RESEARCH ON THE PRESSURE ADJUSTMENT OF WATER INJECTION FOR PNEUMATIC HAMMER DRILLS

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ABSTRACT: The use of wet drilling is mandatory regulated by underground security techniques, with the purpose of avoiding illness with silicosis of the working staff, on horizontal mining works with drilling-blasting technology. For this it has been proposed the creation of a supply, command and adjustment system of water injection for pneumatic hammer drills. Using this system has plenty of advantages, most important: preventing dust in working front improving the visibility conditions, permanently draining debris from the mine hole, avoiding drill blocking which would block the auger into the mine hole; the head auger blades are continuously cooled, thus maximizing its life.

Key words: drilling-blasting, pneumatic hammer drills, water injection, supply, control and adjustment system

1. INTRODUCTION

Optimum conditions, aiming towards maximum drilling speed, must be used to have high drilling productivity. The drilling speed is influenced by geological-mining factors (rock compression resistance, massif cracking degree, mining hole diameter etc.) and by the drilling parameters (the frequency and the energy of the hits, the spinning moment and the auger speed, advancing force), given by the drill and by its advancing mechanism.

The pneumatic hammer drills, which equip the drilling equipments, have central water injection and are built to require the pressure of the injection water supply to be at lower or at least equal to the compressed air pressure, otherwise the water will get into the drill and it will cause its interruption.

These drills are fed to compressed air values between 0.4 and 0.6 MPa. In practice, the local service water pressure may have values of 3-4 MPa. On the other hand it has been found that in some situations (in case of culvert galleries from hydrotechnic

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constructions) the local water supply pressure has values below 0,4 MPa. In this case the low pressure of water injection is insufficient for a proper function of the drill. Another aspect is that the water from local supply often contains solid suspensions, which could lead to the obstruction or even blocking of the small diameter crossing holes, from the water cycle to the end of the auger.

These reasons lead to the need of an automatic system that would achieve, when required, the reduction or raise of the water injection pressure for the drill, to values enough to evacuate debris from mine hole. At the same time, this system had to be equipped with a high capacity water filter with a self-cleaning possibility.

2. ANALYSIS OF THE POSIBILITY TO ADJUST THE PRESSURE OF THE INJECTION WATER

For the supply, control and adjustment of injection water from pneumatic rotary drills there is suggested a system composed of a high capacity water filter with a self-cleaning possibility, an automatic distributor for the control and adjustment of water injection pressure in case of high values for water pressure from local supply, or an automatic distributor for the control and adjustment of water injection in case of low values for water pressure from local supply.

The designed system has the structure shown in figure 1, which is a schematic diagram, pneumatic and of water for drilling equipment. On the supply circuit for the left arm there was inserted the automatic distributor used in case of high values of water pressure from local supply (2), and on the right arm was inserted automatic distributor used in case of low values of water pressure from local supply (2'). The water pressure at the entrance in pressure regulator distributors can be tracked in manometer M_1, while the adjusted pressure of the injection water can be read on the manometer M_2 for the left arm of the supply circuit, and on manometer M_3, for the right arm of the supply circuit, both connected in circuit at the exit from the water distributors 2 and 2'. Schematic diagram also contains the compressed air supply circuit of the pneumatic drills from the drilling facility and from the advance mechanism. This circuit contains the air outlet, the buffer tank with a steam pot role 4, the air lubricators 5 si 5', the distributors for the drill rotation and percussion control, 7 and 7', the inverting distributors 8 and 8', the advance pneumatic engines 9 and 9'. Both circuits of water and compressed air work interdependently.

The function of the scheme and supply system, control and automatic adjustment of water injection pressure for pneumatic drills, is shown below.

The water from the local supply gallery enters the water filter 1 when opening the valve R_1. After going through the filter, the water reaches the pneumatic control distributors 2 and 2'. Their opening control is automatic, together with the action of the pneumatic distributors 6 and 6' to supply the drills' 3 and 3' rotation and percussion.

When the percussion mechanism of the drilling works, noticed by a command pneumatic signal, is sent to the water distributors 2 and 2', they switch to open. Water enters to pressure regulators, so its pressure is adjusted to a value about equal to the

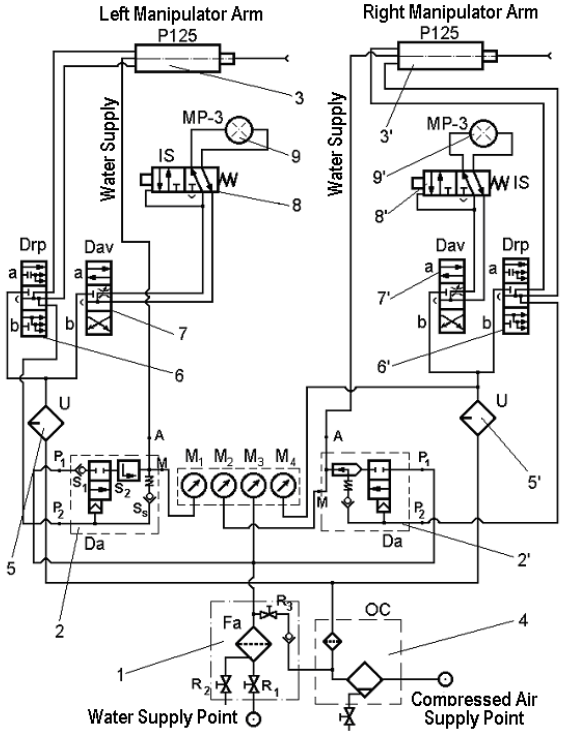

Fig. 1. Schematic diagram, pneumatic and of water for drilling equipment equipped with pneumatic drills

compressed air pressure and then it is sent to the injection circuits of drills. The water filter has high capacity, and it contains a compressed air purge system for the collected impurities, at the same time this system also provides the cleaning of the filter sieve.

The operation of the water filter is shown in figure 2. Initially all valves of the filter are closed. To supply the drills with washing water of the mine holes, the valve R_1 opens, which makes the water from the outlet to get into the filter. Afterwards, the water crosses through the filter sieve, leaves the filter and, through the distributors for automatic control and adjustment for the injection water pressure 2 and 2', reaches the consumers 3 and 3'. All this time, the valves R_2 and R_3 are closed. From time to time, the filter is cleaned by purging, due to the impurities found in the local water supply. To clean the filter, the valve R_1 is closed, interrupting the water supply, and then the valves R_2 and R_3 are opened. Therefore, the compressed air, from the buffer tank 4 of the drilling equipment, gets through the direction valve S and the valve R_3, into the filter, blowing the sieve filter, removing the impurities. By blowing, impurities get to the bottom of the filter body, being evacuated together with the water found there, when the valve R_2 is opened, and then they are removed outside. After cleaning, the valves R_2 and R_3 are closed, to prevent the elimination of water from the filter, and also

to prevent the compressed air from getting in the filter. The direction valve S has the role to prevent water from entering the compressed air buffer tank 4, in case of a inappropriate sealing of valve R_3. To supply the consumers with water, the valve R_1 is opened.

3. CONSTRUCTIVE SOLUTIONS FOR THE AUTOMATIC SYSTEM

3.1. Constructive solution for the water filter

Figure 2 presents the constructive solution for the self-cleaning water filter, part of the supply, control and adjustment automatic system of injection water.

The water filter is made of body 1 – representing a pipe with interior diameter of 290 mm, which has a bottom cover inclined at 30°, and body 2 - which is the superior cover, flanged mounted on body 1 with screws 10. Between the flanges of the two bodies, filter 3 is mounted, made of a fine filtering sieve with 500 μm, provided with two rubber gaskets vulcanized together with the sieve.

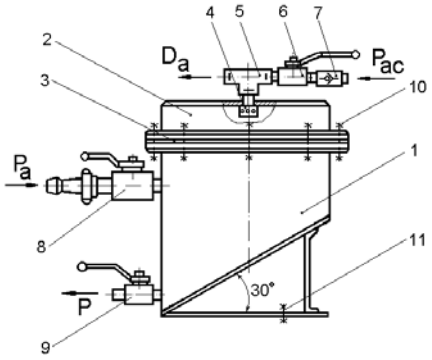

Fig. 2. Self-cleaning water filter

From the compressed air source, it passes through the direction valve 7, and then through the ball 6 valve Dn10, and through the reducing sleeve T, to the lens 4, designed to prevent the damage of the sieve due to the direct exposure to compressed air. The lens 4 performs uniform distribution of compressed air all over the sieve for cleaning. The water supply from outlet is made through valve 8, so the water crosses the filtering element from down upwards, and the existing impurities either get to the bottom sieve, or are deposited to the bottom of body 1, being stored in the area of the purging valve 9 (because of the inclined construction of the filter bottom). For cleaning, the valve 8 is closed, while the valves 6 and 7 are opened, so the compressed air goes through the lens 4, on top of the sieve, removing the impurities deposited on its bottom, leading them to the collection area, where they will be evacuated through the purging valve 9. For fixing the filter, the screws 11 are mounted on the sole support of the filter.

For using this filter in the circuit of the water supply for the injection of drilling facility, its main advantages are capitalized, such as:

- high filtering capacity because of the large surface of the filter element;
- convenient cleaning by purging with compressed air;
- ensuring purity for the injection water;
- eliminating the human intervention for removing the filter element when cleaning;
- increased operation safety, compared to previous constructions.

3.2. Constructive solution for the automatic distributor in case of supply water high pressure

An automatic distributor with double function for controlling and adjusting the injection water was conceived and designed, in case the local supply water pressure reaches values of 3-4 MPa, due to work conditions. The use of this automatic distributor eliminates the possibility of blocking the drill due to decreasing the pressure of water evacuating the debris from the mine hole, or to interrupting the water supply and avoids the possibility of water penetration in the drill in case of high pressure values (double function).

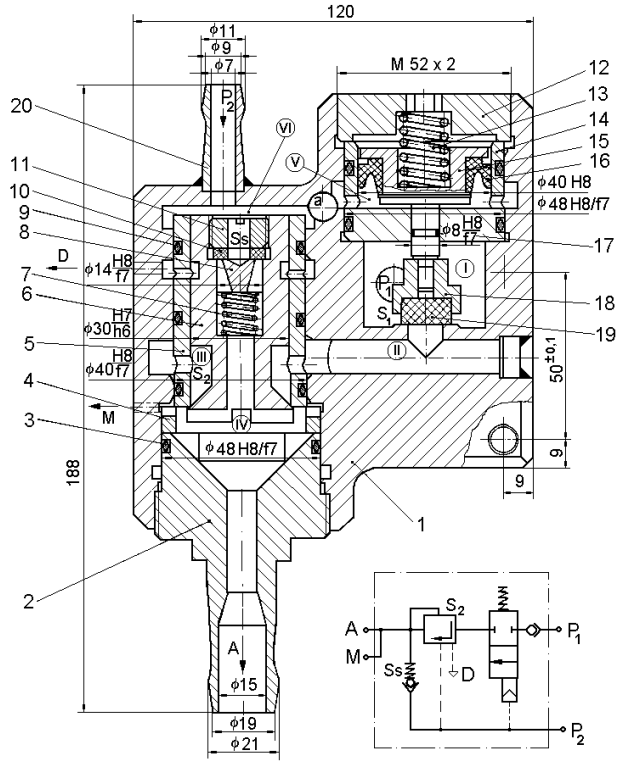

Fig. 3. Automatic distributor in case of high pressure from water supply

Figure 3 presents the constructive solution of the automatic distributor for injection water pressure control and adjustment, in case of high pressure from local water supply. This is made of a distributor with 2 positions (open-closed), a pressure regulator and a direction valve, mounted to one body 1. Body 1, made out of steel, has 2 holes, one with ϕ40 H8 diameter and one with ϕ48 H8 diameter.

The distributor with 2 position is mounted inside the hole with ϕ40 H8 diameter, for controlling the injection water supply of the drill. This distributor is composed of the intermediate element 14, mounted on body 1, where the moving piston which controls the opening of the distributor (valve S_1) shifts, made of the element 15 and the rubber lip 16. Valve S_1 represents the execution element of distributor and is made of the pellet body 18 mounted on the rod of the element 15, the rubber pad 19 and the valve seat, formed in the body 1.

Maintaining the distributor in closed position can be done by spiral 13, mounted prestressed by the screw cap 12. The prestressed arrow of spiral 13 corresponds to an elastic force to be overcome by the force given by the pressure of the

pneumatic command signal that acts on the command piston distributor. The sealing of the intermediate element 14 in body 1 is done by two rubber rings.

In the hole diameter ϕ40 H8 there is mounted the pressure regulator and the direction valve. The pressure regulator is made of piston 6, which slides into nut 5. The conical part of pistol 6, made of stainless steel, together with the internal edge of nut 5, forms the valve S_2 for water pressure control, by strangling its flow section through the valve. The nut 5 is sealed from body 1 by 3 rubber rings.

Piston 6 has an axial hole, where the direction valve is mounted, made of the rubber seat 10, fixed to the piston body by the screw cap 11 and the piston element 8, pressed against the seat by the spiral 7. The screw cap 11 is crossed by axial channel. The spiral 7 has been sized in order to allow the direction valve to open in case of water pressure lower than 0.2 MPa.

Connecting the automatic distributor to the drill water supply system is done with a quick coupling sleeve with clip DN13 which connects the output hose from the water filter and the distributor room I. The pneumatic command signal, the measuring manometer for water pressure on the regulator and on the drainage circuit exit, are connected by hose nipples.

The automatic distributor operation in case of high values from water supply pressure, short called water-air automatic distributor, is presented below. On rotation-percussion distributor operation (fig.1), for supplying with compressed air the pneumatic drill, the pneumatic control signal penetrates the rooms V and VI of the water-air automatic distributor by the connection nipple 20 and by the channel "a" which makes the communication between these 2 rooms. The compressed air acts on the distributor piston (valve S_1), opening it, and on the pressure regulator, opening the regulator valve S_2.

When opening the water distributor, by opening the valve S_1, the water from room 1 of pressure p_1, coming from local water supply, penetrates through the circular channel II to the communicating room III, passes through the valve S_2 and arrives to room IV, and then reaches the drill through the exit tap 2 (exit A) and through the connection hose.

In case the water pressure from local supply, in room IV, is higher than compressed air pressure from room VI, it results in the progressive closing of valve S_2, by moving the piston 6 upwards, performing the strangulation of the flow section through the valve, which makes the water pressure from room IV to be lowered to a value close to the compressed air pressure in room IV. All this time the direction valve S_3 is kept closed due to the force of spiral 7 and of the water pressure in room IV.

The pressure regulator of the water-air automatic distributor performs the drill injection water pressure reducing function, when it has high values (0,6,....4 MPa), avoiding the danger of water penetration inside the drill, which would mean its premature out of order. The strangulation of the wash water passage section to the drill, in case its pressure is higher than the drill compressed air supply pressure, is done by the valve with conical check S_2 formed by the nut 5 and by the piston-valve 6 (fig. 3). This strangulation is proportional with the local supply water pressure value, so at the drill entrance the water will have a pressure close to the compressed air pressure.

3.3. Constructive solution for the automatic distributor in case of supply water low pressure

In case the pressure of local water supply has low values (for example the adduction galleries of the hydrotechnic structures), below the minimum allowable value (lower than 0.2 MPa), there is the danger of plugging the mine hole and so to block the drill. For this situation, there was conceived and designed an automatic distributor to control the injection water for the drill, provided with a pressure regulator which automatically unfolds a compressed air jet that produces a water-air mix, with a pressure value close to the one of the compressed air.

Automatic distributor has a similar construction to the one presented in the previous paragraph and is provided, in this case, with a pressure regulator having the role to raise the water pressure from the network and a direction valve, also shortly called water-air automatic distributor. The pressure regulator works on the principle of a water pump with air injection, where a fluid (water) is accelerated by the action of an active fluid stream (compressed air).

Two fluids with different roles flow through jet machines: the driven fluid, whose total pressure should be increased by the transfer of the momentum he gets in the boundary layer of the jet, and the active fluid having initially a high enough total pressure to ensure the jet formation and consequently the device operation. The injector scheme is unitary and contains three essential parts: the nozzle - for the active fluid acceleration; the mixing chamber – ensuring the fluids momentum exchange; and the distributor – where the increase of static pressure by lowering the kinetic energy is done. For the injector pressure regulator, the primary agent (active fluid) is compressed air, pressure 0.4-0.6 MPa while and secondary agent (driven fluid) is water for mine hole washing, minimum allowed pressure 0.2 MPa.

The peculiarity of this injector type is the big difference between the densities of the two fluids (water and air), which makes the value of the mass injection coefficients to have the order 10^{-5}.

The constructive solution of the water-air automatic distributor, in this case (figure 4), is based on mounting on the same body 1 the distributor with two positions in the hole diameter ϕ40 H8 and the pressure regulator in the hole diameter ϕ40 H8.

In the hole diameter ϕ40 H8 there are mounted the intermediary elements 21 and 27, with nut shape, sealed to the body 1 by two rubber rings. The direction valve S_4 is mounted inside the element 27, made of the work element 23 where the rubber pill 22 and the spiral 24 are mounted. The seat of the direction valve is inside the element 21. The adjustment of the pre-stressing arrow 24 (and therefore the opening pressure of the valve) is carried out by the set of spacer rings 31. The direction valve S_4 is fixed inside the intermediate elements 21 and 27 by the screw cap 28. This forms also the nozzle (hole) of the pressure regulator.

The pressure regulator made of these elements is fixed inside the hole ϕ40 H8 from body 1, through the screw cap 2, which is also the outlet of the water-air automatic distributor. The distance between the nozzle outlet (hole) 28 and the

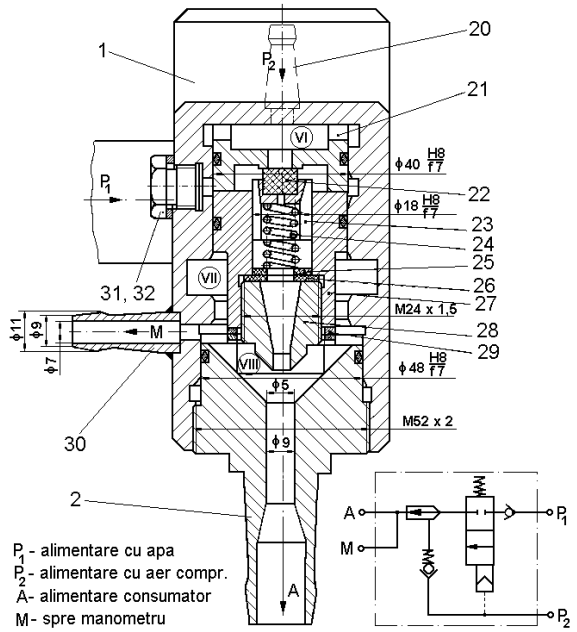

Fig. 4. Automatic distributor in case of low water supply pressure

entrance in the mixing chamber inside the connector 2 can be adjusted (up to 5 mm) by a set of spacer rings 29. The pressure regulator is provided with a nipple 20 for pneumatic signal input, with an outlet nipple 30 for attaching a manometer and with output nipple 2 to the consumer. The threaded hole for mounting the drainage nipple from the previous version, is sealed this time by the screw cap 31, sealed by the copper gasket 32.

The operation of water-air automatic distributor in case of supply water low pressure is described below. When operating the pneumatic distributor 6' (Figure 1) for drill supply, it transmits a command pneumatic signal to the water-air automatic distributor 2'.

It enters through nipple 25 in the VI chamber of the pressure regulator (figure 4) and also through the channel "a" in chamber V of the two position distributor (figure 3). The compressed air from chamber V acts on the distributor command piston 15 moving it upwards, opening the distributor valve S_1. This way the water from the filter enters chamber I through channel II, chamber VII and further to the injector area in chamber VIII. If the network water pressure has very low values (below 0.2 MPa), the compressed air from chamber VI, having the pressure 0.4-0.6 MPa (the pressure needed to operate the pneumatic drill), manages to open the direction valve and pass through the nozzle 28, where it comes out as jet to the injector chamber VIII. The compressed air jet in chamber VIII, makes a hollow which sucks and engages towards the exit the water from this chamber, resulting an water-air mix to the output "A". The

water-air mix will have the pressure value close the one of the compressed air from the pneumatic circuit (0.4-0.6 MPa).

The pressure regulator works, in this case, as a water mini-pump with air injection. This way the pressure regulator raises the water injection parameters (pressure and flow), preventing the risk of damage due to insufficient removal of debris from the mine hole and thus blocking the drill.

5. CONCLUSIONS

The implementation of automatic supply, control and adjustment system of injection water pressure (made of the water filter and water-air automatic distributor) in the construction of drilling facilities leads to the possibility of using intensive drilling regimes, with maximum speeds. This is the result of removing the drill blocking failures in the work front, in case of lack of washing water for mine holes, and the drill water entrance failures when its pressure value is higher than the one of the compressed air.

The two versions of the automatic command and adjustment distributor of injection water pressure for pneumatic drills, represents multitasking elements in mono-block constructions which simplifies the compressed air and water circuits, representing a simple and safe operation construction.

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