in storage when and if the rate of heat generation exceeds the rate of heat dissipation. In order to avoid spontaneous combustion of coals, the principle of minimizing the heat generation and maximizing the heat dissipation capacities of the coal bulk should be applied in all stages of mining, handling, transporting and stockpiling of coals.

References

[1]. Kaji, R., Hishinuma, Y, Nakamura, Y., *Fuel*, 64, 297, 1985.

[2]. Ross, S.M., *Theoretical model of the boundary conditions at the fluid-porous interface*, 1983, AIChE J, vol.29, p.840-846.

[3]. Ünal, S., Wood, D.G., Harris, I.J., *Fuel*, 71, 183, 1992.

STATE-OF-THE ART IN RAIL TUNNEL VENTILATION DESIGN

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Abstract: There have been several disastrous tunnel fires in the last ten years, demonstrating that the risk of fires requires special consideration from designers and operators alike. An adequate ventilation system should be capable to control the smoke and heat generated by the maximum conceivable fire in the tunnel. The importance of an adequately designed tunnel ventilation system is demonstrated and documented by examples from recent fire investigations. Vehicle fires in tunnels can reach high heat release rates, usually produce dense smoke and poisonous fumes at high temperatures and deplete available oxygen, if not properly ventilated. A discussion of how such conditions make emergency response efforts more difficult, if not impossible, is presented. It is generally accepted that in case of a vehicle fire in a tunnel, the tunnel ventilation system should be capable to control the spread of smoke by creating an air stream with a velocity past the fire higher than the velocity required to prevent smoke backlayering. A brief discussion of the "critical velocity" criterion used in fan sizing is included.

Introduction

The population growth in general combined with current urban development around the world and the need to move people from their homes to their places of work, shopping centers or entertainment locations in large metropolitan areas, in particular, are the principal reasons for a continuous demand for more and more transit systems. Whatever innovations will be brought to the design and construction of mass transit systems, one thing is sure: the systems need to move more people, more rapidly, and more safely. Systems will be above ground where possible, but the competition for space, together with the need to suppress noise pollution will cause some of the new traffic to be diverted generally underground (e.g., under cities, rivers, airports, etc.). [1]

Special precautions must be taken to reduce the effect of a fire or of release of toxic substances in very long tunnels, such as the planned Gotthard (57 km) and Lotschberg (33 km) in the Alps [2].

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A new dimension of the safety in tunnels is brought up by the internationalization of risk, for no transportation system in any corner of the world is used exclusively by the nationals of that country. Indeed, in some notorious cases accidents were caused by foreign subjects. In the Mont Blanc fire, a Belgian truck driver abandoned his truck loaded with margarine and flour. In other cases the victims are foreigners or tourists. A good example is the most recent tunnel fire in the small village of Kaprun, Austria, where 155 lives were lost on 12 November 2000. Out of the total number of casualties, 92 were Austrian, 37 were German, 10 were Japanese, 8 were American, 4 were Slovenian, 2 were Dutch, one was British, and one was Czech. In the Tauern Tunnel fire 12 people lost their life, the first victim being a German. More and more fire-fighters, psychologists, and lawyers attend technical conferences and seminars, bringing their viewpoints and expertise to our professional community.

Operating tunnels and subway systems has demonstrated that safety has to be planned and enforced as a high-priority policy in order to ensure that emergency situations can be managed properly and with minimal damage or loss. An appropriate emergency ventilation system is a main component of the emergency plan, recognizing that prevention is much better than dealing with the consequences of such accidents. Sharing experiences and best practice among professionals is of paramount importance. Several good examples are the one-day seminar in Sydney subtitled “Could this be you?,” the seminar in London Heathrow (March 2001) “Escape and crash survival,” or the seminar in Madrid (April 2001) on “Human factors in tunnel safety,” and so on.

Computer modeling and simulation techniques used to design the emergency ventilation systems and to recommend the fan-damper operation modes, based on computer program and on NFPA standards and the American Society of Heating, Ventilating, and Air-Conditioning Engineers (ASHRAE) Handbook-HVAC Applications provide specific design guidelines and operational recommendations for the emergency ventilation systems. [3] While tremendous progress has been made in using computer modeling and simulation, there is room for improvements, as discussed below.

Design concepts for tunnel ventilation

Design Criteria. In order to evaluate the effectiveness of a ventilation system, there must be a basis or criteria to check for compliance. For normal conditions, the ventilation system should maintain acceptable environmental conditions for passengers and personnel as well as suitable operation of equipment and installations. In case of fire in a tunnel or in an underground station, the emergency ventilation system must be able to control the direction of movement of hot air and smoke form the fire to enable flexibility in establishing evacuation routes and points for fire department access.

Currently there are no international safety norms or standards applicable to subway ventilation systems. National standards are slowly emerging, yet there is no general consensus of their applicability, except common practice to have local procedures based on past experience and sometimes to learn from the experiences of other agencies or operators. In USA, the National Fire Protection Association (NFPA)

Standard 130 for *"Fixed Guideway Transit and Passenger Rail Systems"* is the most known safety standard applicable to rail tunnels and underground stations. [4]

In Europe, the EU Directive No.54/EC adopted by EC Parliament in April 2004 aims at ensuring a minimum level of safety for road tunnels in the Trans-European road network that are greater than 500 m in length, but not for rail tunnels. There are separate national standards, for example the German Guidelines for Tunnels RABT 2003, the Special Measures Act for Public Use of Deep Underground Tunnels in Japan (2005), and others.

Criteria for Emergency Conditions. Generally, emergency conditions result from a malfunction of the transit vehicle. The most serious emergency condition is a stopped train on fire in a tunnel, disrupting traffic and requiring passenger evacuation. The ventilation system must be capable of maintaining a safe evacuation path that is clear of smoke and hot gases. The *"Critical Velocity"* concept and computation has been developed based on observations during mine fires and on some small-scale modeling. Critical velocity is a site-specific value based on tunnel geometry, heat release rate, psychrometric conditions of air, and tunnel grade at the location of the fire. Two empirical formulas have been established and have been used for years as a measure of the adequacy of airflow to prevent backlayering of smoke when ventilating a tunnel fire. The simultaneous solution of equations (1) and (2), by iteration, determines critical velocity, which is the minimum steady-state velocity of the ventilation air moving toward the fire that is needed to prevent backlayering [5]:

$$V_C = K_1 K_g \left(\frac{gHq}{\rho c_p A T_f} \right)^{1/3} \quad (1)$$

$$T_f = \left(\frac{q}{\rho c_p A V_C} \right)^{1/3} + T \quad (2)$$

where

A = area perpendicular to the flow, ft^2 (m^2)
c_p= specific heat of air, Btu/lb·°R (kJ/(kg·°K)
g = acceleration caused by gravity, ft/s^2 (m/s^2)
H= height of duct or tunnel at the fire site, ft (m)
K_1 = 0.606
K_g = grade factor (see ASHRAE Handbook, Chapter 13, Figure 6)
q = heat that fire adds directly to air at the fire site, Btu/s (kW)
T = temperature of approach air, °R (°K)
T_f= average temperature of fire site gases, °R (°K)
V_C = critical velocity, ft/s (m/s)
ρ = average density of approach (upstream) air, lb/ft^3 (kg/m^3)

Evacuation routes must remain free of fire products of combustion (smoke, heat) for the duration of the evacuation, regardless of the fire condition. For this, sufficient mechanical ventilation must be provided to move smoke in the required direction to maintain acceptable conditions along a single evacuation route on one side of the fire. Acceptable conditions are defined as follows:

- Maximum temperature in the evacuation route below 60°C (ignoring radiant heating)
- Minimum air velocity in the evacuation path not less than the critical velocity to control the spread of smoke and hot gases from the fire into the evacuation path (prevent the backlayering).
- Maximum air velocity along the egress route should be less than 10 m/s.

For station fires the ventilation system should provide uncontaminated air along station entrances and non-pressurized emergency exits, with maximum air temperature less than 60°C.

<u>Criteria for Emergency Fans</u>. In USA NFPA Standard 130 requires that emergency fans be designed with redundant power supply, fully reversible and able to satisfy the following conditions:

- Fans, their motors, and all related components exposed to the ventilation airflow must withstand a temperature of 250°C for a period of at least one hour
- Local fan motor controllers should be separated from ventilation airflow by a one-hour fire-resistance-rated separation
- Airflow induced by emergency fans should meet critical velocity criteria in either supply or exhaust
- Discharge and supply air openings to the fans should be at a sufficient distance apart or other measures should be taken to prevent recirculation of contaminated air
- Operation and fail-safe verification of fans should be provided at a central supervisory station, with indication provided for all modes of fan operation for each fan as well as from local control points
- Local controls should be provided at the fan location for complete fan operation.

<u>Criteria for Normal Operation</u>. An operation is considered "normal" when trains are moving through the system according to schedule and when passengers are traveling smoothly through the station to and from transit vehicles. Since this is the predominant mode of operation, considerable effort is required and justified to assess the impacts of train movement on the station environment and to determine the requirements, if any, of a station Environmental Control System (ECS).

<u>Tunnel Conditions</u>. Maximum temperatures are defined by equipment manufacturers for operating limitations. Here are some examples:

- The vehicle air conditioning system can operate at its design capacity when the condenser air inlet temperature is less than or equal to 45°C
- Other system-wide and facilities equipment in the tunnel can operate safely at temperatures up to 45°C without a decrease in efficiency and can operate for short periods at temperatures up to 52°C.

Ventilation Design Concepts for New Subway Systems. Implementation of the ventilation system for new subways varies from country to country, and sometimes from city to city. The most effective ventilation system in tunnels would be a transverse system which would allow smoke removal close to the source, thus allowing the passengers to escape safely along the tunnel in both directions in case of a fire. Such a system, however, is very expensive since it involves the installation of extract ducting in the crown of the tunnel and, consequently, enlargement of the tunnel cross sectional area. The longitudinal system where the smoke is driven along the tunnel, away from fire and from passengers, thus enabling them to escape into the oncoming fresh air flow, is much less expensive. [6] In order to design a ventilation system capable of moving air in the most convenient direction to protect passengers and provide access for fire-fighters, the following concepts and design options are most common:

Station fan shafts. In this concept, fan plants are attached to the station, most often at the end of the platform, or 10 to 20 m inside the tunnel. The shafts are designed to operate as blast/relief vents during normal operation (to alleviate the pressure of the incoming trains) and also as fan shafts (by closing the dampers on the relief section of the shaft). This system is popular in North America as well as for newer subways in Western Europe and Asia.

There are, however, systems where fan plants are located in the station and connect to the platform through ducts, often with air distribution along the entire platform (Russia and Eastern Europe).

Mid-tunnel fan shafts. This concept applies mainly where the distance between stations is long, reducing the efficiency of station fans in case of an emergency in the middle of the tunnel. This system is common in Russian and Eastern European subways, as well as in Canada (Toronto).

Combination of station and mid-tunnel fans. This system has significant advantages compared with the others, but its main disadvantage is the higher cost. However, for new subway systems or extensions to existing systems, the additional costs for the inclusion of such dedicated emergency ventilation systems can be justified (example, San Francisco BART Extension to the Airport).

Passive vents (with and without dampers). The oldest subways were designed and built with natural ventilation consisting of bays of vents connecting the tunnels and stations to the ambient at street level. Train movement causes the air to move in and out *("piston-effect")*, producing the necessary air changes and controlling the heat. While suitable for normal operation of trains, this system provides no means of controlling the smoke and heat in case of a major fire in tunnels or in stations. Some newer systems have vents equipped with dampers (Chicago), designed to be closed when emergency fans are operated. This concept has certain advantages, but the operation may be unsure and the maintenance expensive.

In-line or jet fans. This concept is often used in vehicular tunnels, but local application is possible in rail tunnels as well. The jet fans act like booster fans to enhance the air velocity at the desired location. The main disadvantage is the requirement for additional space in the tunnel, and consequently larger cross sectional areas. Another disadvantage is the fact that the fans can be in the fire zone and exposed to high temperatures which may make them inoperable when needed most. Local impulse (booster) fans are sometimes used to supplement the main emergency axial fans (examples, TKO Line in Hong Kong, new Marina Line in Singapore).

Portal doors. These are devices that can be of crucial importance and use in case of a fire close to the portal and when the required ventilation is downgrade, against the buoyancy of the hot air and smoke resulting from the fire. Interlocked with fan operation, the doors will allow the control of smoke and provide for a safe evacuation. Doors are made of collapsible metal sheet or another material that will not damage the train in case of an undesired activation. Applications of this system are in BART's Berkeley Hills Tunnels and in Toronto subways.

Air barriers. This is a new concept to enhance the operation of emergency fans and restrict the air flow at pre-established locations. The devices act like air curtains in mines, except that they are deployed by a mechanism which interlocks with the emergency fans only in emergencies. During normal operation the un-deployed air barriers allow trains to pass without any restrictions or speed limitations. Still in the experimental stage, these devices have been successfully tested in the Washington subway, however, not yet implemented.

Platform edge doors in stations (PSD) is probably the most recent innovation in transit, affecting the subway ventilation system design. A thin wall with doors along the entire platform isolates the tunnel from public areas. When the train arrives and stops, the platform edge doors open at the same time the train car doors open; before the train leaves the station, the doors close. The new Meteor Line in Paris, Lille Metro, Jubilee Line in London, as well as metros in Hong Kong, Singapore and Bangkok are equipped with PSD a system, which is gaining in popularity, particularly where the stations are designed with an ECS.

New Concepts. Other innovations in subway safety which have been tested in the Hong Kong subway consist of pedestrian cross-passages in tunnels, a hard wire telephone and radio communications system linked to the control center, video equipment installed at each station and monitored from the central control room, providing vital information on environmental conditions.

New subways under construction or on the drawing board provide for the installation of heat, smoke or gas sensors in the tunnels in order to detect a fire and its precise location and to transmit the information directly to the central control room. Some of these sensors will be monitored continuously (Los Angeles Metro).

Of particular interest is the design of the ventilation system for the recently built Channel Tunnel, connecting England to France, which started operation in 1994. It is an updated replica of the BART Transbay Tube's system between Oakland and San Francisco. Two ventilation systems have been installed: one for normal operations, the other for emergencies, particularly those requiring the control of smoke. [7] The normal ventilation system supplies air to the running tunnels through air distribution units located above selected cross-passage doors, service tunnel and cross-passages by means of a ventilation plant located on each coast.

For emergency and in order to control the smoke in a desired direction, two pairs of axial fans in parallel are located at coastal sites, near to each end of the tunnel.

The air flow can be modified or reversed by varying the blade pitch, thus avoiding loss of control of air movement which would be caused by reversing the motor direction.

Fire suppression in tunnels. Although not widely accepted, wet suppression systems are under consideration in a number of countries, particularly Australia and Japan, with a few tunnels in United States and several in Europe. There are various types of installations for fire suppression, such as sprinklers (wet or dry), hydrants at regular intervals, deluge systems (open nozzles for dispersion over a set area such as transit stations to extinguish train fires), water curtain/screen or water mist (low or high pressure), etc.

Tests conducted in Europe with water mist suggest a reduction of 40-70% in heat for a 10 to 22 MW fire size range, but not much impact for fires smaller than 5 MW. It was found out that the effect of water mist spray is strongly dependent upon type and location of nozzle and water discharge rate. A rapid reduction in downstream temperature was noted, while the smoke backlayering effect was reduced significantly due to the cooling effect of the mist. On the other hand, the visibility near fire was reduced significantly due to increased steam generation. [8]

Ventilation System Upgrade for Existing Subways. Public's perception of safety in general coupled with the competition from other public transportation systems make it necessary to look for feasible alternatives to upgrade the subway ventilation system for safe evacuation of passengers in case of fires underground. The cost of upgrading the ventilation system to the level required by the current safety standards might be prohibitive due to disruption in service, acquisition of suitable land in built-up areas, congestion of the ground with utilities, etc. Alternative approaches to improving the existing ventilation system and the optimization of safety/evacuation procedures might be the only option in some cases. Possible alternatives that are being considered by several transit agencies encompass one or more of the following options:

- Larger fans at existing locations, which applies to systems with mechanical ventilation but of inadequate capacity
- Platform access doors, to be controlled in case of fire emergency
- Platform edge doors
- Jet fans in tunnels or stations
- Cross-passage fans
- Cross-passage blocking with doors
- Air barriers
- Portal closure (roll-up, train passable).

Several subway systems are currently upgrading their ventilation systems or studying available alternatives: London Underground, New York City Transit, Chicago Transit Authority, Boston's MBTA, Bucharest, Buenos Aires's Metrovias, Toronto Transit Commission and others. [9]

Special issues in tunnel ventilation

Research and Development - Fire Tests. Several research and development programs, including real fire tests have been conducted during the recent years in

Europe, U. S. A., and Japan. In the early 1990s, the Eureka 499 EUROTUN project included tunnel fire tests in an access tunnel to a copper mine in North Norway. A series of tunnel fires was carried out in a gallery on the Health and Safety Laboratory test site at Buxton, U.K., using a range of fire sizes from 0.15 MW to over 4 MW and various fire dispositions. STUVA and ARSENAL research centers in Germany and Austria, respectively, as well as Fire Research Station in U.K. have been actively involved in numerous studies related to tunnel ventilation and safety, mainly for railways.

In the United States, the Memorial Tunnel Fire Ventilation Test Program consisted of a series of full-scale fire tests conducted in an abandoned road tunnel, 853 m long, and having a 3.2% grade, situated in West Virginia. Various tunnel ventilation systems and configurations were operated from 1993 to 1995 to evaluate the smoke and temperature management capabilities of these systems. The tests generated a significant database for the design and operation of ventilation systems mainly for road tunnels, but with relevant information for vehicular tunnels as well. The tests goals and scope were formulated by the Technical Committee 5.9 of ASHRAE. [10]

The tunnel was equipped with instrumentation and recording equipment, including sensors measuring air velocity, temperature, CO, and CO_2. Smoke generation and movement and the resulting effect on visibility was assessed using seven remotely controlled. television cameras. Fires of 10, 20, 50, and 100 MW were generated, and systematic variations were made in airflow quantity, longitudinal air velocity near the fires, and fan response time for each ventilation system tested. A total of 98 fire tests were conducted, using various smoke management strategies and combinations of strategies, including extraction, transport, control direction of movement, and dilution to achieve the goals of offsetting buoyancy and external atmospheric conditions and to prevent backlayering.

Software for Tunnel Ventilation System Design. There are various computer programs available for tunnel ventilation in general, including some with special features for subway tunnels. Probably the most used software for this application is the *Subway Environment Simulation* computer program (SES), which has been used for almost two decades to simulate tunnel fires and to predict the airflow to the incident train using one-dimensional flow simulation. The SES model can be used to simulate air, heat, and moisture flow within a subway system. [11, 12] The simulation includes ambient conditions, train piston effects, fan operation, buoyancy effects, heat dissipation and exchange, etc. It is intended primarily for short-term simulations with results available second-by-second or as a summary for any selected time interval. A simple comparison between the SES predicted airflow and the required critical velocity at the fire location allows a rapid assessment of ventilation adequacy.

The SES is inappropriate, however, when the incident train is stopped at a station platform or across secondary airways like cross-passages, vents or fan shaft connections. Three-dimensional software is required for fire simulation in such stations where the air flow is three-dimensional in nature and turbulent. Such software involves repetitive calculations of three-dimensional fluid dynamics and thermodynamic equations and is, therefore, called *Computational Fluid Dynamics.* There are various software packages based on CFD techniques for simulating the movement, temperature, and composition of fire products and for analyzing the three-dimensional behavior of heat and airflow in a subway station during fire conditions. The simulation results provide air velocities, temperatures, pressures, and relative concentrations of products of combustion. Simulation results can be presented numerically and graphically as colored contours or vectors in any selected sections that cut through the station.

ARGOS, a computer program developed by the Danish Institute of Fire Technology, is used to calculate fire, smoke, and heat development in the tunnel, as well as evacuation times for people. The program simulates smoke and includes optical smoke density under certain conditions. The temperature in various smoke layers, as well as heat radiation from the hot smoke layer as a function of time, is predicted. The program is said to be capable of producing a more realistic portrayal of the smoke patterns in the tunnel (visualization), and to give an indication of the reduction in visibility that follows the fire outbreak.

There are several programs (SIMULEX, STEPS, EXODUS) that have the capability to animate the evacuation process and identify, in a "*virtual reality*" environment, potential areas where bottlenecks might occur. The effects of modifying the exit routes can be evaluated efficiently, allowing the program to dynamically model the changing tenability of the environment in case of a fire.

Professional Associations and Organizations. ASHRAE's Technical Committee 5.9 Enclosed Vehicular Facilities consists of ventilation professionals from North America and some international corresponding members. The committee meets twice a year in formal meetings and is responsible for the specialized section of the society's handbook. Seminars, symposiums, and forums on tunnel ventilation are organized mostly during society's winter meetings.

The American Public Transportation Association (APTA) has a Forum on tunnel ventilation, as part of its structure. Annually, during the Rail Conference, the forum organizes one or two seminars on tunnel ventilation, open for papers from around the world.

The NFPA 130 Technical Committee is in charge of the Fixed Guideway Standard 130, providing continuous review and update of this standard and making recommendations for inclusion of new safety norms.

Specialized international conferences on tunnel ventilation and other safety-related topics are organized at regular intervals by the British Hydromechanics Research Group (BHRG) and Tunnel Management International (TMI) (formerly Independent Technical Conferences) of the U.K. Occasional technical meetings are organized by the European research projects ARSENAL, STUVA, CETU (France), British Rail, and Fire Research Station, as well as by Universities (Graz, Ljubljana).

Conclusions

There is a continuous need for more and safe mass transit systems and the public awareness for comfort and safety require attention from operators and designers alike, worldwide.

Computer modeling (SES and CFD) techniques present real advantages by providing the capability to predict what happens during a fire, showing the spread of smoke and heat in all dimensions, thus enabling development of meaningful evacuation and fire-fighting plans in large and complex subsurface structures. When considering the benefits and costs associated with these relatively new tools, both designers and operators should examine not only their applicability but also the benefits and advantages over other methods.

The CFD modeling technique presents clear advantages over single-dimensional software, as it provides the capability to predict what happens during a fire, showing the spread of smoke and heat in all three dimensions, thus enabling the development of meaningful evacuation and fire-fighting plans in complex subsurface structures, such as stations.

Recent progress in presenting simulation results includes animation (*virtual reality*) that provides a means of creating computer representations simulating the real world. A virtual reality user can "walk-through" the environment at will, can pass through walls to see what lies behind or take a bird's-eye view of the complete field, such as in an evacuation situation.

In conclusion, it is the author's opinion that there is no single method to provide protection to passengers and to avoid material damages, but a combination of prevention techniques and use of mechanical emergency ventilation systems are becoming the norm. The reality is that passengers expect the transit system they use to be safe and, in case of accidents (such as fires), there may be investigations and possible lawsuits for compensation.

Due to the global economy and increasing worldwide tourism, multi-nationals may be involved in both design and construction of subways in other countries as well as in becoming victims of a tunnel fire in a foreign land. Consequently, international law becomes more and more applicable to transportation projects all over the world.

References

[1]. Miclea, P.: "*Current Concepts, Safety Criteria and Technical Approach in Tunnel Ventilation*", 6th International Symposium on Tunnel Construction and Underground Structures, Ljubljana, September 2002.

[2]. Bopp, R. et al. "*Rescue Stations in Long Railway Tunnels Concepts for the Planned Alptransit Base Tunnels Through the Swiss Alps,*" Proceedings of the 1st International Tunnel Incident Management Conference, ITC, May 1996, Korsør, Denmark.

[3]. *American Society of Heating and Air Conditioning Engineers (*ASHRAE), Applications Handbook, Chapter 13 Enclosed Vehicular Facilities, 2007.

[4]. NFPA, 2006 "*Fixed Guideway Transit and Passenger Rail Systems*," Standard ANSI/NFPA 130.

[5]. McKinney, D., Miclea, P., Brunner, D. "*Critical Velocity of Air versus Computational Fluid Dynamics Modeling*" American Public Transit Association (APTA) Rapid Transit Conference, Sacramento, 1994.
[6]. Miclea, P., "*Do we Really Need Emergency Tunnel Ventilation?*", Proceedings of the 4th International Conference on *Safety in Road and Rail Tunnels*, Madrid, Spain, April 2001.
[7]. Morris, Richard "*Safety in Eurotunnel*," Proceedings of the 2nd International Conference on Safety in Road and Rail Tunnels, ITC, April 1995, ITC, Granada, Spain.
[8]. Miclea, P. and Duckworth, I.: "*Current trends in fire detection, instrumentation and suppression in rail and road tunnels - A Pre-Requisite for Effective Emergency Response*" International Conference on Tunnel Safety for Road and Rail, Nice April 2007.
[9]. Miclea, P., McKinney, D., Brunner, D. "*Lessons Learned in Using the Computational Fluid Dynamic Technique in Tunnel Fire Simulation*," Proceedings of the Safety in Road and Rail Tunnels, Granada, Spain, 1995.
[10]. Bechtel/Parsons Brinckerhoff, "*Memorial Tunnel Fire Ventilation Test Program, Final Report.*", 1995.
[11]. *US Department of Transportation, National Transportation Systems Center: Subway Environment Simulation (SES) Computer Program*, Version 4.1, User's Manual, prepared by Parsons Brinckerhoff, Quade & Douglas and Earth Tech, Inc., 2002.
[12]. Miclea, Paul C. et al. "*Towards a User Friendly SES Computer Program*," American Public Transit Association (APTA) Rapid Transit Conference, Sacramento, 1994.

CONCEPT AND STRATEGY OF DURABLE DEVELOPMENT – IMPERATIVE OF ECONOMICAL GROWTH AND NONINDUSTRIAL REORGANIZATION AFFECTED AREAS

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Abstract: Locally and regionally, through closure of large factories and economy reorganization, the affected areas' development and rehabilitation strategies have as mutual approach principle, the analyze of the problems to be resolved, the definition of the objectives and policies to follow, the identification of actions to attack the problems and foresee the mechanisms which will aloud the control of achieved progresses.

Key words: monoindustrial areas, rehabilitation, durable development, action plan

1. Introduction

In the framework of what is implemented through the "ecosystem – efficiency" dualism, the durable development implies the care of human potential towards the present and future situation of its natural, energetically, material and informational resources. As an effect of its responsibilities for the next generations, the efficient utilization of resources implies, in the same time, the working of a durable economy to satisfy the actual requirements of the human society.

Within the work it is presented the durable development concept, are treated some of the representative criteria and principles of the society durable development strategy, and are defined the components and objectives of the local and regional

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development strategy of the non industrial areas affected by reorganization.

2. The concept of durable development (CDD)

In the vision of most of the specialists, the success of durable development of a society is given by the present and future way of handling its natural, energetically, material and informational resources, related to economical growth objectives and assurance of a high quality of life and environment [1], [4], [5].

In the Report of the World Commission on Environment and Development, durable development (DD) was defined as "*a way of development, which responds to present's needs, without compromise the capacity of the next generations to satisfy theirs too*".

In other words, one can appreciate that most human entities are taking in consideration the realization of economical development to assure the reintegration/rehabilitation of the areas in the economical circuit and the growth of life quality, as well for themselves, as well as for the next generations. The unification of these aspirations represents, in deed, the nucleus of durable development concept and it is defined through "*ecosystem – efficiency*" dualism. Therefore, there is appreciated that economical development has as its purpose, beside satisfying the basic material needs, a better co-operation between environment protection interested factors too, in the context of affiliation to the coordinates of European available environment directives and normative.

On principle, a durable development presumes the accomplishing of certain set of conditions, among:

- the necessity of learning to cohabitate according as starting material limits and wastes recycling, seeing that emphatic and uncontrolled environment degradation, can have disastrous repercussions on present and surely future life;
- the necessity of biologic diversity preservation and environment quality.

In the sense of durable development, it is considered that fulfilling of necessary conditions for equal access to the base of resources by each of the next generations; presume autonomy and self-regenerativeness based reasonableness, namely a holistic view over development, participation in a pro-active way to local condition and diversity capitalization, with effect on life quality growth and assurance.

A key concept used to describe the durable development criteria; it is represented by preservation, which usually refers to species abundance and diversity, ecological diversity, important genes reserves and habitat.

In various reports of international forums there are enclosed serial conditions and criteria of durable development, among attention is restrained by humanism and life quality high sustentation, reasonable distribution of wealth and resources, with maintenance of a continuous access to natural resources, preservation of biologic diversity in environment quality.

It is noteworthy the signification of the two terms that signify the concept of Durable Development, distinct [2]:

- *development*, as source of diversification and growth of activities with profit getting for society;
- *durable*, as assurance of activities agelessness into an economical environment, often aggressive in a perpetuate change.

3. Principals and criteria of durable development

Globally, strategic and operational management of durable development presumes, beside assignation of short, medium and long term objectives, the application of a principles and criteria set, among [1], [5]:

- *integrate management*, which presume unitary and holistic approach of production, processing, transportation, depositing and utilization processes, considering life cycle of products and technologies, inter-institutional coordination and synergies for most efficient resources usage;
- *inter-generational reasonableness*, as request according whom present generation is entitled to use an beneficiate by earth resources, with obligation to consider the long-time effect for the next generation;
- *life cycle approach* of products, services and technologies, principle according whom there are evaluated environment consequences, as an effect of economical activities in extraction/processing (execution) and capitalization/commercialization stage of products on free market;
- *substitution*, which presume the replacement of certain products, services and inefficient technologies, great power and environment resources consumers, with anothers more modern and efficient, whose economical impact is greater, and ecological impact is lower and more harmless to life;
- *negative externalities internalization*, or the principle „*polluter pays*”, wherethrough are settling and implementing market mechanisms for totally appropriation by the polluter of activity social and environmental costs, having the possibility of reflection of these costs in the prices and tariffs of goods and effected;
- *positive externalities internalization*, wherethrough there is certified the use of a corrective subventions system, as well as stimulants for the activities that generates marginal benefits to third parties, without them pay for its (research-development, education, regional development, etc.);
- *public – private partnership*, which is based on direct cooperation between parties such as public authorities, institutions, ONG-s, enterprises, and industrial consortium, business networks and businessman, who together can obtain, through self experience and efficiency, a superior added value concerning macro and micro economical growth.

Globally there are regional/sectorial approaches too concerning durable development criteria and principles form its resources point of view.

Next there are presented, for examples, the content, principles and objectives of such a local and regional durable development strategy.

4. Components, principals and objectives of the local and regional durable development strategies

As a working frame for a local action, a development strategy can substitute a certain number of forms, in each case being necessary the analyze approach of areas problems, its possibilities, means and its resources. It defines a scheduled approach of economical development, the success for touching the proposed goals being directly influenced by decision factors attitudes towards the region or specific area perspectives of development.

Form composing elements point of view, a local and regional development strategy contains six components, whose description and characteristics are presented in the following [3].

a) Analyze of problems – a strategy component wherethrough are putted in discussion the forte and week points of local economy, as well as the problems that have to be handled by local businesses and.

To know the area and its importance, in the context of development, there are imposing to be treasured location data and context form resources and actual socio-economical environment point of view:

- area position according to great road axis, railways airports and sea ports;
- natural resources concerning soil (landscape, environment, history, climate, touring possibilities, forests, grass-lands, etc.) and underground (carrier beds, mineral waters);
- the existence of available lands and constructions for future business/enterprises "housing", seeing the imposed by these creation and development on spaces quality exigency;
- infrastructure, with special interest on local transportation and communication, telecommunication and public services of power and thermal energy distribution, as well as identification of those development possibilities in the;
- life quality (living conditions, public health, incomes, education, culture, etc.), with possibilities on reflecting and promoting of new jobs, technological transfer and innovative spirit, emigration and internal stability.

Form business analyze point of view, a great importance has to be given to IMM segment belonging to agriculture, environment rehabilitation, manufacturer and services activity, the information technology and natural, energetically and material resources exploitation and capitalization sectors.

In case of local population analyze, there have to be identified a number of participant factors to area and jobs development, distinct:

- demography ,
- places of employment,
- unemployment,
- qualification,
- training/education and professional training,
- social situation.

About work market and its implication in economy rehabilitation and jobs development, presently there are offered different efficient ways of analyze the problems to be approached incorporately by a local development strategy, distinct:

- local population and work market;
- relations between occupation and unemployment;
- unemployment vulnerability of some „risk groups”;
- training and professional reconversion;
- youth's and transaction from school to work market problem.

b) Information over existing activities, as the second component of the strategy, presume activities efficiency examination, the role of local organizes, development activities management, as well as interact relationships between interested organizations.

Form this point of view, the first elevation switched out by the strategy has to be towards a commune vision and a tight cooperation between local implicated organisms. The current actions will have to be consolidated, all development activities to be identified and monitored, and existent organisms to be encouraged to cover activities deficit.

The key factors considered as trumps, weaknesses, opportunities and risks in strategy implementation are as follows:

- attitudes and influences of local and regional public powers;
- coordination and inventory;
- people life quality form the area;
- localization of the area relating to European high developed areas;
- available lands and buildings, as well as locations for IMM sector, as well as for high technologies;
- image, as an area brand for local population, related to external people;
- working hand, as volume (quantity) and quality;
- inventory competences and working hand training;
- finance and resources, with sustain and development possibilities analyze of private sector;
- industry situation concerning capability, will of innovation and diversification, industrial basis and.

c) Resources, as a component of strategy consists in examination of financial, human and physical resources available in the referred area, for economical development and new jobs creation.

The analyze of financial resources presumes the identification of strategy potential financial price that is to be implemented, in the context of settling resources necessary to cover all new categories of personal, equipment, installation and components relative expenses, which subsequently will make the object of an evaluation casting. The origin of financial resources will represent, in a large measure, the funds came from government defined and financed programs, and if the areas are fitting, the funds can come form EU. Local public powers can contribute with money, clients and local suppliers by sub-rental.

Human resources, equipment and buildings can be identified in private sector, whose firms can also, contribute financial to specific rehabilitation and development projects.

d) The definition of the objects and policies to be followed, as a necessary stage to strategy implementation, has the purpose to define the specific objects and necessary to adopt policies for its accomplishment.

The objectives will have to clearly refer to identified difficulties and opportunities. They must be specified and realistic, to reflect the reservations, assurances and priorities of involved organisms, them representing, in deed, the motor of all activities and resources within the strategy.

From main objectives of an economical rehabilitation and jobs development strategy, there can be accentuated:

- continuous development of created number of places of employment;
- amelioration of area qualification basis;
- keeping and amelioration of life quality;
- amelioration of the possibilities and incomes of specifics groups;
- diversification and consolidation of determined economical sectors;
- amelioration of area infrastructure.

Main adopted policies to objectives accomplishment are:

- local economy support and external investments attraction;
- IMM sector encouraging and concentration over those accentuated through an actual growth potential;
- population employment improvement and specific temporary measures for reducing the unemployment rate

e) The action plans, wherethrough are coordinated the projects, represent a practical description of activities to be done to resolve the specific problems, or to benefit of intervening effects.

Usually, the action plans content include the following priority action categories:

- integrate actions, as unique project, which provide several services, such as places of employment, financial support, advices and consultancy for IMM;
- specific actions, as great projects, which contain the rehabilitation through reconvention and revigoration of an area or sector of a big city;
- creation of an European dimension of all actions, pointing the importance of European market and, in certain cases, influence of law and EU's legislations;
- development of a specific research segment, which can be referred to any aspect of local economy or working force market.

Each action of the plan has to contain a basis data report, directive lines of the designed action, cost of action and necessary personnel to accomplish to action and calendar.

This case, strategy appliance has to be characterized by creativity and empowerment elements, which can be found in industrial and commercial sectors, and succeed best in economical community of the area.

f) Control and evaluation, as the 5-th component of the development strategy, should serve, objectively, to obtain more information on followed policies effects and undertaken actions.

Through a quality control and evaluation it is important to view the tendencies, changes and development perspectives of the referred area. Practically, there are important the following prognoses:

- for private sector, ones interest the places of employment, new markets, new products and services, market segment, education and rehabilitation;
- for persons, it is following the evaluation of unemployment diminution measures, education development and employment alternatives growth;
- for external firms, ones interest, expressly, the reparation and analyzing of associated advantages of an area implantation;
- in local institution's case, there are necessary to control and evaluate the measures of creation of new arrangements and services, the growth of available spaces and uses at the end of employment, as well as alternative activities growth rhythm;
- for area, in its whole, ones interest the way of prestige re-capitalization application measures, as well as the growth ones of trust and development propitious climate.

4. Conclusions

The re-updating and implementation of certain Romanian sectorial and sub-sectorial strategies, which to participate to sustainable economical growth, it is more and more imposed lately, those having to handle, supplementary, to environment more and more pregnant changes redounded over society. For the success of the strategy, will be clearly need to settle the government responsibilities, democracy improvement, citizens strong consciousness, new institutional reorganization for consolidation and support of interdisciplinary researches, science-men and citizens implication in priorities settlement, creation of new scientific knowledge, possible effects evaluation and theirs practical implementation.

Bibliography:

[1]. Gherasim, Z., *Influențele tehnologiilor informației şi ale comunicațiilor asupra dezvoltării durabile.* Buletinul AGIR, Dezvoltarea Durabilă, Bucureşti, Anul VII, nr. 4, octombrie – decembrie 2002.

[2]. Masalar, L., Bucur, M., *Imperativul şi responsabilitatea socială şi societală a întreprinderilor economice în contextul conceptului de dezvoltare durabilă.* Buletinul AGIR, Creşterea eficienței şi utilizării resurselor, Bucureşti, Anul XII, nr. 1, ianuarie – martie 2007.

[3]. Pleşea, V., *Reabilitarea zonelor miniere după lichidarea activității productive.* Editura UNIVERSITAS, Petroşani, 2005.

[4]. Swanson, D., Pinter, L., s.a., *National Strategy for Sustainable Development. Challenges, Approaches and Innovation in Strategic and Coordinated Action.* Unigraphics Winniny, Manitofa, 2004.

[5]. Zaman, Ghe., Gherasim, Z., *Criterii şi principii ale dezvoltării durabile din punctul de vedere al resurselor acesteia.* Buletinul AGIR, Creşterea eficienței şi utilizării resurselor, Bucureşti, Anul XII, nr. 1, ianuarie – martie 2007.
[6]. * * *, *The EFQM Framework for Corporate Social Responsibility,* 2004.

INNOVATION – DIVERSIFICATION PROCESS IN THE DEVELOPMENT OF THE ECONOMIC ACTIVITIES IN THE REORGANIZATED MONO-INDUSTRIAL AREAS

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Abstract: The introduction of new innovative technologies, products and process it's fundamental for diversification and development of new economic activities and creating of new working places. Without these changes the transition between traditional basic industry and new industries that will constitute the fundament of future local and regional economies can not be possible. That's way, today it has to be introduced a new vision over economical diversification and growth, through consideration of innovation and knowledge as strategic factors of development.

1. Introduction

During this work there are made referents and estimation over the innovative process concept, there are described the objectives and actions necessary to be done for promotion and timbering of new technologies and innovations in the view of economical development of a new area or region with mono-industrial character.

In the case of the mono-industrial areas affected by the reorganization, the introduction of the innovating processes is essential for the economical rehabilitation and for developing of new jobs without it cannot be possible the replacement of the traditional industries with the new ones which will constitute the base of the future local and regional economy.

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As a process, the innovation is the main element in economical maintaining and development only in the condition of integration of the science and technology integration in a economic activity.

The implementation of the innovating processes by promoting the technologies and by using of them by the industrial units are essential key elements for encouraging and maintain of the industrial unit's competitively and for reorganization of the industrial areas, particularly the mono-industrial ones, the older ones. In this area the main targets of the local initiatives designated for development and implicitly for new job creation are the middle and little enterprises (the IMM's).

The target objective by developing and adopting new technologies is to ameliorate the existent qualifications and to introduce new qualifications due to the area's economic specifics [3], [4], [6].

The local rehabilitee politics success by promoting the innovative processes must not be understood as a process based by an immediate jobs creation. Actually, the new technologies can compromise the existing jobs, but through an adopted policy at a local level and by a working force reconviction can be fundament some long term objectives considerate as a part from a global strategy designated to the structural economy problems of the area.

In this work are made references and estimations over the innovative process concept and are presented the required actions for promoting and sustaining for rehabilitation and the economic development of certain area or region with an mono-industrial character.

2. The innovation process – definition, concept and promotion initiatives

Innovation is the process by which new products and new systems are integrated in the economy and put on the market. This goal is touched through some series of measures referring to technologies, financial administration, conception, production and marketing. As a product of the innovation process, the innovation is not associated with the newest technologies. Usually, the best innovations are often the simplest.

A classical definition for innovation, largely accepted, shows that **„Innovation includes all the scientific, technical, organizationally and financial measures for ensuring the success of accomplishing, developing and marketing of the materials and new products or improved ones, of the new or improved procedures or for introducing and applying of a new social service"** [6], [7].

As a process, the innovation represents the activity which includes the research-designing, production and distribution as main stages in a interaction system, with shifts between the various functions and different participants of which experiments, knowledge and capabilities are enriched and results in new and innovative knowledge in the economic and social domain (fig. 1).

As a result, the innovation is materialized in a new product, procedure or a social service, respective a new type of activity organization (fig. 2).

The difference between those two types of innovation is not only a theoretical problem, this can explain the existing distance in the favors of the U.S. of A. where the firm and governmental policies are materialized on the product innovation, as in Europe the main objective is the process innovation.

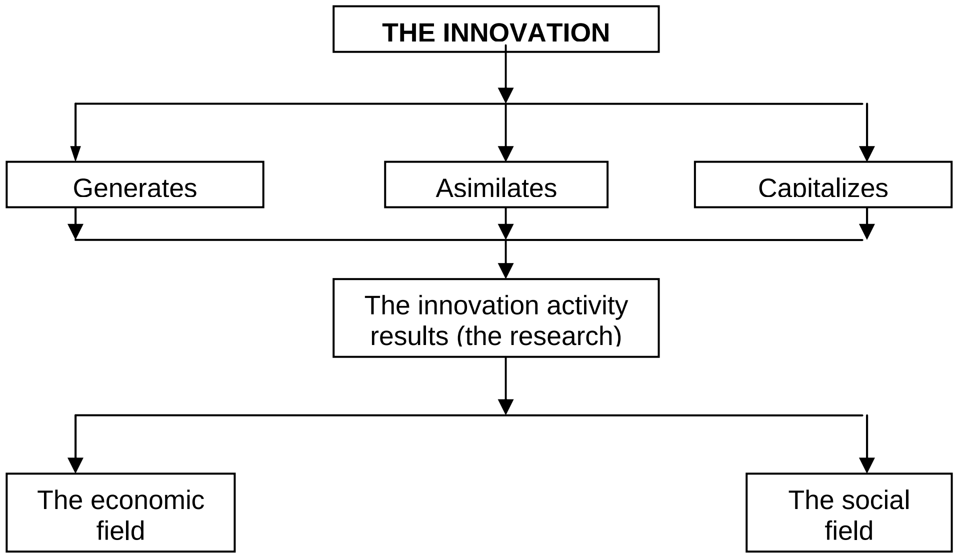

Fig. 1. The innovation function as a process

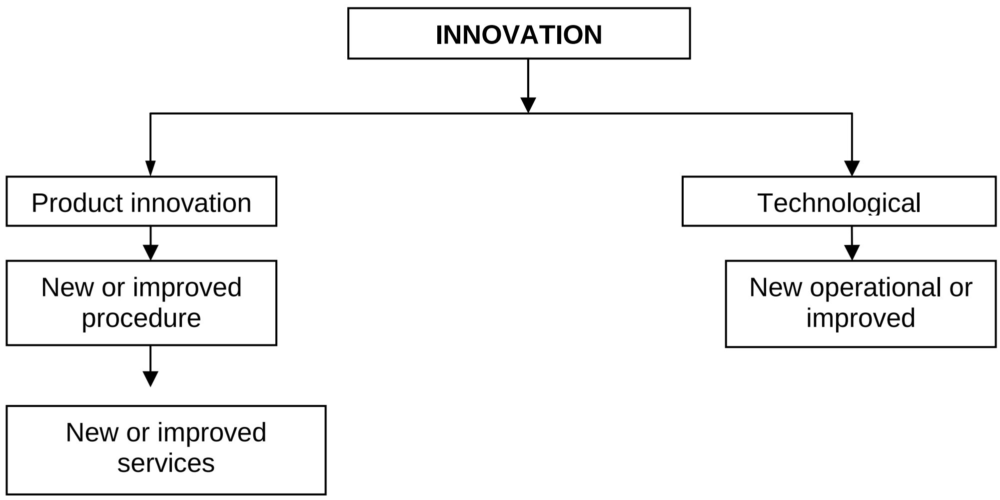

Fig. 2. The functions of the innovation as a result

A main characteristic of the innovation process is **its cumulative nature.** In the most cases a innovation generates another, though the states which successfully developed innovation policies will have, most of the time, future high development performances [7].

The innovation is **a complex integrator process**, which is meet in all evolution stages of a certain process or product, from idea to market.

The innovation needs an favorable environment for thriving. The research-development activity (RD) is a component of the innovation process, as a source of innovative ideas or for solving some problems that may occur in any stage of this process. The role of this activity is to obtain a significant novelty element or to eliminate or to clarify some scientific and technological uncertainties in problems in which the solution is unknown or obvious.

As a physical environment of the innovation, **the technological nurseries** allow the urge of certain types of enterprises with advance technologies to establish in the rehabilitation area. As a local initiative associated to this kind of approaching of the problem, **the scientific park** constitutes the most known type. So, knowing the implication level of the research institutes and universities in favoring the connections between the scientific research and the commercial innovation, the main idea of this type of initiative is that the research institutes and the higher education entities contain a larger knowledge package and unused working modalities or used on a small scale, which can help the local industry, and that the enterprises which prove difficulties in financing the internal develop may record profit from the series connection with the existing scientific community.

By succession, the scientific parks and other alternatives of this kind can be considered as "vehicles" of promoting the development on a long term of the local economy due to the diversification in the new technological fields of interest.

The linear pattern "research – technology – market or „idea – invention – innovation – market had dominated for almost three decades the way of thinking in the science and technology field of interest.

In this pattern the developing and the production of new technologies were **sequential processes** which had their origins in the research activity.

In those days the innovation process is characterized by permanent interactions and feed-backs. The new economic realities were reflected in a theoretical plan by a transition from the linear pattern conception of the innovation to the interactive patterns, although known as "the linking chains" [5], [6].

After an over half century evolution it is considered that the innovation process has a dual nature – loop and chain, which have an special impact over the politics and developing strategies elaborated for the real economy, once with those transition from a firm level to a local, regional and national level.

Today, the necessity of innovation for developing is motivated by:

- non-concordance between the system heritages in 1990 and the world evolution (national);
- the appearance of a concurrencies economy;

- the necessity of reorganization in the condition of a lost market;
- the alteration of the economic system and of the property configuration;
- technical problems generated by the new technologies and products.

In the mono-industrial areas and in Romania in general, the “technological competence” is low in certain industrial sectors.

In the vision of EU countries, the innovation defines:

- the informational society;
- the youth’ professional qualification;
- the technological research and development;
- the telecommunications;
- the audio-visual;
- the culture.

In the E.U. acceptation, a society value system is defined by the working force qualification and by the technological level. As for examples, it is argued that qualified men will bring a contribution to the PIB with 6 times bigger than an unqualified men and the education, by its capability to spread the required knowledge for qualification contributes with 25% more for the increasing of the PIB than the research.

3. Objectives, functions and implementing actions

The innovation objectives are [5], [6], [7]:

- the acceleration of the economical increase;
- the increase of the competition;
- the creativity stimulation;
- the increase of the thinking effort;
- the increase of the products and services value;
- the application of the economy developing strategy.

As a element of the modern economic development, the innovation has several function as follows:

- the dissemination (the spreading) of the scientific, technical and economic culture;
- the upholding of the idea transformation into commercial products creation ideas;
- the develop of the enterprising spirit and the facilitation of the technological and competence transfer between the research and industry;
- the facilitation of creating of innovative enterprises and their development;
- the upholding of the economic and social web into modernization.

As measures for accomplishing the innovation objectives are distinguished:

- a good coordination of the activities, programs and R-D strategies on different socio-economic levels;
- adequate financing support;
- operational transfer mechanisms of the research results;

• the R-D investment promotion, especial in priority domains, as: energy, environment, health, communication environment;

• the strengthening of the links between the universities, research institutes and industry;

• the developing of a products and services market for R-D, due to the importance of the objectives;

• the granting of low interest loans on long time;

• actions initiation by which the implemented measures can be compatible with the competition;

• the correlation of the specialist's innovation capability with the needs exigencies of the modern society;

• the shaping of new innovative/creative skills;

• the shaping of an aware attitudes for promoting of the newer in the social-economic field;

• the shaping of an flexible and dynamic behavior for finding the most efficient solutions in business;

• promoting and strengthening of the IMM's competence and innovation potential;

• promotion and capitalising of the research result by legislative measures;

• promoting of the local, regional and national systems of monitoring and report;

• the developing of the quality ensuring systems;

• promoting of a new relation system between the involved institutions in the innovating process;

• the extend and simulate of the zonal, regional, national and international cooperation in the field of science, technology and innovation.

In EU acceptation, the frame of the basics policies required for sustaining new technologies and innovations for developing is represented by:

• improvement of the technological capabilities of the industries and local enterprises;

• assistance for innovation and adopting of new technologies in the small and middle enterprises;

• promoting of technologies transfer and spreading to the new and existing enterprises;

• providing of an favorable physical environment for developing of the innovative enterprises and of the high-tech enterprises (scientific and technological parks);

• financing of new technologies and innovation;

• schooling for developing and applying of the new technologies and innovation procedures.

On the other hand, the accomplishing of the innovating process is influenced by the following actions:

- transforming of the scientific knowledge in physical accomplish;
- introduction of the new products and services in the economy;
- the practical capitalization of the inventions and new technical solutions;
- the applying of the management and marketing techniques;
- the using of alternative financing sources;
- the discovery of new staple sources;
- spreading, propagation and the transfer of the scientific and technological research results;
- conquer of new markets;
- entrepreneurial learning.

No matter the promoting structure, a certain zone used for developing must be integrated in a research system which must comply the following conditions:

- to align to the market rules, but to keep its individuality;
- to be open, capable to change information with other systems, indispensable for the society development;
- to have an intern logic of the settlement;
- to have structures capable to motivate the taken decisions;
- to be competitive, to assume and resolve the problems at imposed high quality standards;
- to create conditions for developing the entrepreneurial abilities, mentality change and selecting the viable elements of the innovation policy;
- to capitalize the creativity – innovation potential;
- to manifest its concern for the benefit.

In Romania, the Government gets involved in the implementation of the innovation process by:

- establish some national priorities for the economy;
- the legislation improvement;
- reorientation of the educational process;
- creating the flexible mechanism at fast socio-economic changes;
- stimulating of the creative capabilities for technological developing as a social product;
- accelerating of the particularization process;
- promoting and stimulating of the scientifically values and of the R-D standards;
- creating of an economic innovative frame by reorganization and renewing of the R-D system and of the higher education;
- promoting of some anterior domains, as: life science, environment protection, material and new technology science, informational techniques and technologies;
- correlating of the particularization process in the economy whit the reorganization of the R-D units/institutions;
- protecting the intellectual and R-D capabilities potential;

- creating of some flexible structures which will resolve the problems of the applicative structures, technological transfer, license adaptation, a.s.o.;
- harmonizing the local and regional policies for innovation with the policies of the sectorial particularization;
- stimulating of the creativity and innovation processes by promoting and capitalizing the valuable inventions;
- intensive use of the inventive – innovative capacity of the personell involved in the universities and other R-D units.

As against the society changes, the importance of the innovation process for area's economic rehabilitation and developing is measured by its evolution and soving capabilities, its success being in concordance with the social-economical changing level recorded on certain areas.

The implementation of the innovation process in Romania is made by different structures, of which developing is accomplished in specialized institutions, such as:

- The Innovation Pilot Centers
- The Innovation and Business Centers (IBC)
- The Scientific and Technologic Parks
- The Innovative Enterprises

Regardless of the innovation actions and structures for promoting the innovation, the process must be organizationally, political and financial sustained, as being a continuous program that pursues the market application of the innovations. That must be considered and implemented totally, starting with the fundamental research, to the final user.

Bibliografie

[1]. Agean, T., *An introduction to the incubator concept* – Technopark, 1999.

[2]. Bakuros, Y.L., Madras, D., Versakelis, N.C., *Science park, a high tech fantasy Analysis of the science parcs of Grece*. Elsevier Science Inc., 2001.

[3]. Conceiçano, P., Heitor, M.V., Piprno, W., Rubin, I.D., *Perspectives for the observation of italian technology parks*. Project of A.S.I. and Instituto Superior Technico, Lisbon, 2002.

[4]. Lafont, A., *Realities and expectation of some european technology parks*. Proceeding I.A.S.P. International Conference, 2001.

[5]. Năstase, G., *Managementul inovării*. Editura FOCUS, 2002.

[6]. Pleşea, V., *Reabilitarea zonelor miniere după lichidarea activității productive.* Editura UNIVERSITAS, Petroşani, 2005.

[7]. * * *, *Managementul cunoaşterii, al proiectului Ştiințific şi al Inovării – Suport de instruire*. Ed. Sudura, Timişoara, 2003.

THE POLICY STRATEGIES AND CLIMATE CHANGE

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Abstract: An adaptation policy is a strategy for adapting to climate change in all sectors and regions of a country. Like an environment policy it stands on its own but incorporates adaptation into all relevant areas of government policy. At the national level an adaptation policy provides the context and guidance for specific adaptation measures. Usually a policy is not neutral with respect to the choice of measures but guides project analysts towards particular sorts or combinations of measures. Each country will wish to approach the creation of an adaptation policy or policies in accordance with its own practices and traditions. Countries may integrate adaptation into their various policies, as well as set up the institutional arrangements for co-ordinating these policies at the national level. However, no one size fits all.

Keywords: climate change, environment, policy, strategies.

1. The climate change scenarios and socio-economic systems

Presently, many countries have now carried out some studies under [6]:

- planning, which includes studies of possible impacts of climate change to identify particularly vulnerable countries or regions, and policy options for adaptation and appropriate capacity building;
- measures, including further capacity building which may be taken to prepare for adaptation;
- measures to facilitate adequate adaptation, including insurance and other adaptation measures.

The essential feature of Intergovernmental Panel on Climate Change (IPCC) approach is the selection ofclimate change scenarios. The thinking behind the IPCC's seven steps is logical; it proceeds from scenarios to impacts, and the autonomous responses that may take place as ecosystems and socio-economic systems experience

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the impacts. Publicly planned anticipatory adaptation is addressed in the final step of the assessment.

The seven steps of the IPCC technical guidelines for assessing climate change and adaptation is:

- define problem (including the study area, its sectors etc.);
- select method of assessment most appropriate to the problems;
- test method/conduct sensitivity analysis;
- select and apply climate change scenarios;
- assess biophysical and socio-economic impacts;
- assess autonomous adjustments;
- evaluate adaptation strategies.

First, by the time the analysis this reaches, researchers are faced with a battery of results that show the potential impacts of future climate conditions upon economy and society. Often climate change scenarios are imposed upon socio-economic systems as they presently exist. Sometimes consideration is given to the future state of society. However, there are wide confidence limits on the climate scenarios themselves, and it is recognised that the uncertainties about future socio-economic conditions are even greater. Since the scenarios are only plausible futures without any assigned probabilities and over very long timeframes (greater than 50 years), their use for policy formulation is limited to considering measures for longer-term climate change. Such results are less likely to capture the interest of policymakers, since most developing countries are concerned with more pressing issues such as economic growth, productivity and sustainable development; poverty alleviation and equity; public health; energy supply, efficiency and security; and other urgent issues. Longer-term climate change does not present itself as an immediate threat.

Second, climate model projections have two important constraints. Adaptation measures are often site-specific, whereas the best climate scenarios provide information on a large spatial scale for the globe and large regions. Global circulation model (GCM) scenarios are not sufficiently precise at the spatial scale for local impacts assessment. Downscaling can be applied to projections, which can increase their precision in space but not necessarily their accuracy [4]. While regional climate models are being improved all the time, they are still limited by the inherent constraints of the GCM from which they are derived. Furthermore, adaptation is driven more by variability and extremes of climate than by averages. Climate scenarios can only specify average conditions for a few variables. Generally, these are not the variables that are important for adaptation. Also small changes in average conditions can result in large changes in extreme events. Given these constraints, adaptation assessment would benefit from a new analytical framework as proposed here.

Third, impacts assessment alone are not designed to consider a wide range of adaptation measures. For example, crop yield studies can be useful for studying farm level adaptations, such as the effect of fertiliser on productivity but they do not help in considering other adaptations, such as changing land tenure systems, or price subsidies and other market interventions. Nor do they take into consideration possible future socioeconomic changes such as changes in agricultural markets and patterns of trade.

Several of the policies in the clean energy future scenarios are coupled to produce significant positive synergies. For instance, research prepares clean energy technologies to respond to opportunities created by incentives and to meet subsequent codes and standards. Efficiency gains from policies directed at the buildings and industrial sectors prevent or temper price increases from rising natural gas demand in the power sector, which results from policies such as the domestic carbon trading system. At the same time, some policies compete with one another. For example, policies that strengthen the performance of energy-efficient technologies foreclose the rapid penetration of many clean energy supply options in the 2020 timeframe, despite the inclusion of policies intended to promote them, since less energy supply is needed.

The clean energy future scenarios are based on a limited set of policies, many of which are relatively non-intrusive policies. Inclusion of stronger, more intrusive policies would result in more rapid progress toward meeting the nation's energy and environmental goals, though probably at higher cost. Many of these additional policies are explored in other studies, which could be consulted if the nation requires acceleration beyond the transitions described here. Further, the clean energy future scenarios omit policies that some policymakers might consider attractive. Some policies are omitted because their impacts are redundant. Others are left out because of modeling difficulties. Additional policies are excluded because the authors concluded that the required levels of public commitment or costs exceed clean energy future scenario guidelines.

A scenario-based approach is used to allow examination of alternative portfolios of public policies. A scenario is a story – not a prediction – of how the future might unfold. Scenarios are useful for organizing scientific insight, gauging emerging trends, and considering alternatives.

2. Sustainable development policy process

In evaluating the context for climate change policies, several points need to be kept in mind.

Some degree of climate change appears inevitable. Given current emissions trends and the inertia of the climate system, even if emissions were stabilized or substantially reduced, the scientific models suggest that climatic changes and their consequences would continue. To stabilize atmospheric concentrations of greenhouse gases and thus their effects would eventually require very large cuts in emissions from current levels (let alone future levels implied by continued economic growth under a "business as usual" scenario). For example, to stabilize carbon dioxide concentrations at something over twice pre-industrial levels would require emissions ultimately to fall by over 70 percent from their current level.

The problem is global. Rich and poor countries argue over how the burden of greenhouse gas emissions reductions should be allocated. However, no solution can be effective in the long term unless it ultimately leads to reductions in total *global* emissions, not just emissions in selected countries.

It is the human consequences of climate change that will animate public support for policies. The findings of climate scientists or studies of physical impacts from climate change cannot drive policy alone. This simple but important point often seems to be overlooked in debates about "what the science says," and it leads to our next major topic – what kind is useful for evaluating climate risks and policies?

The following suggestions illustrate what is adaptation policy [5].

Hazards policies. Adaptation policy may be developed with respect to specific climate risks. It may include a flood management policy, a drought policy, a coastal one management policy, and so on. In countries exposed to such hazards, a policy may already be in place. In these cases the policy may need to be re-evaluated and revised to take climate change into account. In some cases, there may be no plans or policies in place. Many countries, for example, have not found it necessary to have an explicit policy for coastal zone management. With the threat of rising sea levels, the need for such a policy may become more urgent.

Sectoral Policies. Adaptation policies may be developed with respect to pecific sectors such as agriculture, water resources, tourism, forests, biodiversity, health, and so forth. In most countries there will be policies in place for these sectors, especially where the sector is important to the national economy. In these cases, it may be sufficient to revise existing policies in order to take climate change risks into account.

Regional Policies. Some countries have development policies for specific regions, such as an integrated rural development policy or an industrial and transport development policy. Where this is so the policies may need to be reassessed to ensure that climate change is taken properly into account.

Economic and Social Policies. National governments have various policy levers that can be used to guide or regulate the pattern of the economy. These include taxation, incentives, and an array of rules and regulations. These can be deployed in order to promote adaptation.

Physical Planning. In addition to the broader-scale social and economic policy instruments, governments can also set rules for the location, design and construction of infrastructure and buildings, including housing. Physical planning is often carried out at the local or municipal level within guidelines set by national governments and can be a potent instrument for the promotion of adaptation.

Integrated National Adaptation Strategies. Regional and sectoral adaptation policies may be more effective if integrated at the national level. However, the feasibility of this approach will depend on the particular circumstances of the country. Many countries may find it better to leave most of the work on adaptation to the relevant sectoral or regional agencies of government which are hazards-based, not all necessarily at ministerial level, and to co-ordinate work through the creation of an interagency process or interagency body. Many countries carry out environmental impact assessments on all major projects. A comparable strategy would be to assess climate vulnerability for all relevant projects above a certain level of cost [3]. No single approach is recommended.

Adaptation baselines are more readily developed on a sectoral basis or on a hazard basis. For example, an adaptation baseline for droughts would consist of an inventory of drought adaptation policies and measures now in use, and a measure of the extent of their use within a given population at risk. If farms in Area A have adopted supplemental irrigation as a drought standby measure then they would have a higher or better adaptation baseline than farmers in Area B where there is little or no supplemental irrigation in place, or where only a small minority of farmers use it. Similarly, the extent to which roads and bridges have been designed to take present climate variability into account represents a higher or lower adaptation baseline.

Measurement of the baseline is difficult in quantitative terms, but one surrogate measure is residual loss after adaptation. Where drought or flood or other climate risks result in high losses this may be taken as indicative of a low level of adaptation. In some instances increasing losses from climate and weather events have been recorded. This may suggest a decline in the adaptation level. Adaptation can both improve or deteriorate over time. The adaptation baseline for a particular sector is a snapshot of the level of adaptation at a particular moment in time.

The choice of future adaptations is most relevant in the near term, that is five to ten years. The further away in time, the greater the uncertainty, and the less relevant to today's decision-making. While both present baseline adaptation and future adaptation have longer-term implications, attention to the recent past (the last decade) and the near future (the next decade) is likely to be most policy relevant. While the science of climate change deals in timeframes of decades or centuries, the timescale for many adaptations is between months and years and decades. Some adaptation measures such as forecasting, warnings and emergency relief, rehabilitation and reconstruction can be very short term. Tropical cyclone and flood warnings typically range from a few days to a few hours. Where major engineering works are contemplated, such as coastal defences, flood control dams or irrigation schemes, analysis has to extend over the economic and physical life of the structures, typically several decades or longer.

Climate change risks and response capacities vary with income level [1]. There is also a fundamental asymmetry between the timing of response costs—which will be borne to a significant extent by the current generation – and the benefits of reduced climate change – which will largely accrue to future generations. This asymmetry complicates a comparison of benefits and costs, since we cannot simply compare the expected costs of reducing the risk with the expected future value of the ultimate benefits. Instead, we must assess both the costs members of the current generation would bear and the strength of our concerns for the well-being of future generations—not just our own descendants, but all those who would be vulnerable in the future. These are economically and ethically complex questions about which we know little and which require a very mature political debate.

3. Alternative policy for reduction greenhouse gas emissions

In assessing climate change policies, we must consider complex “portfolios” of actions that include abating emissions, investing in technical innovations to reduce emissions sources and increase adaptation capacity, and improving risk assessment. In putting together a portfolio of policies, it is important to consider the synergies among them, such as the effects of economic incentives to reduce greenhouse gas emissions on the rate of innovation for new energy sources and other types of emissions reduction options [2]. Because of the long-term nature of the climate change problem, the ultimate goals for responding to it also must be long-term. Such a perspective offers increased opportunities for implementing low-cost strategies to reduce emissions and promote adaptation opportunities through new investments.

The incentives are crucial to both short- and long-term policy successes because they make emissions limitations less expensive. Both a large body of analysis and a small but growing body of evidence in areas other than greenhouse gas control show that incentive-based policies help bring about the lowestcost options and stimulate innovative new methods for abatement.

The main alternatives for incentive-based policies (beyond “no regrets” actions like reductions in energy subsidies) are carbon taxes on energy sources, and various forms of “tradable permits” systems. The latter approach would effectively establish quotas on emissions but allow trade in emissions, so that sources with higher control costs could (in effect) pay emitters with lower control costs to assume more of the reduction burden. It should be noted, however, that both types of policies have advantages, and neither should be written off. Hybrid policies combining tax and quantity restrictions may be very useful. Moreover, there are many policy combinations that might be relevant in future policy debates (such as a mixture of emissions trading with command and control for different sectors) whose performance is still largely unknown.

Conclusions

Adaptation is part of an optimal response strategy in any event. Indeed, it is the means of transcending the narrow concern about our vulnerability to climate change from greenhouse gas emissions to a broader concern with global-scale changes that place stress on natural systems and pose threats to human well-being. Furthering human capacity to adapt to climate change entails investment in improved understanding of the options and their international diffusion. It also entails adjusting economic and other distortions that limit adaptation potential (such as assistance programs that subsidize coastal development or water use). In many cases, the best climate policy may have less to do with greenhouse gases or climate per se, and more to do with developing better basic social infrastructure for natural resource conservation and use and public health protection.

REFERENCES

[1]. Alley, R.B. et al., *Abrupt climate change.* Science, **299**, 2003.
[2]. Azar, C., *Post-Kyoto climate policy targets: costs and competitiveness implications.* Climate Policy, **5**, 2005.
[3]. Burton, I., **Aalst, M.V.,** *Come hell or high water: integrating climate change vulnerability and adaptation into bank work.* World Bank environment department papers, **72**, 1999.
[4]. Hulme, M. et al., *Using a climate scenario generator for vulnerability and adaptation assessments.* University of East Anglia, Norwich, UK, 2000.
[5]. Jonathan, C., *What do producers want? On the origins of societal policy preferences.* European Journal of International Relations, **9**, 2003.
1. Stott, P.A. et al., *Human contribution to the European heatwave.* Nature, **432**, 2004.

DES SOLUTIONS POUR L'AMENAGEMENT REALISES SUR LE SITE DU "TRIANGLE DE MARIENAU"

EMILIA DUNCA*

Résume: La présence de polluants dans les sols (source) est problématique, car il faut savoir que cette pollution est mobilisable (transférable), et donc il y a un risque de pollution après l'arrêt du pompage de l'eau de la mine (puits Marienau) dans le cas particulier du Bassin Houiller. La connaissance des mécanismes de mobilisation et de transfert joue à cet égard un rôle largement aussi important que l'identification de la présence d'un contaminant à un endroit donné. Si le site dont un traite (lagunes du Triangle de Marienau) est susceptible d'être pollué il doit faire l'objet d'un diagnostic initial (analyse historique complétée par des prélèvements et analyses sur le site et dans son environnement) et d'une évaluation simplifiée de l'évolution des risques pour l'homme et la ressource en eau.

Mots clefs: pollution mobilisable, pollution, l'évolution des risques

1. Objectif des travaux

Dans le cadre de la lutte contre la pollution, le Service des Mines a demandé, au début de l'année 1984, aux H.B.L., de trouver une solution au problème posé par les différents déchets déposés dans "Triangle de Marienau". En effet, cette zone a servi pendant 30 ans de dépotoir pour les déchets principalement ceux issus de la Cokerie Marienau.

L'espace en question a la forme d'un triangle rectangle dont le petit côté est long d'environ 120 mètres en bordure du Morsbach et l'hypoténuse est d'environ 300 mètres en bordure de la Rosselle. Plus précisément, le triangle se compose de trois bassins d'une profondeur variable entre 0,7 et 1,7 mètres, séparés de la Rosselle par une digue principale de même longueur ainsi que de autres digues moins importantes. Les digues on était faites dans le cadre des travaux d'aménagement décrit ci-dessous. (Figure n°: 1)

La solution proposée devait permettre de:

- Traiter les déchets entreposés et fermer l'entrée du système;
- Isoler les déchets de la nappe phréatique.

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2. Description des travaux réalises

Les travaux effectués pendant l'été 1984, à proximité de la rivière Rosselle et du Morsbach ont consisté en premier lieu à la réalisation d'une digue de protection de 2 mètres de haut, de 11 mètres de large et 430 mètres de long. Ces travaux on été effectués avec des matériaux traditionnels (schistes 100/300).

Les travaux ont consisté tout d'abord en un remblai avec de schistes de lavoir dans le premier bassin. Des schistes ont été mélangés avec des boues pour stabiliser et solidifier ces déchets contenus dans le bassin. Une partie des boues est lors apparue en surface. Ces boues ait été pompe et envoyée vers cokerie de Carling pour être traite.

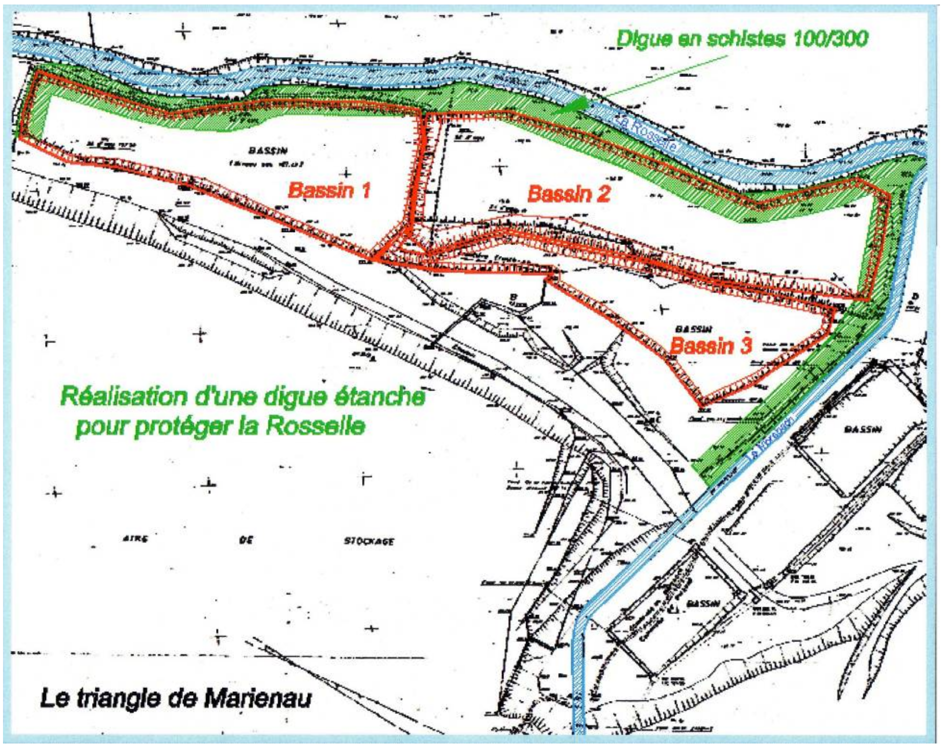

Figure n°: 1 Plan de situation avec les bassins de dépotage

On a continué à remblaye progressivement avec des schistes et une partie des boues a pu s'infiltrer entre les cailloux. Pour faciliter les travaux d'assainissement de trois bassins, on a construit de petites alvéoles pour mélanger les boues avec les schistes et assurer une stabilisation du terrain afin d'on assurer l'accès par les camions. (Cf. figure n°: 2.).

Première tranche des travaux

Compte tenu des essais réalisés dans le bassin n°1, le traitement des boues a été réalisé comme suite:

- Réalisation de petites alvéoles sépares par de digues;

- Remblayage progressif pour permettre aux boues de s'infiltrer entre les cailloux;
- Pompage des boues excédentaires (Cf. Figure n°: 2.a et n°: 2.b);
- Nivellement.

Les zones remblayées de cette manière sont restées stables et aucune résurgence de boues n'a pu être observée. Sous réserve de traiter les boues en excès lors des ces travaux, il était donc possible d'envisager cette technique pour le traitement de ces boues.

Figure n°: 2. a. et 2.b. Les travaux de remblayage de bassin 1

Les schistes 100/300 se sont révélés des matériaux tout à fait appropriés pour stabiliser les terrains mouvants, permettant le passage des camions par fortes pluies et absorbant la boue. (Cf. Figure n°: 3)

Deuxième tranche de travaux

Les travaux de remblayage en schistes on été réalisés pendant l'été 1985 par l'entreprise COCHERY. Ils comprenaient:

- La construction de digues transversales pour la réalisation de petits bassins;

Figure n°: 3 Remblayage progressif, une partie des boues s'infiltre entre les cailloux

➢Le remblayage d'une partie du bassin supérieur (bassin III);

➢Les remblayages des zones instables en bordure des bassins.

La méthode employée a permis de fixer les boues sur une grande étendue mais présentait l'inconvénient de ne traiter qu'une partie des déchets. Les boues en excédent non traités niveau du bassin supérieur (bassin III), qui a pu s'écouler dans le bassin non encore remblayé (bassin II). La partie surmontant la digue a été évacuée dans le bassin inférieur (bassin II) lors de la troisième tranche de travaux.

Troisième tranche de travaux

Un remblayage par cendres humides sur une partie du bassin III on a réalisé. Les cendres ont été déversées en bordure du bassin et poussées directement sur la surface des boues à l'aide d'un bull de marais (Cf. Figure n°: 4). La méthode qui nécessitait une couche d'environ 150 cm de cendres humides, présentait de sérieux inconvénients:

✓Nécessité d'isoler des petits bassins séparés par des digues en schistes;

✓Remontée de goudrons lors de la circulation d'engins non munis de chenilles;

✓Déplacement d'une partie des goudrons;

✓Nécessité de recouvrir les cendres par une couche de finition pour éviter les envols.

Figure n°: 4 Dépotage des cendres sèches et mélange avec les boues

Une partie des cendres humides livrées a été utilisée pour étancher la digue longeant la Rosselle.

Des essais effectués au laboratoire de la Cokerie Marienau ont montré qu'il était possible de solidifier la boue du ″Triangle de Marienau″ avec des cendres volantes. A condition de réaliser un mélange suffisamment intime, la solidification était réalisée dès l'ajout d'environ 30 % de cendres. La méthode a été expérimentée en trois endroits du triangle. (Cf. Figure n°: 5)

Figure n°: 5 Solidification et recouvrement par schistes fins

Les cendres sèches ne peuvent être transportées que par camion-citerne et sont normalement dépotées à l'intérieur de silos pour maîtriser les envols. Pour pouvoir décharger les cendres, la méthode a consisté à immerger un flexible avec un support dans la boue de manière à créer une sorte de lit fluidisé. Les cendres ont été ensuite mélangées à l'aide d'une pelle et les expériences faites ont montré qu'il fallait en ajouter environ 50 % pour pouvoir obtenir la solidification volume. Les surfaces traites ont été ensuite recouvertes d'une couche de finition en schistes fins. Cette technique a permis d'éliminer par stabilisation par de cendres.

Les travaux effectués au printemps 1986, ont demandé une grande quantité de cendres sèches. Les opérations suivantes ont été nécessaires:

- ❖ Réalisation de bassins séparés par des digues en schistes 100/300;

- ❖ Solidification des boues par mise en œuvre de 3 000 tonnes de cendres volantes;
- ❖ Couverture par une couche étanche de 2 300 tonnes de cendres humides et réalisation d’une pente vers la Rosselle pour l’écoulement des eaux;
- ❖ Couverture finale par une couche de schistes fins de 940 tonnes;
- ❖ Une couverture finale avec de la terre végétale.

Les H.B.L. apportaient les précisions suivantes: les travaux d’assainissement du triangle ont été effectués pendant les étés 1984, 1985 et 1986 et les travaux de remblayages des décanteurs et des lagunes se sont déroulés en octobre 1987 à l’aide de schiste 100/300. A l’issue des travaux, il a été décidé de renforcer la partie amont du triangle qui souffrait d’inondations.

Cette partie a été assainie en 1984 et n’avait pas profité des techniques développées ultérieurement. La berge naturelle de la Rosselle étant la plus étroite à ce niveau, les travaux consisté à en améliorer l’étanchéité par apport de cendres volantes. (Cf. Figure n°: 6)

Figure n°: 6 Travaux de couvert par de cendre humides

3. Propositions et conclusions

Dans ce cas pour du ”Triangle de Marienau” on propose de:

- mettre sur le site un piézomètre de surveillance de la qualité de l’eau souterraine et un autre en aval du site;
- mettre sur le site un réseau de sondage pour voir si il y a d’éventuelles pollutions dans ce site pour choisir le scénario de réhabilitation;
- effectuer des analyses d’eau de la Rosselle en amont et aval du ”Triangle de Marienau” pour voir si il y a une influence sur la qualité de l’eau de surface dans le tronçon où se trouvent les trois bassins et les deux lagunes;
- d’étudier en laboratoire des prélèvements de sol du ”Triangle de Marienau” par la méthode de lixiviation pour les polluants éventuels;
- d’effectuer, le cas échéant, un biotraitement sur le site du ”Triangle de Marienau.

Conclusion:

- la surface du site est entièrement végétalisée;
- lors de la construction des bassins du ”Triangle de Marienau” aucun dispositif de protection des sols et de la nappe phréatique n’a été mis en place;
- une partie du goudron extrait de ces bassins, a été acheminée vers la cokerie de Carling;
- les travaux de réhabilitation ont été réalisés sur le site après que des essais de mélange de cendre et goudron aient été effectués en laboratoire;
- le fond des décanteurs n’a pas été bétonné et non pas été nettoyée avant l’opération de remblayage avec des schistes;
- les fonds de la lagune n’ont pas été nettoyés avant d’être remblayés avec des schistes;

Actuellement on ne dispose ni de diagnostic des sols ni d’analyses des eaux ni d’aucun autre de nous permettre d’établir un constat d’impact sur l’environnement.

Bibliographie

[1]. F. Meinck, H. Stooff H. Kohlschutter, *Les eaux résiduaires industrielles* Masson et Cie, Paris 1970.

[2]. P.J. Wilson, J.H. Wells, *Charbon, coke et sous-produits.* Librairie Polytechnique Ch. Beranger, Paris 1953.

[3]. M. Daniel, *Le traitement de eaux résiduaire des cokeries*. ATS 1973.

[4]. J. Bernot, R. Chantereau, *Traitement biologique des eaux de cokerie.* ATS 1968.

[5]. J. Bebin, *Le lagunage aéré*. TSM L’eau novembre, 1973

[6]. S. Hains, K.E. Martel, D. Millette, R. Samson, *Etude du potentiel d’atténuation naturelle d’un site à pollutions mixtes résultant des activités d’une ancienne cokerie.* Ecole Polytechnique de Montréal. CRSNG en assainissement et gestion des sites. 2001.

ESTABLISHING THE AVERAGE QUALITY IN A COMPANY

NICOLAE DOBRIȚOIU*

Abstract. The competitive environment of modern society has laid down a set of very restrictive rules for all the firms that rise to the challenge; one of the most important problems that arise is the average quality met by a firm. The great demand of products and services that satisfy the demands forces firms to continuously improve the quality of all their activities in order to meet all the demands of the clients. If non-quality appears – during a certain activity – the quality of the services or products offered by the firm may seriously compromise the reputation of the firm. In order to avoid this phenomenon, it is compulsory to bring into practice, besides that the quality systems, a new method to determine the level of quality achieved, from the employee, the staff, the organizational subdivision and the firm's point of view.

Key words: product, utility, average quality, overall quality, quality level

1. The concept of quality

A given product can be technically perfect, it can be manufactured out of adequate materials and through an effective technological process and yet, it may be rejected by target customers proving to be unsuccessful on the market.

This means that technologist's opinion concerning the concept of quality does not always match that of consumers. Products that meet the standards are not necessarily successful from a commercial point of view. Well, then what is the use of quality if, despite its complying with standards, the product is not accepted thus being unable to yield the profit needed by the company to hold out? Should the concept of quality be revised and then redefined?

The idea of quality viewed only as adjustment to standards used to be of use within a background where the ratio demand / capacity were higher than the unit. This situation held through in the fifties and sixties.

But as the balance between these two terms became more obvious, selling also became more difficult, others strategies being necessary. Therefore marketing underwent

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an important development as a means of selling products facing greater competition (in the seventies).

At present, one can find saturated markets and ever more demanding consumers. It is already no longer enough to manufacture well. What is needed is to facilitate what consumers do expect, to adjust products to their needs, demands and expectations.

For this reason, it is necessary to devise a new conception concerning quality which is expected to take into account the target customer for the product or service and even more than that, to place the customer on the central axis of organizational activities. In order to best point out the concept of quality several definitions that go beyond the classical meaning of quality will be introduced further on.

-Predictable degree of uniformity at low cost, adequate to market needs (Deming).

-Designing, producing or providing goods or services that are as economically useful as possible as well as satisfactory to the beneficiary (Ishikawa).

-Quality: the extent to which a body of intrinsic characteristics (distinctive feature) meets the demands (need or expectation which is declared, generally implicit or compulsory), SR EN ISO 9000, February 2001.

-"Extension through which a product or service fulfils a customer's specifications and is in compliance with its use". (U.S.A. Administration and Budget Department, 1988).

In the foregoing definitions, it can be noticed that reference to customer and to meeting his needs is a common element. If a choice were to be made, that would probably be Juran's definition (1993) :

"Quality is the body of characteristics of a product that meet the demands of customers and, consequently, make the product be satisfactory."

In conclusion, quality can be said to possess a dynamic in space, time and in the customer's level of education.

2. Overall quality

Quality consists in bringing forth products or services that are satisfactory to the customer; consequently, one has to incorporate into it all the activities through which this satisfaction is received, irrespective of the place or type of company where the process is taking place.

This implies ensuring: the quality of products and services; the quality of resources; the quality of processes; the quality of both technical and human resources; the quality of administrative activities.

This conception comprising all of the organization and all of the activities is called overall quality. However, overall quality is not only a way of thinking but mainly a body of principles and methods aiming at satisfying the customer at the lowest cost. In order to fully understand overall quality mention must be made of a body of fundamental concepts.

Overall quality implies:

-Orienting the organization towards the needs of the customer. Meeting demands is the main issue. With this objective in mind, the unit is expected to focus on important processes which bring added value and make the achievement of this aim possible.

-The broadening of the concept of customer. The organization can be conceived as a system integrating providers and customers. Applying quality also means meeting the needs of the inside customer.

-Holding the leading position as far as prices are concerned. Quality is costly but non-quality is even more costly. If attention is to be focused on the needs and expectations of the customer, they will be better complied, with on condition that costs transferred to customer are lesser.

This cut in costs ensures competition on the market with genuine chances of success. It is therefore necessary for the costs of non-quality to be quantified.

-Prevention-based management. The underlying idea is that of doing things well from the first time and each and every time. It is better than in the case of the classical operations of detection and correction. The need to resort to control is reduced thus minimizing costs. This is the meaning Crosby gave to the phrase zero-faults.

-Improvement of the human factor. Quality is not to be controlled; it is achieved by the people belonging to the organization concerned, by all of them without exception. Therefore, the establishment of a management of human resources is necessary, starting with motivation for quality and participation.

-Continuous improvement. Quality is to be conceived as being a horizon rather than a goal. Overall quality cannot be achieved; instead, one is in pursuit of a horizon which keeps on broadening as one goes further on. This implies the idea of the continuous improvement of quality. It is always possible for products and services to be of higher quality and better adjusted to the needs and expectations of the customer which, on the other hand are dynamic.

3. Quality representation

Companies producing and providing products or services have as beneficiaries segments of population within a certain geographical area such as: age groups, professional groups, groups of population of certain level of education, political groups, social groups, etc.

If a company is to work and develop, it must, first and foremost, produce and provide products or services demanded by society. In other words, services must meet, to a high degree the needs, requirements and expectations of the population.

The existence of a fraction of inadequate products and services produced within a certain period of time and the possibility of taking a wrong decision concerning the quality of the products or services provided require the fixing of the following quality indicators:

1. Average quality after control (*AOQ*) - is an indicator of the efficiency of a certain plan of control and it represents the average quality of the products and services provided after the control of a certain number of batches.

Within the sequence of control operations, apart from the accepted batches there will be rejected batches which will be checked up wholly and the inadequate products and services will be corrected.

If the sample, in the case of the accepted batch, has been reintroduced into the accepted batch without inadequate products or services being corrected, the average quality after control will be:

$$AOQ = P \cdot P_a + 0(1 - P_a) = P \cdot P_a$$

If, however, the sample is "filtered" out of the inadequate products or services before its being returned to the batch after the control operation then the indicator is determined as follows:

$$AOQ = P \cdot P_a\left(1 - \frac{n}{N}\right).$$

Both the beneficiary and the provider are interested in knowing the *AOQ* indicator; the former is interested in benefiting from batches of services of an average quality after control corresponding to his flow of achievement of services while the latter is interested in having an average quality after control very much like the quality of the batches he presented on the taking of delivery to avoid having to sort out a large number of rejected batches.

2. The limit of average quality after control (*AOQL*)

It represents the maximum value of indicator *AOQ*, being the lowest level of the accepted average quality i.e.:

$$AOQL = \max_{0<P<1}(P \cdot P_a) = \max_{0<P<1}\left[\sum_{d=0}^{A} C_n^d \cdot P^d \cdot (1-P)^{n-d}\right].$$

3. Acceptable quality level (*AQL*)

It represents the maximum percentage of inadequately solved situations or the maximum number of inadequate solutions out of one hundred situations (Number of inadequate services/100 situations) for which the batch of services is considered to be acceptable from the point of view of the average quality of production.

The *AQL* value (Acceptable Quality Level) is fundamental to the application of the standards of quality statistic control, providing the real basis for the acceptance of a number as large as possible of adequate batches and the rejection of a number as large as possible of batches inadequate from a qualitative point of view.

Reference literature as well as control standards recommend that the fixing of the value *AQL* should be done at the level agreed upon by the contract concluded between the partners.

If there is a great number of characteristics to be controlled and if there is a distinct *AQL* for each of them (AQL_1, AQL_2,…,AQL_n) and distinct admissible faults respectively (A_1, A_2,…, A_n) then the global AQL_g level is determined by means of the formula:

$$AQL_g = \sqrt[n]{AQL_1 \times AQL_2 \times \cdots \times AQL_n}$$

and

$$A_g = \sqrt{A_1^2 + A_2^2 + \ldots + A_n^2} \quad \text{respectively.}$$

AQL represents in the standards for quality control as well one of the invariable elements of identification of a plan of control.

4. Assessment of average quality for a company

The average quality can be found using several methods, namely:

1. Determining average quality at the level of existent and taken up post and at the level of the department respectively. This method requires knowledge of the following pieces of information:

-structure, meaning types and number or organizational departments; characteristics which describe the activities carried out by the company;

-structure, meaning number and types of leading positions; at level of leading position one must have knowledge of the description of every position subordinated to them, in minute detail.

In order to determine the average quality for a department or leading position, the following items have to be calculated: the results obtained and the indices characterizing each quality feature separately.

Each item characterizing the quality of a result is estimated by a measured value.

Example: To determine the average quality of an operation one must identify the result, the qualitative characteristics which describe that result. The planned values and the obtained values are required for the values that estimate the qualitative characteristics.

2. Assessment of average quality at the level of component activity and at company level.

This method implies having the following pieces of information:

- job titles and types of activities carried out in a company;
- competence, assignments and amount of work to be performed within each activity required by a post and by an activity from the planning point of view and obtaining points of view, at a company level;
- results obtained by a different posts as the activity is carried out at company level;
- qualitative characteristics which describe the results obtained by each activity;
- values of each quality characteristic (planned and obtained).

The following items are to be calculated: indices which characterize each result obtained at department level separately; the average quality obtained by each result at department level separately; average quality obtained at department level.

3. Assessment of average quality at the level of the type of result obtained and at department level.

This method implies the knowledge of the following information's:

-classified list of results obtained at department level;

-planned and performed values for each result;

-the amount of work that has to be performed within each type of result obtained at company level;

-characteristics of quality which describe each type of result obtained at company level and the values of these quality characteristics.

Observation. The databases used for the three methods of assessment of the average quality at company level are different but the results obtained using the three methods will be approximately the same.

Example of calculation

Let be a company that deals with naval constructions. The graphics given in fig. 1 represents its organizational structure.

We consider that, for this company, the average quality values have been obtained first for each organizational subdivision. These values are written in the flowchart.

Observations

-the average quality for an organizational subdivision is ≤1;

-the values of the average quality for each component of the hierarchy have the same importance;

-the values of the average quality for each hierarchical level have the same importance;

-AQL – the acceptable quality level; AQL will have, from now on, the meaning of average quality.

The average quality at company level is determined as follows:

1. Determine the average quality for the 7th hierarchical level

Here we have two organizational subdivisions, and the value of the average quality is:

$$AQL_7 = \sqrt{0{,}95 * 0{,}95} = 0{,}95$$

2. Determine the average level for the 6th hierarchical level

From the organizational subdivision "Production Preparation and Ship Repairs Department" we have two subdivisions, on the 7th level of the hierarchy, and this leads to the following formula for the calculation of the average quality:

$$AQL_{6-7} = \sqrt[2]{0{,}95 * 0{,}95} = 0{,}95$$

Then, the values of the average quality for each organizational subdivision group that is directly related to the organizational subdivisions on the superior hierarchical levels are determined as follows:

$$AQL_{61} = \sqrt[3]{1 * 0{,}9 * 0{,}95} = 0{,}949$$

$$AQL_{62} = \sqrt[5]{1 * 0{,}95 * 0{,}98 * 0{,}95 * 0{,}9} = 0{,}955395$$

$$AQL_{63} = \sqrt[8]{0{,}9 * 0{,}98 * 0{,}9 * 0{,}98 * 0{,}95 * 1 * 0{,}9 * 0{,}85} = 0{,}931194$$

$$AQL_{64} = \sqrt[3]{1 * 0{,}95 * 1} = 0{,}98304$$

3. Determine the values of the average quality for the 5th hierarchical level, with the relations:

$$AQL_{61-51} = \sqrt{0{,}95 * 0{,}949} = 0{,}9495$$

$$AQL_{62-52} = \sqrt{0{,}955395 * 0{,}95} = 0{,}952694$$

$$AQL_5 = \sqrt{0,9495 * 0,952694} = 0,951096$$

4. Determine the values of the average quality for the 4th hierarchical level

The value of the average quality for the “Assistant Manager + R. M. C.” post will be determined using the relation below:

$$AQL_{41} = \sqrt{0,951096 * 1} = 0,975242$$

The value of the average quality for the “Economic Manager” is:

$$AQL_{42} = \sqrt{0,931194 * 0,9} = 0,915464$$

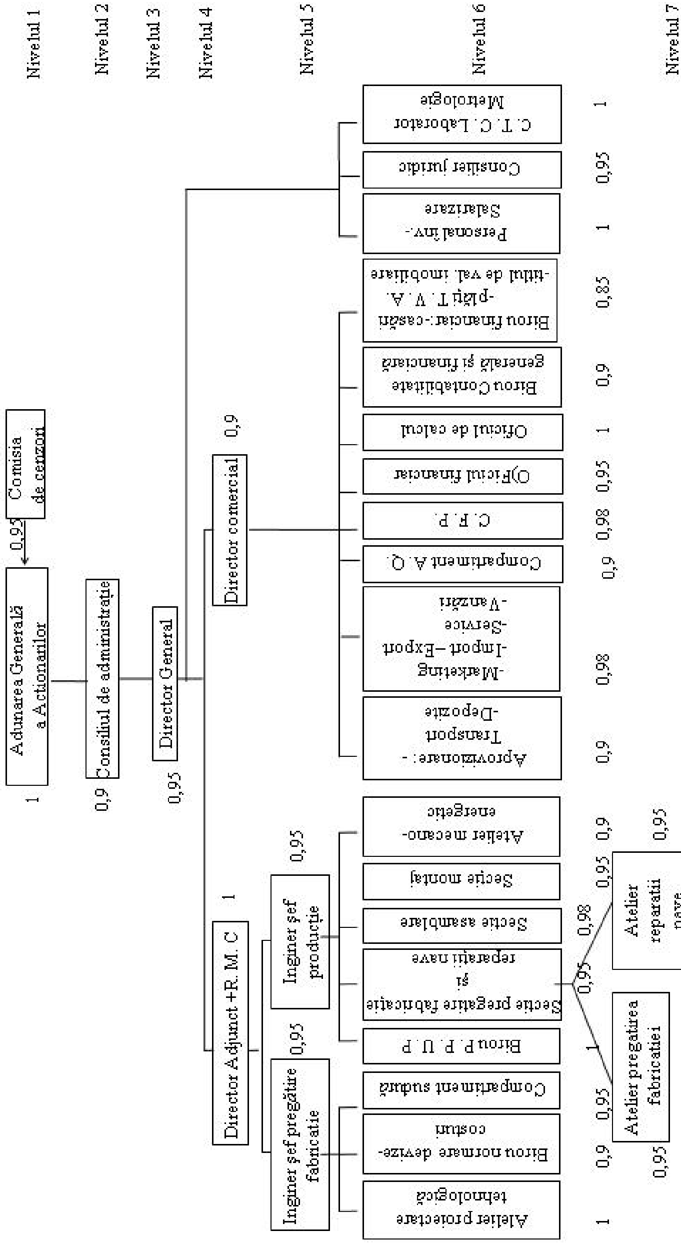

Fig. 1. Organigrama de funcționare

Because, both positions are on the 4th hierarchical level and these positions are directly connected to the “Economic Manager”, we will determine a value of average quality of these inputs, with the relations:

$$AQL_4 = \sqrt{0{,}975242 * 0{,}915464} = 0{,}94488$$

5. Determine the value of the average quality for the 3rd level.

On this hierarchical level, the “General Manager” post is connected to the 4th and 6th hierarchical level. Therefore, there will be calculated the value of the average quality of all the exits from this position using the relation below:

$$AQL_{4-6} = \sqrt{0{,}98304 * 0{,}94488} = 0{,}963771$$

The value of the quality obtained on the 3rd level is:

$$AQL_3 = \sqrt{0{,}963771 * 0{,}95} = 0{,}956861$$

6. The average quality for the 2nd hierarchical level

$$AQL_2 = \sqrt{0{,}956861 * 0{,}9} = 0{,}927995$$

7. The average quality for the 1st hierarchical level

$$AQL_{2-1} = \sqrt{0{,}927995 * 1} = 0{,}963325$$

The value of the average quality obtained at company level is:

$$AQL_1 = \sqrt{0{,}963325 * 0{,}95} = 0{,}956639$$

5. Conclusions

One the purpose of setting up a company is to obtain results that meet the demands of potential clients.

Quality is considered to be one of the main reasons for an increase of the demand of the results obtained by a company.

A company that raises the quality level of their services will prosper and the business environment together with it.

The average quality in the case we have studied was determined using the method "Determine the average quality at organizational level".

This method allows us to:

-determine the values of the average quality of each position and hierarchical level;

-determine the values of the average quality of an organizational subdivision and of all the organizational subdivisions coordinated by this certain subdivision.

The database that is used in this purpose is very complex, containing data from all domains of activity carried out at company level; some of the analytical data have double values (planned values, obtained values), where necessary.

Such a database can be created using IT systems specialized on: general management, human resources management, quality management, quality, etc.

The information obtained in this way allows the leading staff to determine the best way to improve the quality of all activities carried out by the organizational subdivisions and the company.

6. Reference

[1]. Baron, T., (Coordinator) – *Quality and Reliability*, Editura Tehnică, Bucuresti, 1988
[2]. Juran, M., – *The Quality of Products*, Editura Tehnică, Bucureşti, 1973
[3]. Rusu, C., –coordinator *–Manual of Economic Engineering -„The Foundations of the Management of Quality*". Editura Dacia, Cluj-Napoca, 2002.

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THE TITLE OF THE PAPER WILL BE WRITTEN WITH CAPITAL LETTERS, CENTERED, AT 7.0 cm FROM THE UPPER EDGE OF A4 FORMAT, ALONG THE ENTIRE WIDTH, TIMES NEW ROMAN, 14 POINTS, BOLD.

· (14 points)

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· (10 points)

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<Tab> **Key words: (Times New Roman, 10 points, bold)** 5 – 10 words, in English, along the entire width, Times New Roman, 10 points.

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<Tab> **1. THE TITLE OF THE CHAPTER IS WRITTEN WITH CAPITAL LETTERS, BOLD, TIMES NEW ROMAN, 11 POINTS AND WILL BE NUMBERED WITH ARABIC NUMBERS.**

· (11 points)

<Tab> The paper text paragraphs will be left – right aligned. The lines of the entire text will be single spaced with Times New Roman fonts, size 11 points.

The paper will be edited in a language of international circulation (English, French, German) on A4 format (210 x 297), page setup: top 5,6 cm, bottom 4,6 cm, left 3,7 cm, right 3,7 cm, in WORD or WORDPERFET or WINDOWS. The size of the symbol is given next and is written in the instructions used to assist in editing the text. It indicates a blank line and does not show in the text of the paper, being obtained by pressing <ENTER>. The size of a <Tab> is 1,27 cm. No blank line is left between the paragraphs. Between the last line before the title and the title of the chapter and between the title and the first next line a blank line is left for each.

[1] *Professor, Ph.D. at the University of Petroşani*

<Tab> **1.1 Subchapter. Subchapters can be used in the text, numbered with the number of the chapter and a number showing the number of the subtitle within the chapter. The subchapters and the numbers are Times New Roman, 11 points, bold.** · (11 points)

The text is written in new paragraph and not continuing the subtitle, an 11 point blank line being left between the subtitle and the following text.

· (11 points)

2. PRESENTATION OF THE FIGURES

· (11 points)

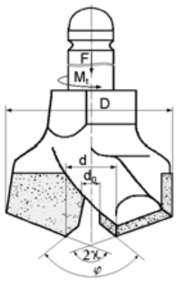

Fig. 1. Detachable bit

Figures should be enclosed in the text in the order of their presentation, as far as possible on the page where reference is made to them. They shall be numbered with Arabic numbers. Black – and – white, high contrast figures are recommended. Photos can be used as well, but they should be of good quality, clarity and sufficient contrast. The figures will have a legend (name of the figure), which, along with the number, will be written underneath with Times New Roman, 10 points, centered as to the figure. The figures will be surrounded by text.

· (11 points)

3. PRESENTATION OF THE TABLES

· (11 points)

The tables will be enclosed in the text, a 10 points blank line being left above and under the table, and will be numbered with Arabic numbers. Both the number and the explanations to the table are written with Times New Roman, 10 points, italic, for the number and bold for the explanation to the table, centered in the space of the table and above it. The table entries will be Times New Roman, 10 points, bold, and the data in the table will be Times New Roman, 10 points. The thin lines of the table will be ½ points (0,02 cm), and the thick ones will be ¾ … 1 points (0,03 … 0,04 cm).

· (11 points)

4. PRESENTATION OF THE MATHEMATICAL EQUATIONS

· **(**11 points)

The mathematical equations will be with times New Roman, 11 points, center of the page and numbered on the right with Arabic numbers between round brackets.

· (8 points)<Blank line 8 point high>

$$X^2 + Y^2 = Z^2 \quad (1)$$

· (8 points) < Blank line 8 point high>

An 8 point high blank line is left between the last line before the relation and the relation and between the latter and the next first line.

The last page will be at least 2/3 full.

The pages of the paper will only be numbered by a pencil outside the printing space.

· (11 points)

REFERENCES (will be written according to the model, Times New Roman 10 points).

· (10 points)

[1]. Marian I., *Mecanizarea în minerit,* Editura Tehnică, Bucureşti, 1969.