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Ph.D. THESIS SUMMARY

IMPROVING THE VENTILATION SYSTEMS OF INDUSTRIAL ENCLOSURES IN ORDER TO ENSURE OPTIMAL SAFETY CONDITIONS

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1. KEYWORDS

For a better understanding of the following presentation, it is necessary to list some notions that are specific to the approached field: *industrial ventilation systems, legislation, dimensioning of the necessary air flow at the work front, ventilation systems and fan operation curves.*

2. INTRODUCTION

Finding of effective methods and ways for the prevention of working accidents and occupational diseases fits perfectly into the quality concept of work, safety and health and is included in current programs.

Starting point in improving the prevention for work accidents and occupational diseases in a structure, is the assessment of the risks in that structure. The risk assessment involves the recognition of all risk factors in the analyzed structure and quantification of the proportions based on the combination of two parameters: the severity and frequency of the maximum possible consequence on humans.

The obligation to assess the existing risks in the workplace in order to improve the safety and health measures of the workers it is specified within the Council Directives no. 89/391 / EEC. It is also specified that strategies for identifying and combating risks must be based on consultation and participation of employers, managers, workers and/or their representatives. In the spirit of Law no. 319/2006, which transposes the Council Directive no. 89/391 / EEC, the managers of the economic agents, through the established obligations and responsibilities, are the only ones responsible for the health and safety of the employees.

The fundamental concept of this law places the head of the unit at the center of the activity of risk prevention and ensuring the health and safety of its employees. The prevention of occupational risks must also be a constant activity among employees and all persons involved in the work process.

The safety and health documentation shows that, in the event of an accident or occupational disease to which employees are exposed, during the exercise of work, the employer must have the assessment of the risks of injury and occupational disease for all jobs, to ensure an improvement in the level of protection of employees and be integrated into all activities of the unit.

It is also highlighted that jobs and equipment are safely designed, operated and maintained.

All risks must be treated in the following order of priorities:

• be eliminated;

• be controlled at source;

• be minimized by various ways (development of safe working technologies);

• to the extent that it persists, provide for the use of personal protective equipment.

Risks are present in all economic and industrial activities that are manifested by both economic losses, failures in installations, equipment and by the occurrence of minor or major accidents with particularly serious consequences resulting in deaths and injuries and environmental pollution. The assessment of risk levels stimulates the interest of economic operators to improve their working and environmental conditions, respectively to take measures for the transition from high risk levels to lower or acceptable levels.

The need to identify the risks encountered at the industrial level and in particular the risk of explosion, is an urgent one for the following reasons:

• some of the most important risks are the risks of explosion, intoxication and asphyxiation;

• in the continuous operation of the economic objectives related to the industrial branches, substances in the form of gases, mists, dusts or powder which may create potentially explosive, toxic or suffocating atmospheres;

• in order to avoid the risks of explosion, intoxication and asphyxiation, it is necessary to eliminate the emergency situations that can lead to the loss of human lives, material losses, respectively the shutdown of some industrial objectives;

• avoiding or reducing the risk of explosions, intoxications and asphyxiation by providing a proper ventilation system as a proactive measure is a priority;

• the main measure to prevent the phenomena of explosion, intoxication and asphyxiation is represented by the achievement of an optimal ventilation at the level of closed or semi-closed enclosure;

• the issue of the risk of explosion, intoxication or asphyxiation in industrial premises must be addressed both in terms of achieving an optimal ventilation system and in terms of monitoring the atmosphere of industrial premises;

• the danger and risk of explosion, intoxication and asphyxiation present in industrial premises under certain conditions, in accidental situations, in non-compliance with safety measures and procedures, in case of technical malfunctions or human errors and exposure of workers during work is an extremely strong motivation for identifying new means and ways to optimize ventilation systems.

All these aspects support the importance and the opportunity of the scientific research dedicated to the analysis of the piping systems, fans types as well as the optimization of the industrial ventilation installations.

The results of the research within the doctoral thesis can be directly used by all specialists/decision makers in the field of Health and Safety at Work within the industrial units and especially by those responsible for ensuring the optimal operation of ventilation systems.

3. THE IMPORTANCE AND NECESSITY OF THE TOPIC. OBJECTIVES AND STRUCTURE OF THE THESIS

The objective of the thesis

The main objective of the doctoral research is based on a completely new methodological approach regarding the exhaustive analysis of ventilation systems in order to optimize their functioning with a decisive and proactive role, in terms of ensuring safety and health at work.

The intended result consists in identifying the constructive elements specific to the industrial ventilation installations in order to make their operation more efficient. The intended result also consists in identifying and establishing the mathematical tools that are necessary in order to establish the optimal flow regime of the geometric and aerodynamic characteristics specific to mono or multifilament ventilation pipe-lines and to establish the optimal operating characteristics specific to fan-motor units including the geometric shape and the aerodynamic characteristics of the connecting elements.

Specific objectives

Identification of dimensional elements specific to ventilation systems.

Dimensioning of a long sized industrial ventilation system.

Exhaustive analysis of industrial ventilation installations.

Identification of the specific features of industrial ventilation installations.

Establishing the mathematical approach regarding the choice of ventilation systems in order to optimize them and optimize an industrial ventilation installation.

Thesis structure

The doctoral thesis begins with an introductory part dedicated to exposing the importance, purpose and objectives of the research. The basic content is structured in eight chapters for the presentation of the scientific approach and an annex, in a total of 167 pages. Each chapter has an appropriate size, graphic and logical presentation, and the whole work is supported by inserting 70 figures and 35 tables, and a list of 110 bibliographic references cited in the paper. The thesis presents synthetically and systematically the author's research, representing the results of documentation efforts, the results of experiments performed on ventilation installations of several industrial companies, the analysis and interpretation of data obtained from measurements and design. The doctoral thesis is conceived as a unitary whole based on case studies and is completed with the methods and tools necessary to improve the operation of industrial ventilation systems.

Chapter I, entitled “Elements for dimensioning of industrial ventilation systems”, presents the ways of sizing the air flow at work front specific for both exploitation works under the general depression of a main ventilation installations and for opening and preparation works ventilated with partially ventilation installations. At the same time are analyzed the ventilation systems partially used for the ventilation of potentially explosive/toxic/asphyxiating environments. Ventilation systems are presented in an analytical way, comparing their advantages and disadvantages. Also, the characteristics of the partial ventilation installations are presented, by explaining the sizing of both the geometric elements and the establishment of the aerodynamic parameters, specific to the industrial ventilation installations. It is highlighted that the estimation of air losses at a uniformly applied pressure is extremely difficult to achieve, because the pressure inside the ventilation columns varies continuously, which is why a calculation algorithm has been developed to eliminate this inconvenience.

Chapter II, entitled "Dimensioning of a long-length ventilation system - Case study" presents a case study of the analysis of the ventilation system of the front Amonte Castle, hydro technical work equipped with a long-term ventilation system, over 3100 ml. The mathematical approach necessary to determine the required air flow in underground and, in particular, at the work front is established. At the same time, the ventilation solutions of the main intake gallery in front of the Castle Amonte are analyzed, taking into account the position in row of the fans on the ventilation column, using for this purpose the QL diagrams and the possibility of using of a single fan for the ventilation of the main supply gallery front Castle Amonte, fan to serve the entire monofilar structure of the ventilation installation and to ensure the optimal air flow to the work front.

It is known that as the length of the ventilation columns increases, the required air flow to the fan increases due to the increase in air losses because of leakage of the tube column. For these reasons, providing of high air flows into the work fronts of long-term mining works raises difficult issues. Given that the final length of the tube column is 3500 ml in the case study, the parameters required for the fan will have maximum values. Under these conditions, it was decided that the aeration should be done in several phases, using several fans corresponding to the respective phases of digging the gallery. In this way, the necessary parameters for the fan (QV and hV) were calculated for the final length of 3500 m of the column in the tubes.

Chapter III, entitled 'Assessment of industrial ventilation systems', begins, in the introductory part, with a summary of the specific legislation applicable to ventilation installations. The substantial section of the chapter is dedicated to the ways of making/operating industrial ventilation systems and - in particular - to determining their efficiency. In this case, based on the results of the existing measurements at each of the analyzed economic units, the efficiency and operation of industrial ventilation installations were performed on a number of 524 ventilation installations belonging to important economic agents. Thus, the installations from OMV PETROM S.A. were evaluated. PETROBRAZI working point (Sulfur gas desulphurization plant; Cogeneration plant; DAV 2 plant; Catalytic cracking plant; TH DEMI CPP section; Tanks and AD pumps parks section; Isomerization plant; Coking plant 3 -CX3; RC plant , objective 120, 121, 123 and 130); SC ARCELOR MITTAL GALATI SA (Department of Agglomeration and Raw Materials; Department of Furnaces (DAMP); Department of Finishing and Department of Plate - IPPC; Department of Steelmaking - DO; Department of Maintenance and Spare Parts - DMPS; Department of Energy Production and Distribution in Steel-DPDES; Wagon operation and overhaul station); SC MICHELIN ROMANIA S.A. - Zalău tires working point (Chemical laboratories, solution preparation station and pump room; Semi-finished section (battery charging), logistics and B.U. workshop); S.N.G.N. ROMGAZ S.A. - S.Î.S.G.N. Ploiești (Compressor stations Butimanu, Bălăceanca and Urziceni). The analysis of the ventilation installations included both specific measurements regarding the determination of the aerodynamic, electrical and state parameters, as well as the analysis of the geometric and adjustment characteristics specific to the ventilation installations. The chapter concludes with a summary of the mathematical approach for the calculation of industrial ventilation pipe-lines, taking into account mainly the strength of industrial ventilation pipes-lines and pressure loss, the theoretical and practical aspects of series and parallel connection of ventilation pipes in systems.

In Chapter IV, "Analysis of the specific features of ventilation systems", are presented, in a concise manner, the results of measurements made by the author in the ventilation columns. In order to determine the aerodynamic parameters that characterize the ventilation columns, R0 - unit aerodynamic resistance and K0 - unit coefficient of air losses due to leaks, measurements were performed at four industrial ventilation installations, from four different economic agents, installations that operates in suction mode. The measurements performed in the representative points specific to each ventilation installation under study, aimed at obtaining the following parameters: a) Static depression (pressure) in the ventilation column and in the points for measuring the speed of air currents; b). Average air velocity in the column, in the air flow measurement points; c) The air flow to the fan, to the suction hole, in the branch points or in the zero static depression points; e) The air temperature in the ventilation column and in the air flow measurement points; f) Atmospheric pressure; g) Dimensions and length of the ventilation column; g) The distance between the fans and the column length corresponding to each fan and each branch. It explains the way of achieving the ventilation of the premises served in the 4 representative cases of industrial ventilation installations and evaluates and interprets the results obtained from measurements for each of the 4 cases studied.

Chapter V entitled “Reasoning for the choice of ventilation systems" is devoted to the technical ways of choosing the matrix elements of ventilation systems, by using the operating curves of axial and centrifugal fans. The Q-L diagrams and resistance nomograms of the ventilation pipes are also used, as well as the nomogram of the respective speeds and friction losses in order to choose the optimal diameter/size of the ventilation pipes. The chapter presents a new vision on the influence of the system connection type on the fan performance. For this purpose, both the effect of the connection to the suction hole and the effect of the connection to the discharge hole of the fan were taken into account. It should be noted that a perfect connection between the main system and the fan is one that ensures an air intake into the fan evenly distributed over the entire surface of the suction hole and an air outlet from the fan outlet made in a way that allows the use integral of the developed pressure. Only under these conditions can the fan provide the parameters that correspond to the operating point. Disruptions caused by the entry of air into the rotor or the wastage of kinetic energy after leaving the discharge port lead to poor fan performance, which is often incorrectly explained as being caused by lower engine efficiency. In order to assess the likely effects of the different ways of connecting the suction ports of the fans, tables have been prepared showing how much the flow decreases in the presence of an unfavorable part and how much the static pressure must be increased when choosing fans to compensate.

Chapter VI, “Improvement of industrial ventilation systems” presents the methodology for designing exhaust systems operating in suction regime and the identification of types of ventilation pipe-lines with higher air parameters. It is appreciated that the design of an efficient suction system is a very complex process that involves the knowledge of a large number of factors. Each suction port must be designed in such a way as not to allow dust and/or toxic and/or explosive gases to be recirculated, but at the same time, it becomes necessary to capture coarse particles that can clog the ventilation pipe-lines. In this regard, several types of ventilation ducts were evaluated, respectively fan curves and pressure losses.

Chapter VII, “Improvement of industrial ventilation systems. Case Study". In order to validate the proposed methodology for optimizing the industrial ventilation systems, the branched VOC emission exhaust and neutralization installation was chosen, served by a centrifugal fan, which has a VOC emission neutralization filter on the discharge side. The system - object of optimization - is operational at an economic agent and measurements of the relevant parameters were performed. The exhaustive analysis of the initial situation indicated that the aspiration of the toxic/explosive atmosphere is carried out, by means of four suction holes, located in the two chambers inside the enclosure. From the place of production of the toxic atmosphere to the fixed column placed on the walls of the two chambers, corrugated flexible columns are used, having different lengths, depending on the area where the toxic / explosive atmosphere is released. The flexible columns on the suction side are provided with closing devices (knobs) if the working operations are not performed at one of the suction openings. Optimization was possible with the help of the pressure loss balancing methodology, which has the advantage that the sections that make up the route with the highest resistance are calculated successively, to balance a branch using the change in air flow, which substantially simplifies balancing calculations. The ventilation sections that make up the piping system were resized, the corrugated flexible pipes with a diameter of φ = 150 mm were replaced with metal pipes of the same diameter, the highest degree of tightness and low roughness, elbows were used at an angle of 90 ° (with radius of curvature) and instead of the pipe with a diameter of 250 mm, we opted for a pipe with a diameter of 300 mm, respectively the pipe with a diameter of 350 mm was replaced with the pipe of 400 mm. At the same time, special parts were taken into account that change the direction of air flow, namely: bends, curves, branches, parts with sudden widening or reduction of the section, shutters, confusers and diffusers, parts that can increase the resistance of the installation with consequences in not achieving flow rates. air at workplaces, respectively at the fan level. In order to evaluate the industrial ventilation system, it was checked whether the total pressure loss is equal to the pressure released by the fan of the installation, to ensure air flow. At the end of the chapter, a comparative graphical analysis of the parameters developed by the ventilation system before and after optimization was performed, resulting that the fan flow increased by 33.1% compared to the initial flow; fan depression decreased to 22.41% of the initial depression; the required rated power of the drive motor after optimization is 20,33% of the rated power of the drive motor before optimization; the resistance of the ventilation network decreased to 13.25% of the resistance of the ventilation network from the initial phase.

Chapter VIII "Conclusions, personal contributions and further research directions" highlights the most relevant results that were found in the analysis of theoretical notions, models, approaches, case studies and experimental research undertaken. The author's contributions to the doctoral research are highlighted on the two planes that intertwine and intercondition each other: the theoretical plan, respectively the pragmatic plan, with emphasis on how to apply them in practice. In the last part of the chapter, a series of main research directions were highlighted that could be addressed in the future and which, according to the doctoral student, could bring more understanding and knowledge regarding the factors that make the efficiency of the operation of industrial ventilation systems. . It constitutes a chapter of synthesis of the conclusions and explicit formulation of the contributions to the approached research field.