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INCREASING THE DESTRUCTIVENESS OF PULSATING JETS BY THE APPLICATION OF HYDRODYNAMICALLY ACTIVE SUBSTANCES

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We give the results of experimental studies of the destruction of plaster and coal-cement blocks by pulsating jets of water and water solutions of water-soluble solid polymer compounds on a base of polyethylene oxide. It is shown that the use of water-soluble solid polymer solutions as the working fluid in the generator of the pulsating jet leads to an increase in the depth of the holes and grooves by a factor of 1.5–3.5. Three figures. One table. Bibliography: 4 titles

Many studies [1, 2] have demonstrated the possibility of using pulsating jets to destroy various solid materials (rock, coal, slag, etc.). However, to enlarge the sphere of application of hydropulse technology, it becomes necessary to improve the geometric and dynamic parameters of the jets. The traditional ways—increasing the diameter of the nozzle that forms the jet, raising the pressure, choosing a rational grooved portion of the machinery, involve the need for significant alterations in the structure of the fundamental nodes of the system and an increase in the power consumed by the generator. Moreover, in the industrial use of hydropulse machinery the problem of reducing the hydraulic loss in the pipes that transport the energy vector (the working fluid) and increasing the destructive action of the jet in deep holes of depth 0.2–0.3 m or larger arises, since in this case the interaction of the jet with a monolith acquires the character of a "flooding" jet, sharply reducing the productivity of the hydropulse machinery.

One method of increasing the effectiveness of the operation of a pulse jet generator without altering its structure may be to use as the working fluid water solutions of hydrodynamically active substances (for example, high-molecular polymers—polyethylene oxide, polyacrilamide, etc.). Two of the authors and others [3, 4] have demonstrated the possibility of a significant decrease in the hydrodynamic resistance and action on turbulence through the introduction of such additives into Newtonian flows. The effectiveness of applying them depends on a number of factors, one of the most important of which is the process by which the solutions are prepared. In recent years there has been intensive work on the formation of various rapidly dissolving polymer compounds and special equipment for introducing them into the stream of water.

In the present paper we develop solid water-soluble polymer compounds on the basis of the hydrodynamically active polymer polyethylene oxide. These compounds, which have elevated mass ratio, can be made into briquettes of the required geometric shape with a given mass-absorbing surface of polymer. We study the destructive action of water jets and jets of solutions of a solid water-soluble polyethylene oxide.

The theoretical scheme of the location of the equipment during the comparative tests is shown in Fig. 1, where the following notations are introduced: 1 denotes the space for the water or water solution of solid water-soluble polyethylene oxide; 2 denotes the feeder pump; 3 is the control desk; 4 is the pump assembly; 5 is the pressure line; 6 are casettes with briquettes of the solid water-soluble polyethylene oxide; 7 is the pulse jet generator; 8 is the working nozzle; 9 is the pulse jet; 10 is the plaster (or coal-cement) block being tested, of dimensions $1 \times 1 \times 1$ m.

The experiments were conducted in three stages. At the first stage we made a comparative estimate of the destructive power of the jet formed by a homogeneous solution prepared in advance and by a solution obtained by washing the briquettes of solid water-soluble polyethylene oxide in the casettes as it is being fed to the pulse jet generator. At the same stage we chose a rational location for the casettes (from the point of view of preserving the quality of the solution).

At the second and third stages we tested the effectiveness of the use of jets with and without additives by destroying blocks of plaster and coal-cement mixture. The results of these studies are shown in Figs. 2 and 3 and in the Table.

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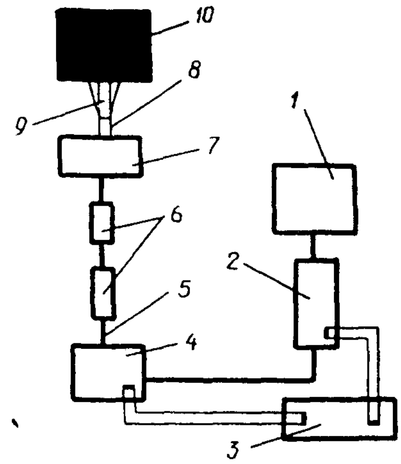

Fig. 1

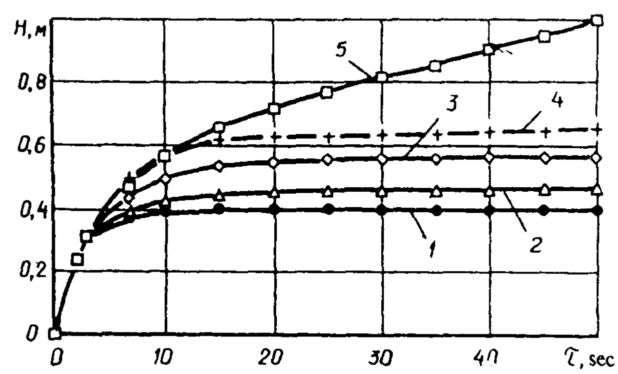

Fig. 2

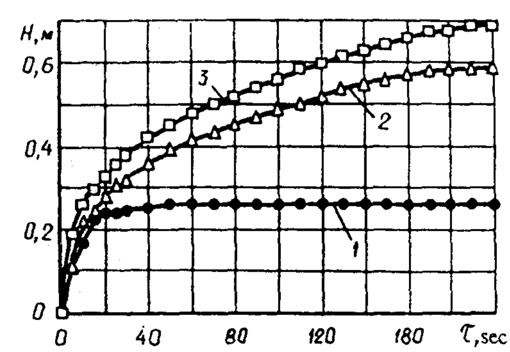

Fig. 3

Figure 2 gives the curves of variation of the depth of the hole dug in a plaster block as a function of the time the jet acts. Curve *1* was obtained for a water jet; curves *2* and *3* were obtained by applying jets formed of homogeneous solutions of solid water-soluble polyethylene oxide prepared in advance containing polyethylene oxide at 0.002% and 0.004% respectively by weight; curves *4* and *5* correspond to jets of solid water-soluble polyethylene oxide prepared in the casettes at times 25 minutes and 4 hours respectively from the first contact of the material of the solid water-soluble polyethylene oxide with the water.

As follows from Fig. 2, the pulse jets formed by the pulse jet generator and with uniform solutions prepared in advance has greater destructive capability than the water jet. However, the depth of the hole dug increases only slightly. This is due to the mechanical destruction of macromolecules of polyethylene oxide in the feeder pump and in the high-pressure pump assembly. Consequently it does not make sense to use solutions prepared in advance, while casettes with briquettes, used in order to preserve the quality of the solution, must be set up in the high-pressure region between the pump assembly and the generator. Increasing the time of contact between the material of the water-soluble polyethylene oxide and the water increases the effectiveness of the destruction of the plaster block (compare curves *4* and *5* of Fig. 2). This is due to the mass ratio of the polyethylene oxide of the briquette, and it leads to an increase in the content of hydrodynamically active substance (polymer) in the solution.

Later studies of the destructive capability of water jets and jets of a solution of solid water-soluble polyethylene oxide were conducted using two coal-cement blocks made of a mixture of cement (grade 400) and anthracite (particles of dimensions 6–10 mm) in various ratios. Such blocks make it possible to mimic coal seams of various hardness and have been used traditionally in experimental studies. The initial distance from the nozzle to the surface of the coal-cement block was 0.14 m.

Figure 3 shows the relation between the depth of the hole H dug in a coal-cement block with coefficient of hardness 1.6 on the Protod'yakonov scale and the time τ the jet has been acting. Curve *1* corresponds to destruction by a water jet, curves *2* and *3* to jets of solutions of solid water-soluble polyethylene oxide made in the two casettes. Here curve *2* refers to the case when the center of the hole being dug is at a distance of 0.5 m from the lateral and upper edges of the cube, and curve *3* refers to the case when these distances are 0.35 m.

It can be seen from Fig. 3 that if the working fluid is a solution of solid water-soluble polyethylene oxide, the depth of the hole is 1.5 to 3.5 times as large (depending on the duration of the functioning of the pulse jet generator) as that of a hole dug by a water jet.

The results of experiment on the destruction of a coal-cement block with hardness coefficient 2.5 when the distance from the nozzle to the surface of the block was increased to 0.22 m are of particular interest. This experiment verified the effectiveness of the jet in conditions that model a coal seam of high hardness. The block was worked on until the depth of each hole ceased to increase. The greatest depth of the hole dug by a pulsating jet of water was 0.22 m, while the greatest depth for a pulsating jet of solution of solid water-soluble polyethylene oxide was 0.71 m.

Water			Water Solution of Solid Polyethylene Oxide		
τ, sec	H, m	d, mm	τ, sec	H, m	d, m
10	0.19	0.75	10	0.34	45
20	0.22	0.75	20	0.37	45
30	0.22	0.75	30	0.49	48
40	0.22	0.75	40	0.56	48

Subsequent studies were directed toward determining the dependence of the depth H and the diameter d of the holes dug on the time τ during which the pulse jet generator has been working. The results of the experiment are shown in the table, from which it can be seen that a water jet digs a hole of depth 0.22 m within 20 seconds, and that further action by the jet has no effect. At the same time, in the destruction of the block by a pulsating jet of a solution of solid water-soluble polyethylene oxide the depth of the hole dug continues to increase.

The results of this experiment, which imitates the process of hydropulse cutting of coal (destruction of a coal-cement block by pulsating jets moving at a prescribed speed along the face) confirmed the increased effectiveness of jets of solutions of water-soluble polyethylene oxides. Thus, for example, the depth of the groove formed in the block after one pass of a water jet was 0.19 m, while after one pass of a jet of solution it was 0.34 m.

It was also established experimentally that when the working fluid was a solution of solid water-soluble polyethylene oxide the diameter of the hole dug was decreased. Thus the water jet forms a hole with mean diameter 77 mm in a plaster block, while a jet of solution forms a hole of diameter 52 mm. The analogous data for a coal-cement block with hardness coefficient 2.5 were 75 and 48 mm respectively. This is due to the fact that hydrodynamically active polyethylene oxide not only increases the effectiveness of the jets; it also makes them more compact.

Thus the use of solutions of solid water-soluble polyethylene oxide as the working fluid significantly increases the effectiveness of the working of a pulse jet generator by increasing the depth of the hole dug through a significant reduction in the hydrodynamic resistance in the grooved portion of the fundamental nodes of the generator and transport pipes, and also an increase in the geometric and dynamic parameters of the jet.

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