PLOTTING THE CHARACTERISTIC CURVES FOR MINE VENTILATION FANS USING THE „VENTMEX" SOFTWARE

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ABSTRACT: *VENTMEX v0.1 is a software application designed and built at INCD INSEMEX - Romania , been the subject of the research project PN 07-45-02-44 Nucleus Program. The software is portable for Windows operating systems and represents an extremely useful tool for researchers and specialists in mining and industrial ventilation, providing a simple and intuitive interface for entering data collected " in situ" . Based on the input data, consisting mainly of : fan flow - Qv , its depression - hv , the general mine airflow - Qm and depression created in mining construction - hm and by considering other functional characteristics of the fan , the program calculates and displays tabular parameters relevant for plotting characteristic curves - pressure curve, power curve and yield curve. The graphical representation is realized in distinct windows, allowing comparison by viewing multiple data sets. Both the input data and results can be saved as files with .txt extension and graphs can be stored as files with .png or . svg . extension.*

KEY WORDS: ventilation software, characteristic curves, mine ventilation, VENTMEX, INSEMEX

1. INTRODUCTION

In the process of the mining ventilation, the mean ventilation turbo machinery has the essential role of continuous fresh air supply for mining works and the evacuation of the return air from the mining network.
The ventilation system is how to reunite in a common the air currents that flow through a ventilation network and includes itself the causes that lead to the qualitative and quantitative flow and distribution of the air currents (depression, resistance etc.).
When a fan operates at a specific velocity, its performance or high efficiency consists of a narrow field. Because of that, it is recommended to have more fans of different design to ensure the ventilation of the entire domain of flow-pressure required.
In order to avoid accidental selection of the types of ventilators the design of them requires the use of specific velocity diagram presented in figure 1 [1].
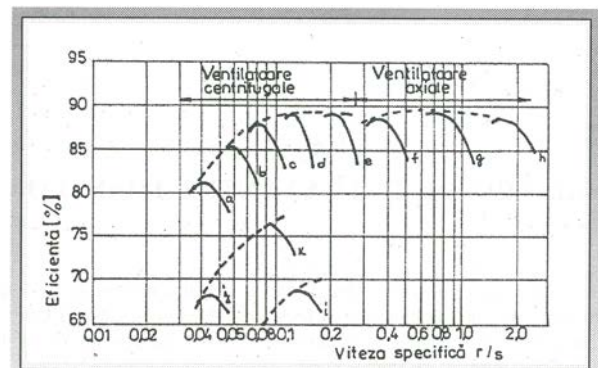

Fig. 1. Characteristic curves related to axial (f, g, h) and centrifugal vents with back curved blades (a-d), radial blades (j-k) and in front curved blades

The dependence between the pressure developed by the vent and its flow rate, expressed in a graphical form, represents the performance curve of the fan.
The theoretical curve pressure – flow rate of an ideal fan (without loss) is represented by a straight line between the points $Q = 0$ and $H = 0$ (figure 2, line AB). The efficiency curve is obtained by reducing the theoretical curve with losses due to shocks and friction.
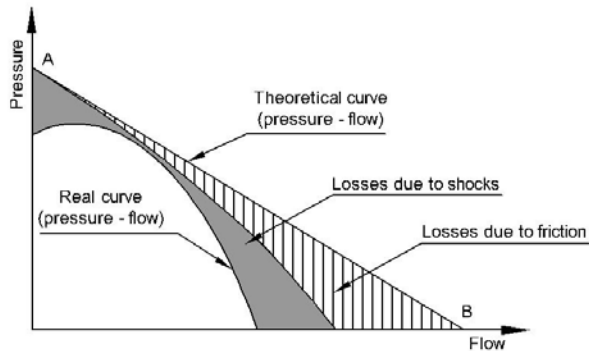
Fig. 2. *H – Q* theoretical and efficiency curves

The shape of the performance curve is mainly conditioned by the configuration of the rotor's blades. Every type of fan has own efficiency curve.

Characteristic curves express the functional dependence existing between different parameters and the achieved flow, Q_v, at a given resistance and revolutions. The curves determination is made on stands, by laboratory tests, factory tests or operating conditions.

2. VENTMEX APPLICATION

To sustain the interest of the specialists and the researchers in mining and industrial ventilation, The National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX Petrosani – Romania contracted a Romanian Research Program named "NUCLEU" PN 07-45-02-44. In this program, a group of researchers, together with the author of this article, had developed an application for calculating and plotting the characteristic curves of the fans, using JAVA programming language. Thus, the VENTMEX v1.0 application is portable software and can run from any memory stick, external hard drive or direct from PC. No installation required, simply copying the program to the desired location is sufficient, but running the installation requires Java version 1.7.0_45 or higher. VENTMEX v1.0 application has been successfully tested both on Windows 7 and on Windows XP. Its icon is presented in figure 3.

Fig.3. The icon of the VENTMEX application

2.1. VENTMEX Interface

VENTMEX main interface is very intuitive, easy to operate even for inexperienced users (figure 4).

Fan performance can provide significant decreases during operation, with immediate effect on the ability of mining network ventilation. Thus, the real performance of the main ventilation device can be established only by determination of the characteristic curves of the vents, in operating conditions [2].

These curves are as follows:

- Curve of the fan depression, $H_v = F(Q)$;
- Curve of the absorbed power, $P_a = F(Q)$;
- Efficiency curve of the fan, $\eta = F(Q)$.

From these curves, the most important is the curve of pressure variation, depending on the flow [2]. To obtain the necessary data for plotting characteristic curves determined for operating conditions, the fan runs at different operating modes.

First mode involves shorting the air circuit with the surface of the ground, and the other modes are obtained by gradual obscuration of the ventilation channel. Every mode has its own set of measurements. Based on these sets, calculation of the power output, of the efficiency of the ventilation device and of the energy consumption can be done.
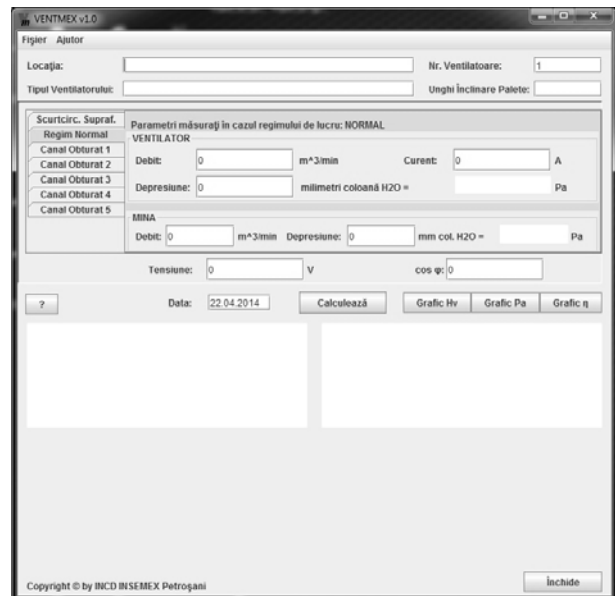

Fig. 4. VENTMEX v1.0 main window

For now, the main window is available only in Romanian language, but soon it will be written in English and other languages. It consists of the following fields for input data: location of the main ventilation device, number of the vents that form main device, type of the vents and the angle of the vent's blades.

Also, the window allows input data for seven operating regimes of the vent: one for shorting the air circuit with the surface of the ground, one for normal operating conditions and five regimes for gradual obscuration of the ventilation channel.

2.2. Input Data

Each operating regime need to take in account requires entry data consist of flow rate (in m^3/min), depression

(in mm H$_2$O) and current (in Ampere) for the vent. Additional for normal regime, the user must insert the values of the mine flow rate (in m^3/min) and mine depression (in mm H$_2$O). Voltage (in Volts) and power factor (cos φ) of the vent are required too. All these input data are those values collected *in situ*, by measurements performed in ventilation channel and by reading the vent's operating parameters. After the fields have been completed, all input data ca be saved as a text file, for later use.

2.3. Calculation and Results

Running a calculation in VENTMEX application, after input data have been inserted, is a very simple task. Activating the calculation button will display the results in a tabular form inside the main window, as it can see in figure 5.
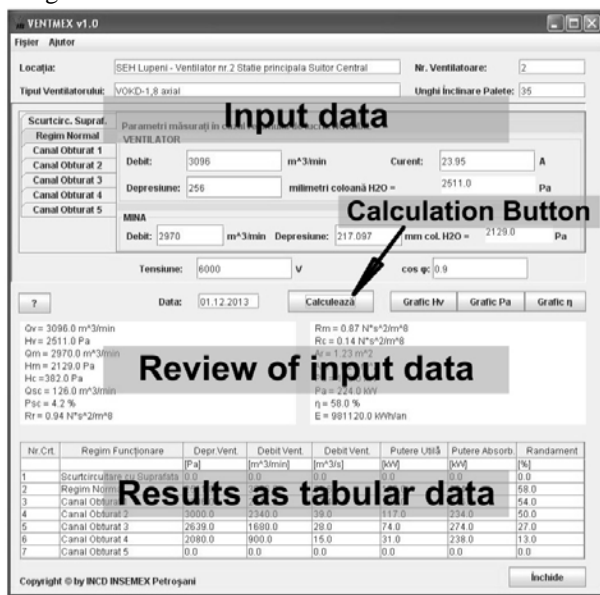

Fig. 5. Results as tabular data

Also, the two fields above the results contain a review of all input data. Corrections can be made immediately, by replacing wrong data in corresponding input fields. Calendar data can be replaced as well. Any correction requires a recalculation. On the middle – left side of the main window can be found a question button ⟨ ? ⟩ that activates a list with all used abbreviations (figure 6).
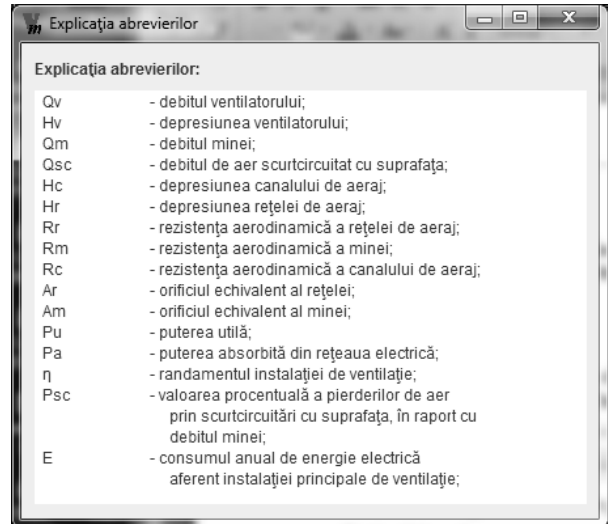

Fig. 6. List of abbreviations

2.4. Graphical Display

In order to visualize the fan's characteristic curves, there are placed three buttons on the same line with the calculation button of the main window (figure 7).
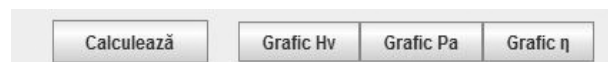

Fig. 7. Buttons for graphical display of the characteristic curves

Each of these buttons opens a graphical window, as follow:

- "Grafic Hv" button shows the graphics for the curve of the fan depression, H_v (figure 8);
- "Grafic Pa" button opens the graphics for the curve of the absorbed power, P_a (figure 9);
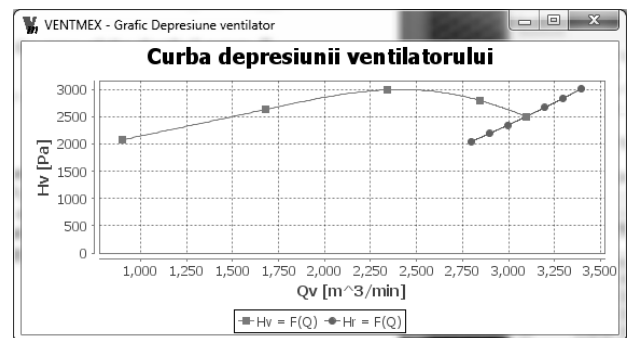- "Grafic η" button shows the graphics for the efficiency curve of the fan, η (figure 10).

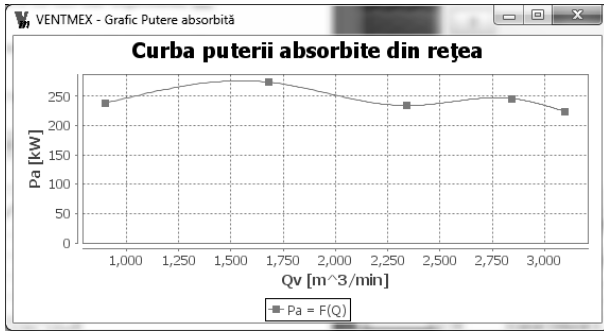**Fig. 8.** Graphical representation of the curve of the fan depression

Fig. 9. Graphical representation of the curve of the absorbed power of the fan
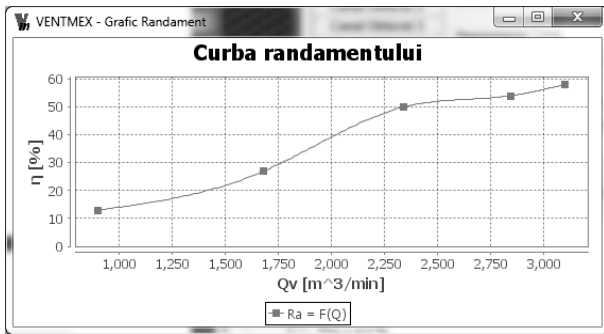

Fig. 10. Graphical representation of the efficiency curve of the fan

All of these graphical representations can be easily customized through chart properties window (figure 11) opened by a right click on the chart. Here, the labels, fonts, colours, range axis, background and others can be changed. The right click menu allows to copy the image of the chart, save it as .png or .svg file, print the image, autorange the axis or zoom in and zoom out functions.
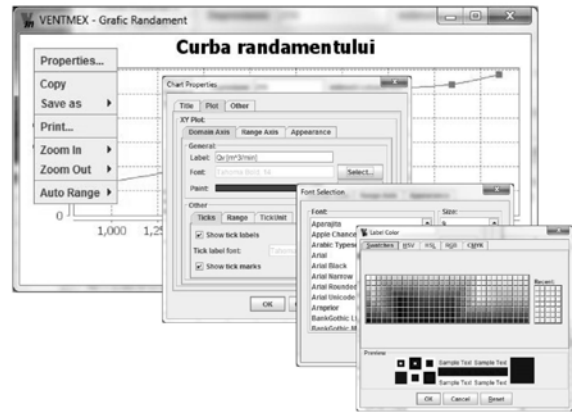

Fig. 11. Right click menu of the chart

2.5. Results Validation

One of the data set used for testing the VENTMEX v1.0 application consist of in situ measurement sets from Lupeni coal mining exploitation (Jiu Valley – Romania) that has one of the main ventilation devices composed of two VOKD-1.8 axial fans.

The results provided by the VENTMEX program shows a perfect similarity with the results obtained through common methods [3], as it can be seen in figure 12 a. and b.

Nr. crt.	Regim de funcționare	h_v (Pa)	Q_v		Puterea utilă - P_u (kW)	Puterea absorbită - P_a (kW)	Randament η %	Observații
			m³/min	m³/s				
		STAȚIA DE VENTILARE SUITOR CENTRAL - Ventilator nr. 2, VOKD 1,8 , $\alpha = 35^0$						
1.	1	2511	3096	51,6	130	224	58	Regim normal de funcționare
2.	2	2806	2844	47,4	133	246	54	Canal de aeraj parțial obturat
3.	3	3000	2340	39	117	234	50	Canal de aeraj parțial obturat
4.	4	2639	1680	28	74	274	27	Canal de aeraj parțial obturat
5.	5	2080	900	15	31	238	13	Canal de aeraj parțial obturat

a. Results obtained through common calculation method

Nr.Crt.	Regim Funcționare	Depr.Vent. [Pa]	Debit Vent. [m³/min]	Debit Vent. [m^3/s]	Putere Utilă [kW]	Putere Absorb. [kW]	Randament [%]
1	Scurtcircuitare cu Suprafata	0.0	0.0	0.0	0.0	0.0	0.0
2	Regim Normal	2511.0	3096.0	51.6	130.0	224.0	58.0
3	Canal Obturat 1	2806.0	2844.0	47.4	133.0	246.0	54.0
4	Canal Obturat 2	3000.0	2340.0	39.0	117.0	234.0	50.0
5	Canal Obturat 3	2639.0	1680.0	28.0	74.0	274.0	27.0
6	Canal Obturat 4	2080.0	900.0	15.0	31.0	238.0	13.0
7	Canal Obturat 5	0.0	0.0	0.0	0.0	0.0	0.0

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b. Results obtained running VENTMEX application
Fig. 12. Comparison of the obtained results

3. CONCLUSIONS:

Several tests were made on multiple sets of real data with known results. Every VENTMEX provided solution was identically with the results obtained through common methods, which demonstrates the correctness of the software algorithm.

VENTMEX interface is very intuitive, easy to operate even for inexperienced users. It is a program with extremely low hardware resource consumption and it has been successfully tested both on Windows 7 and on Windows XP.

A very important feature of the program is portability; it can be run from external storage drives (memory stick, external hard drive). No installation required, simply copying the program to the desired location is sufficient, but running the program requires Java version 1.7.0_45 or higher. It occupies a very small space on the hard disk, only 2.54 MB.

VENTMEX v1.0 has a top speed of work, displaying almost instant results and graphics. It presents advanced options to change the appearance of the characteristic curves corresponding windows. Graphs curves can be saved as images in .png and .svg formats.

Further work consists of developing the English and other languages interfaces of the program, writing a help file and construction of facilities for other industrial ventilation areas of interest.

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