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LIGHT PNEUMO-HYDRAULIC POWER PACK FOR THE SUPPLY OF MINING HYDRAULIC CYLINDERS

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Abstract: The paper brings forward the researches of the authors concerning the development of a pressure source for the supply of hydraulic installations intended for underground coal mining.

Starting from the constructive and functional particularities of the pump comprised by the IUS 250/32 installation used to moisten the underground layers of coal, are established the conditions in which this type of pump may become the basic element of a system used for the supply of hydraulic operated machines and small mechanised tools underground mining of coal specific, with a fire-retardant liquid.

Key-words: mining machineries, hydraulic powers

1. INTRODUCTION

The use of machines, machineries, and equipments in exploitation of underground coal is conditioned by a series of norms which imply strict requirements, manly safety requirements.

Considering the operational reliability and safety within hazardous explosive atmospheres, hydraulic operation is mainly considered safe. Moreover, hydraulic oils, in certain extreme conditions may become a hazardous factor due to their flammability. This is why it is recommended to use flame-retardant liquids in environments which present a high explosion hazard.

In underground coal mining, where the atmosphere becomes potentially explosive due to methane and firedamp, the safety norms impose very strict conditions to the technology and equipment used: therefore, in the case of hydraulic supports the norms imply for their operation an oil in water emulsion weak in oil, i.e. a hydraulic agent which belongs to the flame retardant category. This choice has been made considering the safety and environmental protection criteria as well as an economic

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criterion, because, due to the operating principle of most safety valves (which spray operational liquid in the working atmosphere) and the working technology using an individual hydraulic pillar (which is not foreseen with a return circuit to the tank for the abduction of which it is necessary to unlock the valve and evacuate the liquid from under the piston directly onto the bed stone) the losses of the hydraulic agent are considerable and influence the operational expenses.

The present underground activity has determined the use of force and command elements for the hydraulically operated supports and for the development of small mechanisation installations: hydraulic jacks, cranes, and pushers etc.

The electric pumping stations used as pressure sources for the operation of supports are high flow pumping stations, reaching even 200 L/min, being a lot higher for the supply of small mechanised installations; moreover, they remain tributary to electric operation norms, the operation of which is conditioned by the mining atmosphere parameters.

These are the reasons for which it is desirable to study the possibility to realise an alternative pressure source for the supply of the installations of the supports and those of the small mechanisa-tion ones in case the supply of electric energy is cut off and when the only form of energy accepted by the norms is the pneumatic one (non-hazardous for the firedamp environment).

2. DESCRIPTION OF THE LAYER MOISTENING INSTALLATION IUS 250/32

The IUS 250/32 moistening installation is destined for the injection of water under pressure within the coal layers of the mining face: the micro-fissure of layers is therefore realised, favoring the degassing phenomenon, simplifying the cutting or breaking process of the massif improving the efficiency during exploitation and reducing the amount of dust in the atmosphere of the mine work resulted during milling or blasting

The main part of the installation is constituted by a special manufacture PUS pumping group, pneumatically operated, which uses water as agent, group which comprises the following main elements: the double action pneumatic motor, the high pressure pump and the preparation group, and the compressed air command [1]. The main technical characteristics are the following:

- Pressure amplification ratio- 1 : 61;
- The pressure of the supplied compressed air- 0.4 – 0.6 MPa;
- Maximum pressure of the supplied water- 1.5 MPa;
- The flow for the supplied water for a 0.5 MPa and for an outlet pressure of 5 MPa- 541.7 cm^3/s (32.5 L/min);
- Outlet water pressure- max. 25 MPa;
- Weight- about 75 kg.

Mainly, the motor – pump group constitutes a double effect pressure multiplier, which amplifies the lower pressure of the compressed air and transforms it into high water pressure for injection. The group for compressed air preparation also comprises a regulator for the outlet pressure o the pump, ensuring the suspension of pneumatic energy of the operating motor when the hydraulic outlet circuit reaches the preset pressure value.

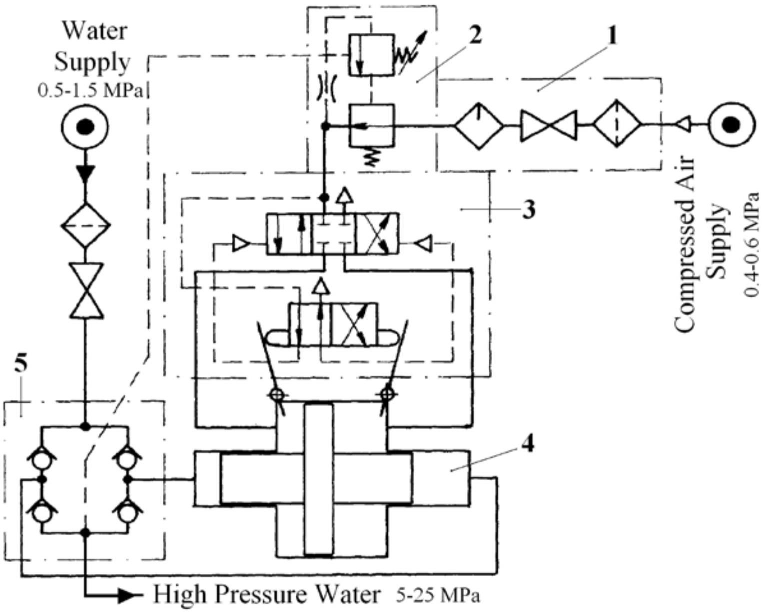

Fig. 1. Hydraulic diagram of the PUS 250/32 pump

The pneumatic-hydraulic basic diagram of the pump is presented in figure 1, where: 1- is the air preparation-supply block; 2- safety-regulation block; 3- distribution system; 4- pneumatic-hydraulic pump; 5- valve block.

Starting from the function this pump accomplishes and considering the necessary opening speed of a hydraulic cylinder, the conclusion that the pumping power pack of the IUS 250/32 pumping installation may be used with several changes and adjustments, as an oil in water pressure source, is drawn. As the physical-chemical properties of the oil + water emulsion 3 – 5 % are close to those of clean water, it may be considered that the operating parameters of the pump will remain the same.

3. CHECKING THE HYDRAULIC CHARACTERISTICS OF THE PUS 250/32 PUMP

If it is considered that the range of the hydraulic cylinders comprised by the mining machines and equipments is between 40 – 150 mm [2], then, for the main hydraulic parameters of the installation, the mechanical performances of the cylinders are situated in the following domains:

- The force developed by the piston for the supply pressure p = 5 MPa,

$$F = p\frac{\pi D^2}{4} \cong 6{,}3 - 88{,}4 \text{ kN}; \tag{1}$$

- The force developed by the piston for the nominal supply pressure p_n = 20 MPa,

$$F_n = p_n\frac{\pi D^2}{4} \cong 25{,}1 - 353{,}4 \text{ kN}; \tag{2}$$

- The force developed by the piston for the maximum pressure p_{max} = 25 MPa,

$$F_{max} = p_{max}\frac{\pi D^2}{4} \cong 31{,}4 - 441{,}8 \text{ kN}; \tag{3}$$

- The maximum speed developed by the piston during its opening stroke and by the flow Q_{max} de 541.7 cm^3/s,

$$v_{max} = \frac{4Q_{max}}{\pi D^2} \cong 43{,}1 - 3 \text{ cm/s}; \tag{4}$$

all the previous calculations were made without taking into consideration the counter-pressure of the return circuit and the influence of internal mechanical friction. It results therefore that the pump of the IUS 250/32 installation may ensure the successive supply of the hydraulic cylinders for the operation of a machinery or equipment.

In order to verify the previous statements, the paper presents the calculation for a hydraulic prop comprised by an individual support, the diameter of which is D = 110 mm, and the following developed mechanical parameters:

- The force developed by the piston for the supply pressure of 5 MPa,

$$F = p\frac{\pi D^2}{4} \cong 47{,}5 \text{ kN}; \tag{5}$$

- The maximum force developed by the piston for a pressure of 25 MPa,

$$F_{max} = p_{max}\frac{\pi D^2}{4} \cong 237{,}6 \text{ kN}; \tag{6}$$

- The maximum developed speed by the opening stroke of the piston and by the maximum flow of 541.7 cm^3/s,

$$v_{max} = \frac{4Q_{max}}{\pi D^2} \cong 5{,}7 \text{ cm/s}. \tag{7}$$

If the characteristics of the SVJ local individual hydraulic props (used for individual supports in Jiu Valley mines) are taken into consideration, which state a pre-seizure force of 100 kN, it results that it may be realised following the supply of the PUS pump which is correspondingly regulated (pilot valve of system 2 in figure 1 is regulated at 10.5 MPa), while the opening speed is adequate to the operating technology.

4. EASY TYPE POWER PACK FOR HYDRAULIC OPERATION OF EQUIPMENT USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES

In order to supply the hydraulic systems of the supports of the face as well as other underground hydraulic installations (pushers and hydraulic cranks, etc.) with operational liquid, pumping stations also called hydraulic power packs, using a flame-retardant operational liquid such as oil in water emulsion 1 – 5 % batching oil, are used.

A hydraulic power pack comprises one or more pumping installations PI, a tank for the storage and eventually the preparation of the oil in water emulsion TE, safety, regulation, distribution equipments as well as auxiliary elements. The construction of hydraulic power packs may be distinct when the PI and TE are separate parts connected either hydraulically or unified when they also form a mechanical complex [3].

In order to change the PUS 250/32 pump into pressure source / easy type hydraulic power pack with oil in water emulsion, it needs to undergo a series of changes and adjustments. The two distinct technical solutions may be identified:

- The configuration of a system composed of a PUS pump and a tank which is able to operate with an already prepared oil in water emulsion;
- The configuration of a system composed of a PUS pump and a batching oil dosing circuit, with an automated preparation of emulsion.

The system composed of the PUS pump and the tank containing the readymade oil in water emulsion is more simple and easier to realise and configures a power pack: as it may be seen in figure 2, the supply of the PUS pump (mark 1) is made by connecting the inlet orifice of the block of valves to the aspiration pipe from the left of tank 2, while the readymade oil in water emulsion with the required concentration with a pressure required by the load and superiorly limited by the regulation realised within the safety and regulation block, figure 2, emulsion which shall be blown in the main pressure pipe. In order to ensure the conditions for a good operation of the pump (as it may be seen in figure 1, the minimum pressure of the supplied water is required to be 0.5 MPa), the tank is required to be pressurised and a 0.5 – 1 MPa pressure needs to be ensured in a pneumatic buffer. As it may be observed, this kind of system may supply double action hydraulic motors, the return pipe allowing the operational liquid to return to the tank.

The pump 1 and oil in water tank 2, also generically called hydraulic power pack may form a compact mechanic-hydraulic complex, or they may be regarded as separate elements connected only hydraulically; this type of power pack is a type of installation with two hydraulic lines, which supposes a substantial increase of the weight compared to the PUS pump.

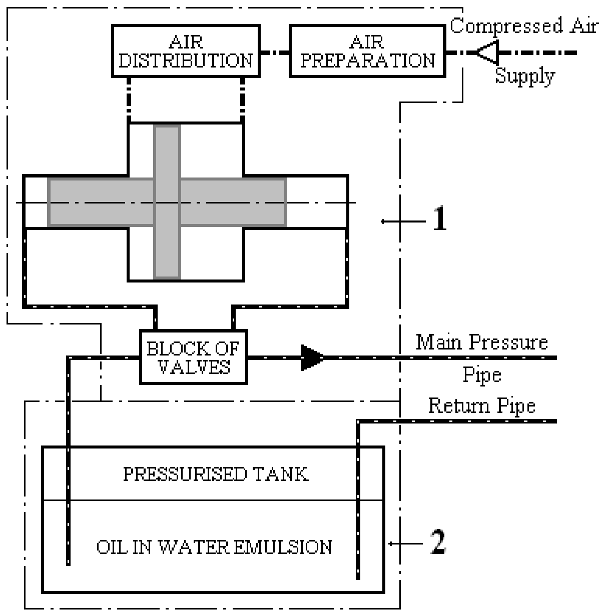

Fig. 2. Oil in water emulsion unified power pack

The complex composed of the PUS pump and the automated batching oil dosing circuit preparing the oil in water emulsion, is a complex installation which can be used for the supply of simple action motors, being therefore foreseen with a return circuit. It supposes therefore:

- The realisation of a batching oil dosing installation for automatically obtaining the oil in water emulsion and ensuring the required oil and water ratio;
- Fitting the complex with a batching oil tank which is to be integrated into its general construction, to make possible the manual relocation of the installation from one working place to another; the dimensioning of the tank needs to be made in order to ensure a sufficient operational autonomy and not to excessively increase the weight of the installation.

Figure 3 represents the basic pneumatic-hydraulic diagram of the installation capable to autonomously prepare its oil in water emulsion, where 1 represents the main PUS pump, 3- the batching oil dosing pump, and 4- the oil tank. In order to dose the oil in the oil in water emulsion, the use of a small flow pump is proposed which operates on the same principle and which shall blow oil directly into the water stream intake of the main pump into each working cylinder. Both pumps have the same cycle frequency, operating simultaneously, and as both flows remain constant, it is maintained a constant concentration of the emulsion in any given working conditions.

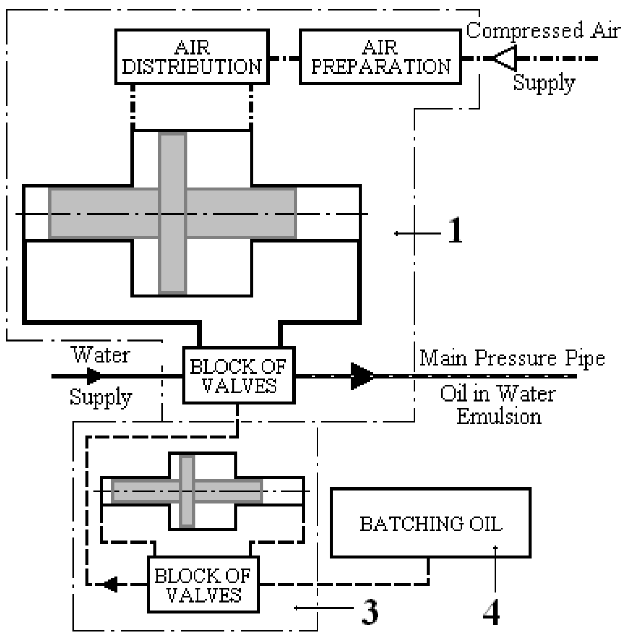

Fig. 3. Power pack with emulsion preparation.

The second solution may be used for the supply of individual hydraulic props mining supports, the operating principle of which supposes only the connection to the blowing circuit of the supply station. The volume of the batching oil tank is established considering the operation of the installation during a certain amount of time, without a new filling it up with oil, depending on the number of individually supplied hydraulic props and their type, but considering as well the limitation regarding the weight of the installation in order to render its maneuverability through tight spaces.

The two pressure sources proposed may be used in hazardous explosive atmospheres without any reservations, being therefore safe both concerning the supply energy (pneumatic) as well as concerning the operational liquid (3 – 5 batching oil in water ratio emulsion); the hydraulic supply systems need to be therefore realised with elements compatible to this type of operational liquid. The sources may be useful both in underground coal mines as well as in the extraction of different mineral substances, allowing the supply of specific hydraulically operated equipments and machineries.

The sources such as the one presented in figure 2 may operate with hydraulic oils, their characteristics being therefore influenced by the change of the operational liquid. These oil sources may supply the classical hydraulic systems, the safety level of the supplying energy allowing a safe use of the installations within a hazardous explosive atmosphere; but there are some reservations determined by the operating oil which, in certain conditions, may become a risk factor.

CONCLUSIONS

The paper brings forward the researches of the authors regarding the development of an easy type pressure source for the supply of hydraulic operational installations destined for use in underground mines with potentially explosive atmospheres.

Considering as starting point the study of the constructive and functional particularities of the pump comprised by the IUS 250/32 layers moistening installation, the conditions, in which it may become the basis of some flame-retardant supply systems for hydraulic operated machineries and equipments which are placed in hazardous explosive atmospheres, are established, making special reference to the underground extraction of coal.

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