Research Regarding the Variation of the Cost of Fluido-dynamic Lost Energy on a Pneumatic Network of Compressed Air

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Abstract: This paper provides an in-depth theoretical and practical presentation of the energy cost variation and it is about the fluido-dynamic lost energy during an hour on a meter of pneumatic network. This study follows two steps. First, we calculate the value matrix of the cost of fluido-dynamic lost energy for two extreme values of the coefficient of proportionality depending on the diameter of the compressed air pipe and also we determine the dependency of the cost of fluido-dynamic lost energy for extreme values of the coefficient of proportionality on the diameter of the network. Then, on the second step of the study, we will present the dependency of the cost of fluido-dynamic lost energy for the extreme values of the coefficient of proportionality on the volumetric flow of compressed air.

Key Words: energy saving, cost, fluido-dynamic lost energy, network, pressure loss, determination application

1. Generalities

Pipes, together with all elements that provide transportation and distribution of compressed air they all make a pneumatic network.

The distribution network of compressed air can be branched (radial) or annular (complex, looped, mixed).

If not considering new installations, the section is often the result of the successive evolutions of mining exploitation.

The most commonly used are the annular distribution networks with pipes interconnection on the most part of used area and short branched extensions towards the extreme points.

The annular system has the advantage of providing parallel ways of air distribution from a point to another, which significantly reduces load losses and it can create the possibility of obtaining a grater flow. Another advantage is that the annular system allows the pipeline maintenance by isolating and going round the section without stopping the supply of consumers.

This kind of network, when expands, extends through new branches while old ones are connected to each other joining the annular part.

The steams are located in big stations laid out gravity centers of the consumers.

In some cases for raising the air pressure at consumers it is used recompressed plants, usually placed at the end of the pneumatic network.

The connection of various sections of the network can be done by welding, operation that eliminates the leakages and ensure inexpensive plants. Instead flanged or screwed joints can be easily removed allowing easy replacement and cleaning of various sections.

Unfortunately, even in big modern enterprises with an organized maintenance service, the distribution networks of the compressed air register flow loss representing 10-20% of the total flow of steams. In many cases the flow loss reaches 40-50%.

In all gas plants (which are dangerous and expensive) the losses through leaks doesn't exist, which proves that the problem is not a technological one.

Because of the fact that the air is odorless, colorless, harmless and reputable free fluid, nobody deals with the problem of this losses. It is well known that if we don't take into account the flow losses of 10, 15, or 30%, the expenses with compressed air will rise with exactly the same percentage.

Considering that the mining pneumatic networks measure tens of kilometers and register flows of hundreds of m^3/min, any attempt of reducing energy losses and to improve the efficiency of the compressed air is appropriate.

Any decision, regarding the conceiving and designing of a pneumatic network it is taken on a objective-function, which tries to minimize the operating costs, the cost of constructions, to maximize the return on investments, the reliability of the plants.

In terms of thermodynamic, the mining pneumatic networks are open systems that change with the environment both energy and mass (in the case of flow losses through leaks).

The energy transfer between the opened thermodynamic system and the environment is achieved as heat and mechanical work or through the energy involved in mass transfer between system and environment.

The energetic accountancy of producing, transporting and distributing the compressed air has the following components:

- the energetic cost of the pipes;
- the energetic content of the operational energy;
- the energetic content of the steam, of its annexes and related constructions.

Forward, we will present some aspects related to the energetic content of the operational energy.

The basic problem, when dimensioning a pneumatic supply network for subterranean consumers, is the determination of the diameter of the pipe. There are a series of methods, either simple or complex, with a good theoretical basis, all of them considering as a basis a certain established experience such as air flow rate inside a pipe or pressure drop on the length of a unit (100 m; 1 km). Without stating that these methods do not correspond from a practical point of view it is reminded that they do not consider the exploitation period of a pipe and the purchase, installation and maintenance costs. It is known, though, that a main component of transportation costs is represented by the amortization rate of the installation. Therefore, supply expenses for temporary installations (digging of wells, galleries, etc.) are higher than for long term installations, thus the preponderance in the total transportation cost is that of the installation. In these cases, a small diameter pipe is preferred, therefore a cheaper one. Oppositely, for long term installations, the diameter may be larger, the energy loss generated by a smaller diameter reaching considerable values on a long period of time. The values of the diameters and of the volumetric flows depending on the parameters involved in the construction and exploitation of a compressed air network shall be established as follows.

To apply the thermodynamically rules and relations when studying gas flow, it is necessary to agree with some simplifying assumptions:

- during the flow, gas remains homogeneous and behaves as a perfect gas;
- in any section of pipe flow, the speed and thermodynamic parameters vary continuously and the flow is constant;
- the thermodynamically evolution of the gas is balanced, that requires an uniform internal gas state, the essential condition for representation in diagrams of the thermodynamic transformation of the gas during the flow;
- although there is friction both between gas molecules (viscosity) and marginal layer between gas and pipe's walls (roughness), not allowing the transmission of the friction heat through the gas mass and considering that the change between heat and the environment is possible without temperature gradient.

The following relation is proposed in the determination of the proportionality coefficient of the energy cost / kWh practiced by each country, cost which reaches the value of 0.44 lei/kWh in Romania.

2. Calculus Method

There are some practical cases where we meet the relaxation phenomenon like: the movement in a gas that suffers another slowly process, for example, the dissociation or movement of a fluid containing solid particles with a relatively large mass. In this study it is not taken into consideration the case of a very different movement of the particles compared with the fluid movement.

Generally, when studying the gas flow into the industrial plants, the main parameters are: pressure, specific volume, temperature and flow speed.

The calculus rationality is based on the hypothesis for the simplification of isothermal flow, in real life this happens on the networks of the mines at a certain distance from the compressor. Compressed air will also be assimilated to a perfect gas with the R = 287 J/(kg·K) constancy. It is worth mentioning that the temperature of the flow is almost the same with the environment temperature and this is the reason this component wasn't analyzed in this paper.

In order to determine the cost of the fluido-dynamic lost energy the pressure loss Δp and air flow speed w are considered first. The study shows that after reaching the critical speed, the flow is transformed from stationary to a pulsating one, characterized by relaxation and successive compressions of gas. This phenomenon is followed by the energy losses and hence increases the entropy. It is considered that the flow speed of the gas through pipes doesn't exceed the speed of sound, the flow being stationary.

Under these conditions, the loss of pressure in pipe flow is given by the well known relation:

$$\Delta p = \lambda \cdot \frac{l}{d} \cdot \frac{w^2}{2} \cdot \rho \tag{1}$$

if we replace the speed w[m/s] according to the flow $\dot{V}$ [m^3/min] that passed the pipe it is obtained:

$$w = \frac{\dot{V}}{15 \cdot \pi \cdot d^2} \tag{2}$$

where d pipe's diameter.

The result is:

$$\begin{aligned}\Delta p &= \lambda \cdot \frac{l}{d} \cdot \frac{\rho}{2} \cdot \frac{\dot{V}}{225 \cdot \pi^2 \cdot d^4} = \\ &= 0.225 \cdot 10^{-3} \cdot \lambda \cdot \frac{l}{d^5} \cdot \dot{V} \cdot \rho\end{aligned} \tag{3}$$

The power required for air transportation is determined with relation:

$$P_f = \Delta p \cdot \dot{V} \ \ [\mathrm{W}] \tag{4}$$

where $\Delta p[N/m^2]$ is the pressure flow, and $\dot{V}$ [m^3/s] the volume flow that passed the pipe.

Usually, the flow pressure is measured in bar (1bar = 10^5 N/m^2), and the flow in m^3/s so we obtained:

$$P_f = \frac{10^5}{60} \cdot \Delta p \cdot D_m \cdot 10^{-3} = 1.67 \cdot \Delta p \cdot \dot{V} \ \ [\mathrm{kW}] \tag{5}$$

equal with consumed energy [kWh] during an hour, that is the time unit for the study. Replacing Δp in bar we've obtained:

$$E_f = 0.225 \cdot 10^{-3} \cdot 10^5 \cdot 1.67 \cdot \lambda \cdot \frac{l}{d^5} \cdot \dot{V}^3 \cdot \rho \tag{6}$$

The mechanic work that is consumed for gas transportation is used to frictions and at the possible modifications of the potential energy, in the case of the inclined pipes.

Making the calculations and further by referring to l = 1m of pipe is obtained:

$$E_f = 0.375 \cdot 10^{-8} \cdot \lambda \cdot \frac{\dot{V}^3}{d^5} \cdot \rho \tag{7}$$

The air density varies with temperature and pressure and is given by:

$$\rho = \frac{p}{R \cdot T} \cdot 10^5 \tag{8}$$

where p[bar] is the air pressure and T[K] is the absolute temperature of the air that is constant.

If the pressure drop is appreciable we can make successive attempts to determine the average value although it is not necessary.

Replacing R = 287 J/(kg·K) - the air constant is obtained:

$$E_f = 1.306 \cdot 10^{-6} \cdot \lambda \cdot \frac{\dot{V}^3}{d^5} \cdot \frac{p}{T} \ \ [\mathrm{kW/m}] \tag{9}$$

For the reason that generally the unit measure for consumption is m^3 in the suction state we will make the replacement according to the Clapeyron -:Mendeelev equation:

$$\begin{aligned}\dot{V}^3 \cdot \frac{p}{T} &= \dot{V}_a{}^3 \cdot \frac{p_a}{T_a} \cdot \frac{T}{T_a^2} \cdot \frac{p_a^2}{p^2} = \\ &= \dot{V}_a^3 \cdot \frac{p_a}{T_a} \cdot \frac{\alpha^2}{\alpha_p^2} = V_a^3 \cdot k_1\end{aligned} \tag{10}$$

where $\alpha \geq 1$ and $\alpha_p \geq 1$, the "a" index refers to the suction operation.

k_l coefficient depends only of the suction and compressed air parameters, compressed air that passes through the network section.

With regards to the flow coefficient of friction, specialty literature offers a series of tables and determination relations. For a turbulent regime, the flow coefficient of friction λ generally depends by the value of Reynolds' Criteria and the relative ruggedness of the pipe. The following relation may be used for the determination of the flow coefficient of friction λ:

$$\lambda = 0.0624 \cdot d^{-0.148} \cdot Re^{-0.148} \tag{11}$$

In this relation it will be replaced the Reynolds figure with:

$$Re = \frac{w \cdot d}{\upsilon} = \frac{\dot{V}}{15 \cdot \pi \cdot d \cdot \upsilon} \tag{12}$$

The variation of kinematic viscosity with pressure is given by:

$$\upsilon = \frac{\upsilon_1}{p} \quad [m^3/s] \tag{13}$$

where υ_1 is the kinetic viscosity at 1 bar. For 1 bar air kinetic viscosity values are given by the following relation:

$$10^6 \cdot \upsilon_1 = 0.098 \cdot T - 13.5 \quad [m^3/s] \tag{14}$$

For λ is obtained:

$$\lambda = 0.0143 \left[\frac{T_a (0.098 \cdot T - 13.5)}{p_a \cdot T} \right]^{0.148} \cdot \dot{V}_a^{-0.148} \tag{15}$$

where $\dot{V}_a$ refers to the flow of aspiration.

The following relation exists between the flow $\dot{V}$ at a pressure p and a temperature T:

$$\dot{V} = \dot{V}_a \frac{p_a}{p} \cdot \frac{T}{T_a} \tag{16}$$

With regards to air parameters it has to be reminded that pressure is taken in the case of air density determination as an average value on the considered length of pipe. The determination may also consider the inlet pressure because the pressure drop on a length of a network is relatively small and pressure drop leads to decreasing density therefore to the increase of the specific volume. This pipe leads to the increase of the volumetric flow travelling through the pipe.

If the observation that there are inherent flow losses on the network is added and the 2 values, V and ρ represent opposite variations, the fact that $\dot{V}^3 \cdot \rho$ is constant on a certain length of network may also be accepted.

The energetic capacity of compressed air is defined as a maximum mechanical work (its exergia), and happens isothermal and irreversible. From the point of view of pneumatic energy production, the ration between the energy kept by the air and the spent energy for producing the respective compressed air quantity is defined by the isothermal efficiency. It results that the value of pneumatic energy cost towards the electrical one is found in the same ratio:

$$C_p = \frac{C_e}{\eta_{iz}} \tag{17}$$

where C_e and C_p in lei/kWh represent the cost of one electric kWh respectively pneumatic.

The cost of lost energy during an hour on a meter of pipe is determined using the following relation[4]:

$$\begin{aligned} C_l &= E_f \cdot C_p = 1.306 \cdot 10^{-6} \cdot \lambda \cdot \frac{C_e}{\eta_{iz}} \cdot \frac{\dot{V}_a^3}{d^5} \cdot k_l = \\ &= 1.306 \cdot 10^{-6} \cdot k_l \cdot \frac{C_e}{\eta_{iz}} \cdot \frac{\dot{V}_a^3}{d^5} \cdot 0.0143 \cdot k_v \cdot \dot{V}_a^{-0.148} \\ &= k_T \cdot \frac{\dot{V}_a^{2.852}}{d^5} \end{aligned} \tag{18}$$

where k_T is a parameter dependant on the parameters of sucked air p_a , T_a and the network parameters p_r, T_r. this parameter is called the proportionality coefficient of the cost of energy, the expression of which is the following[4]:

$$k_T = 1.306 \cdot 10^{-6} \cdot 0.0143 \cdot \frac{p_a^3}{T_a^3} \cdot \frac{T_r}{p_r^2} \cdot \frac{C_e}{\eta_{iz}} \cdot$$
$$\cdot \frac{T_a^{0.148} \cdot (0.098 \cdot T - 13.5)^{0.148}}{p_a^{0.148} \cdot T^{0.148}} \tag{19}$$
$$= 0.0187 \cdot 10^{-6} \left(\frac{p_a}{T_a}\right)^{2.852} \cdot \frac{T_r^{1.852}}{p_r^2} \cdot \frac{C_e}{\eta_{iz}} \cdot$$
$$\cdot (0.098 \cdot T_r - 13.5)^{0.148}$$

Consequently, for a given pipe diameter, the cost of lost energy C_l depends exclusively on the parameters of the environment and the specific conditions of the installation. The parameters needed to be correlated, flow and diameter, are not involved in this coefficient, the parameters being discussed in the following paragraphs.

The values domain (matrix) for the proportionality coefficient in the cost of energy k_T will be established by extrapolation depending on the range of suction and outlet parameters based on the measured values of a compressing station.

Next, the paper deals with the determination of cost variation of fluido-dynamic lost energy depending on three independent variables (the proportionality coefficient of the cost of energy, the diameter of the pipe and the flow of the volumetric compressed air). Therefore the value matrixes of the fluido-dynamic lost energy cost for the 2 extreme values of the coefficient of proportionality of the cost of energy will be determined. Thus, 2 steps will occur.

In the first step of the study, the following will be determined:

- the value matrixes of the fluido-dynamic lost energy cost for the 2 extreme values of the coefficient of proportionality of the cost of energy with regards to the variable diameters of pipes for compressed air;
- the dependency of the cost of fluido-dynamic lost energy for extreme values of the coefficient of proportionality with regards to the variable diameter of the network;

In the second step of the study the following will be determined:

- the dependency of the cost of fluido-dynamic lost energy for extreme values of the coefficient of proportionality with regards to the variable volumetric flows of the compressed air. In this case, the matrixes are similar to the ones determined in the first step, and that is why they haven't been presented previously.

3. Results and discussion

3.1. The validation of the coefficient of proportionality of the cost of energy

A pipe with the diameter d = 100 mm is considered. The compressor sucks in air at a 10^0 C temperature and blows it further to a 45^0C temperature. Theoretically speaking the pressure for air suction is considered 1 bar, and the realized compress ratio is $\pi = 6$. Considering these rough data for a compressor station, the coefficient of proportionality of the cost of energy k_T is determined by relation 8, considering the Romanian practiced value for 1kWh, $C_e = 0.44$ lei/kWh:

$$k_T = 0.0187 \cdot 10^{-6} \left(\frac{p_a}{T_a}\right)^{2.852} \cdot \frac{T_r^{1.852}}{p_r^2} \cdot \frac{C_e}{\eta_{ad}} \cdot$$
$$\cdot (0.098 \cdot T_r - 13.5)^{0.148} = 4.71 \cdot 10^{-8}$$

With the help of relation (7), the cost of fluido-dynamic lost energy during one hour on a meter of pipe for one value of the coefficient of proportionality considering the measured value of the volumetric flow $\dot{V}_a = 0.8\ m^3/s$ [9]:

$$C_l = 0.0471 \cdot \frac{0.8^{2.852}}{(100 \cdot 10^{-3})^5} = 2.49 \cdot 10^{-3} \frac{lei}{m \cdot h} =$$
$$= 2.49 \frac{lei}{km \cdot h} = 0.48 \frac{Eur}{km \cdot h}$$

In order to establish the value domain (matrix) for the coefficient of proportionality of the cost of energy k_T depending on the range of suction and outlet parameters, the pressure and temperature values have been measured for suction: p_a =0,981 bar, T_a = 283 K. Depending on the necessary amount of compressed air underground and the outlet parameters determined experimentally p_r = 4; 5; 6; 7; 9 bar and T_r = 300; 310; 315; 330 K the value matrix of the coefficient of proportionality of the cost of energy has been determined (fig. 1).

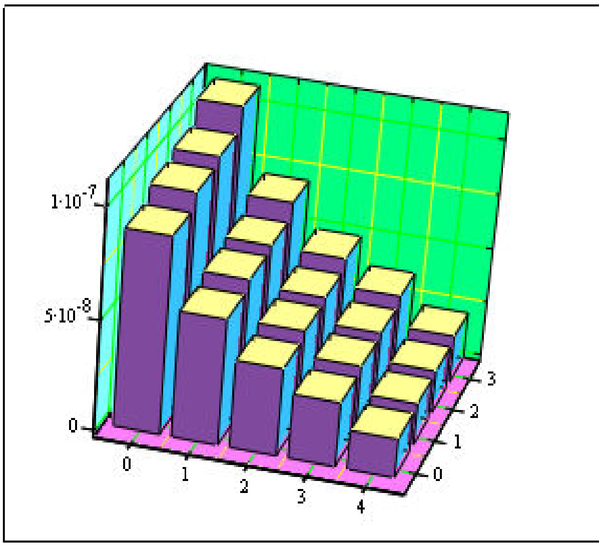
$$K_T = \begin{pmatrix} 8.902\times 10^{-8} & 9.544\times 10^{-8} & 9.873\times 10^{-8} & 1.089\times 10^{-7} \\ 5.697\times 10^{-8} & 6.108\times 10^{-8} & 6.318\times 10^{-8} & 6.970\times 10^{-8} \\ 3.957\times 10^{-8} & 4.242\times 10^{-8} & 4.388\times 10^{-8} & 4.840\times 10^{-8} \\ 2.907\times 10^{-8} & 3.116\times 10^{-8} & 3.224\times 10^{-8} & 3.556\times 10^{-8} \\ 1.758\times 10^{-8} & 1.885\times 10^{-8} & 1.950\times 10^{-8} & 2.151\times 10^{-8} \end{pmatrix}$$

Fig. 1. Value matrix of the coefficient of proportionality of the cost of energy

The 3D representation of the value matrix may be seen in figure 2.

Because the value matrix of the coefficient of proportionality of the cost of energy k_T is very small, only extreme values will be considered 1.758 10^{-8} and 1.089 10^{-7}.

The matrix of the coefficient of proportionality of the cost of energy has been determined considering the admitted-measured variation of the outlet parameters in a vector form and the considered suction parameters.



K_T

Fig. 2. 3D representation of a value matrix of the coefficient of proportionality of the cost of energy

3.2 Determining the value of the coefficient of proportionality of the cost of energy depending on the coefficient of proportionality of the cost of energy, the diameter of the pipe and the volumetric flow of the compressed air.

In order to solve the proposed theme, the cost of the fluido-dynamic lost energy during an hour on a meter of pipe will be determined, depending on three independent variables, namely, the coefficient of proportionality of the cost of energy, the diameter of the pipe and the volumetric flow of compressed air. Therefore, the value matrixes of the cost of fluido-dynamic lost energy will be determined for the two extreme values of the coefficient of proportionality of the cost of energy. The study has been divided in two stages.

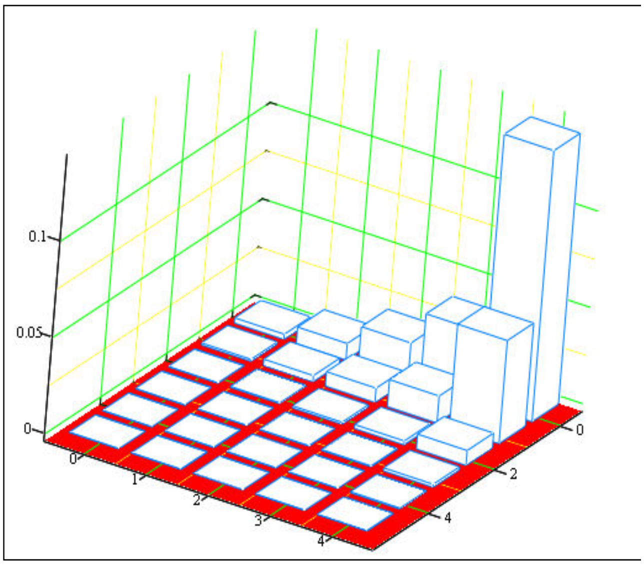
The first stage of the study deals with the determination of the value matrixes of the cost of fluido-dynamic lost energy for the two extreme values of the coefficient of proportionality of the cost of energy, depending on the diameter of the pipes for compressed air. A more expressive visualisation of the value matrixes will be possible through their 3D representation.

Flow measurements, for one of the mines belonging to the National Company of Brown Coal Petrosani, using different diameter pipes for compressed air have been made. Consequently, the interior diameters of the pneumatic network have been measured resulting in the following values: 89, 108, 159, 219, 273, 325 mm. The volumetric flow rates of compressed air have been defined in the following range, depending on the necessary amount of compressed air: 0,5 – 2 m^3/s with a pace of 0,25. The value matrix of the cost of fluido-dynamic lost energy during an hour on a meter of pipe considering the maximum value of the coefficient of proportionality depending on the diameter of the pipe is presented in figure 3:

$$C_l = \begin{pmatrix} 2.701\times 10^{-3} & 8.585\times 10^{-3} & 0.02 & 0.037 & 0.141 \\ 1.027\times 10^{-3} & 3.263\times 10^{-3} & 7.412\times 10^{-3} & 0.014 & 0.054 \\ 1.484\times 10^{-4} & 4.718\times 10^{-4} & 1.072\times 10^{-3} & 2.025\times 10^{-3} & 7.737\times 10^{-3} \\ 2.994\times 10^{-5} & 9.517\times 10^{-5} & 2.162\times 10^{-4} & 4.085\times 10^{-4} & 1.561\times 10^{-3} \\ 9.947\times 10^{-6} & 3.161\times 10^{-5} & 7.181\times 10^{-5} & 1.357\times 10^{-4} & 5.185\times 10^{-4} \\ 4.16\times 10^{-6} & 1.322\times 10^{-5} & 3.003\times 10^{-5} & 5.675\times 10^{-5} & 2.168\times 10^{-4} \end{pmatrix}$$

Fig. 3. The value matrix of the cost of fluido-dynamic lost energy for the highest value of the coefficient of proportionality

A more expressive visualization of the matrixes will be possible by their 3D representation(fig. 4).



C_l

Fig. 4 3D representation of a value matrix of the cost of fluido-dynamic lost energy for the maximum value of the coefficient of proportionality

Figure 5 represents the dependency of the cost of fluido-dynamic lost energy for the maximum value of the coefficient of proportionality depending on the diameter of the pipe.

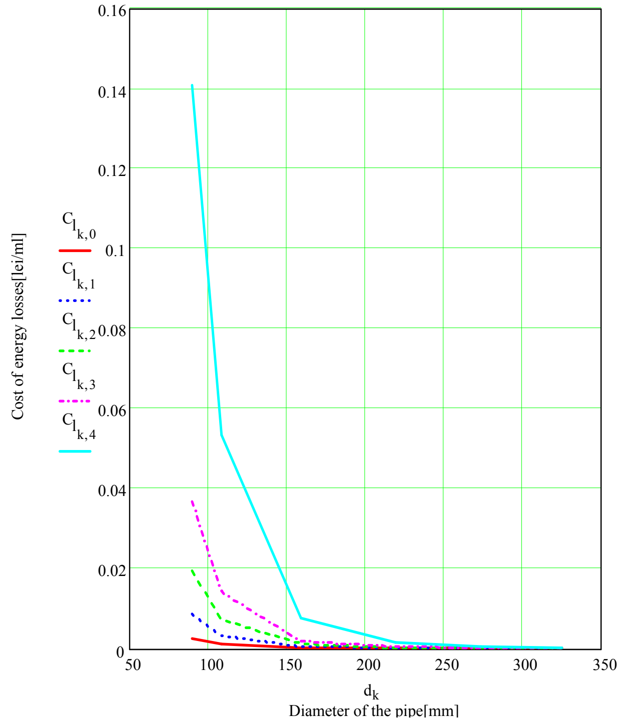


Fig. 5. The dependency of the cost of fluido-dynamic lost energy for the maximum value of the coefficient of proportionality

The cost of fluido-dynamic lost energy during an hour on a meter of pipe for the minimum value of the coefficient of proportionality is presented in figure 6:

$$C_l = \begin{pmatrix} 4.36\times 10^{-4} & 1.386\times 10^{-3} & 3.148\times 10^{-3} & 5.949\times 10^{-3} & 0.023 \\ 1.657\times 10^{-4} & 5.267\times 10^{-4} & 1.196\times 10^{-3} & 2.261\times 10^{-3} & 8.638\times 10^{-3} \\ 2.396\times 10^{-5} & 7.616\times 10^{-5} & 1.73\times 10^{-4} & 3.269\times 10^{-4} & 1.249\times 10^{-3} \\ 4.833\times 10^{-6} & 1.536\times 10^{-5} & 3.49\times 10^{-5} & 6.595\times 10^{-5} & 2.52\times 10^{-4} \\ 1.606\times 10^{-6} & 5.104\times 10^{-6} & 1.159\times 10^{-5} & 2.191\times 10^{-5} & 8.37\times 10^{-5} \\ 6.715\times 10^{-7} & 2.134\times 10^{-6} & 4.848\times 10^{-6} & 9.162\times 10^{-6} & 3.501\times 10^{-5} \end{pmatrix}$$

Fig. 6. Value matrix of the cost of fluido-dynamic lost energy for the minimum value of the coefficient of proportionality

The 3D representation of the value matrix may be seen in figure 7.

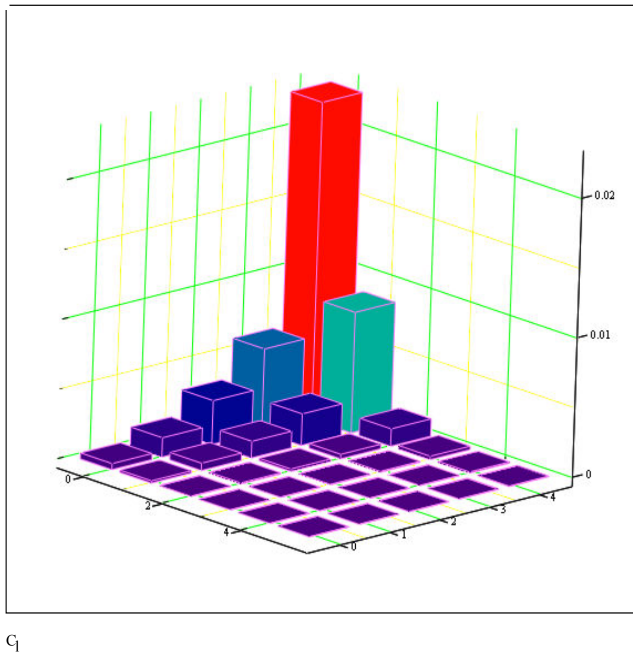


Fig. 7. 3D representation of the value matrix of the cost of fluido-dynamic lost energy for the minimum value of the coefficient of proportionality

Figure 8 represents the dependency of the cost of lost energy for the minimum value of the coefficient of proportionality on the diameter of the pipe.

In the second stage of the study, the value matrixes being the same as those in figures 3 and 6, the dependency of the cost of fluido-dynamic lost energy for the extreme values of the coefficient of proportionality on the volumetric flow of compressed air shall be presented.

The interior diameters of the pneumatic network have the same values, namely, 89, 108, 159, 219, 273, 325 mm, and the variable flow rate of compressed air is measured in a 0.5–2 m^3/s interval with a pace of 0.25.

Figure 9 represents the dependency of the cost of fluido-dynamic lost energy for the maximum value of the coefficient of proportionality on the volumetric flow rate of compressed air.

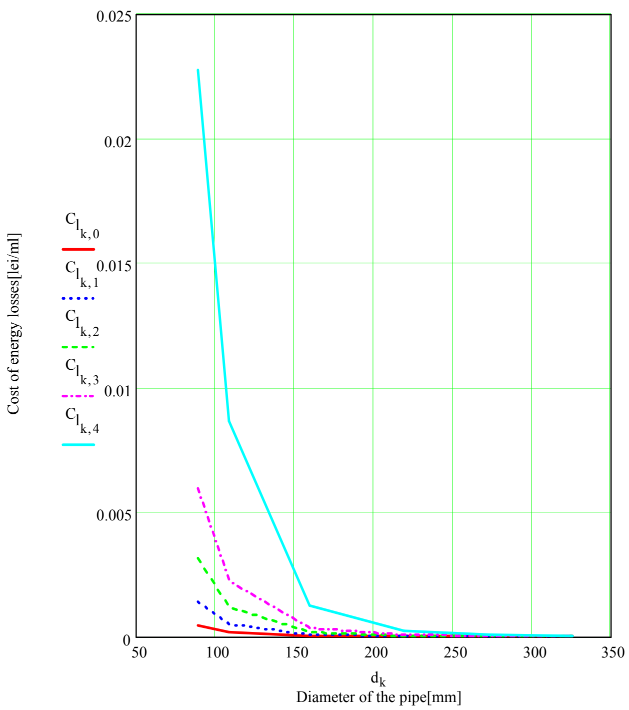


Fig. 8. The dependency of the cost of lost energy on the diameter of the pipe for the minimum value of the coefficient of proportionality

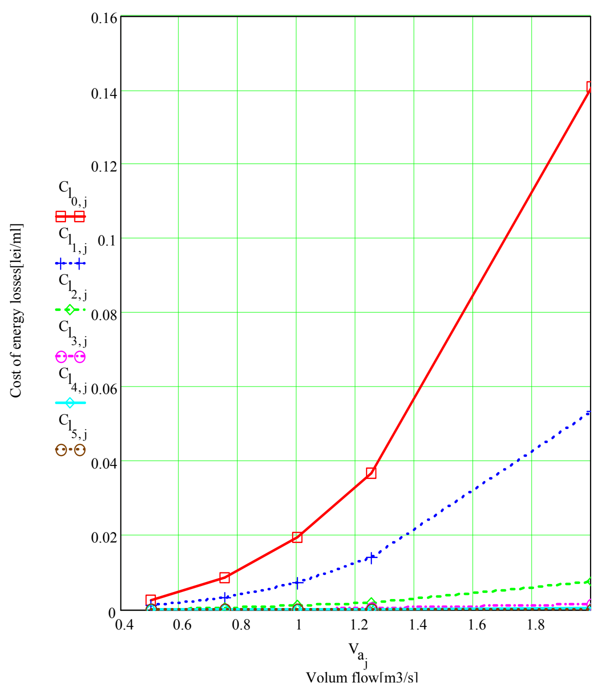


Fig. 9. The dependency of the cost of fluido-dynamic lost energy on the volumetric flow rate of compressed air for the maximum value of the coefficient of proportionality

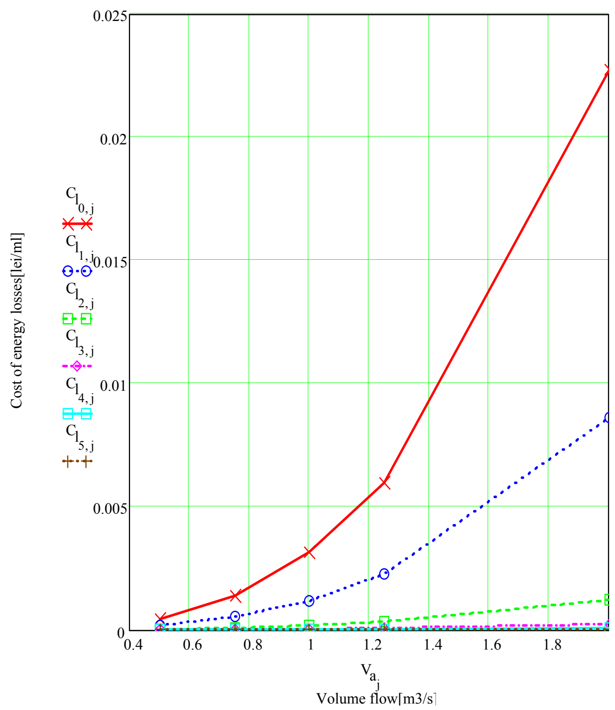


Fig. 10. The dependency of cost of fluido-dynamic lost energy on the volumetric flow rate of air for the minimum value of the coefficient of proportionality

Figure 10 represents the dependency of the cost of fluido-dynamic lost energy for the minimum value of the coefficient of proportionality on the volumetric flow rate of compressed air.

4. Conclusions

Making a technological system operating optimally in the mining pneumatic networks requires knowledge of the flow, pressure and temperature values in the essential points of the network.

The method used to determine the variation of cost of fluido-dynamic lost energy during an hour per linear meter of exposed network has the advantage of being expedient and leading to optimal values. It can be successfully applied in designing the main network pipes. Also, it can be applied in designing secondary pipes but, in this case, it is necessary a technical recalculation just because these pipes are mounted and removed several times, as needed and in this study we didn’t analyze these aspects.

After a comparative analysis of the existent situation in the mines of Jiu Valley, as well as after the quantification of the fluido-dynamic lost energy, it has been observed that there are significant deviations from the values obtained in the study.

These lead either to the increase of pressure losses, a frequently dealt with fact, or to the increase of the investment cost.

After the analysis of the functions the dependencies of which have been determined, the following conclusions may be drawn:

1. As the network pressure increases, the coefficient of proportionality of the cost of energy decreases, as it may be observed in the matrix presented in figures 1and 2;
2. As the network temperature rises, the coefficient of proportionality of the cost of energy increase, as it may be observed in the matrix in figures 1 and 2;
3. The cost of fluido-dynamic lost energy has a polynomial decreases together with the diameter of the pipe, as it may be seen in figures 5 and 8;
4. The cost of fluido-dynamic lost energy depending on the diameter of the pipe and the volumetric flow rate increases together with the increase of the coefficient of proportionality, as it may be seen in figures 3, 4 and 6, 7.
5. The cost of fluido-dynamic lost energy has a polynomial increase together with the increase of the volumetric flow as it may be seen in figures 9 and 10;
6. The cost of fluido-dynamic lost energy depending on the volumetric flow reduces significantly together with the diameter of the pipe as it may be seen in figures 9 and 10.

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