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SCIENTIFIC CHALLENGES OF THE USE OF ABRASIVE WATERJET TECHNOLOGY IN MINING

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Abstract. It has been conducted observing research of existent theoretical groundwork in the area of abrasive waterjet technology referring to mining. It also has been marked some principal challenges and possible directions of their solving.

Keywords: abrasive waterjet, waterjet technologies, challenges.

Introduction. Nowadays it is given special attention to the creating and development of the mining equipment providing increase of technical and economic performance and secure labor conditions. One of the most preferable decisions of the problem from this point of view is the use of waterjet technologies [1, 2]. They have following advantages as to the mining [3]:

- Increase of depth and velocity of cutting in several times;
- Ability to destruct hard rocks;
- Absence of dust formation;
- Explosion, intrinsic and fire safety.

At this the effectiveness raises sharply with add of abrasive to the water stream [2 – 4]. Thus the abrasive waterjet (AWJ) is of exceptional use in extreme conditions either for hard rocks destruction. But there is a pronounced tendency to apply this technology without paying attention to its features and properties [5]. So giving a view of them as well as designating scientific challenges is an evident need to foster development of the AWJ in mining.

Common section. At first let us consider what is established and known reliably about this technology in general.

There are two ways in which abrasive slurry could be formed – either by direct pumping system or by entrainment system [3]. In the first one abrasive is pre-mixed with water and then pumped through a nozzle in order to form an abrasive waterjet. The second way is when abrasives are mixed with stream of water in existence by this time.

Destruction of materials with AWJ is caused mainly by impact of abrasive particles in the stream, so it is possible in most of tasks connected with the considered technology to neglect an influence of the water [2, 3, 6]. In this case

the main function of the water is to accelerate particles within the formed abrasive water jet, then carry them off surface of the destructed material.

Parameters that influence on the effectiveness of AWJ could be divided on parameters of abrasive particles, technical parameters, and parameters of hydro system and geometry of an instrument.

As criteria of estimation of the efficiency of material's destruction by AWJ is used such indices as depth of cut and wearing.

Parameters of abrasive particles that influence on the named indices are their size, density (mass/volume), shape and type [2, 3]. Shape of a particle commonly is a sphere [3]. Abrasive's type is significant in some productions where one of the most important indices of a process is a quality of a machined surface. In mining, except of decorative processing of natural stone, such tasks do not exist. More dense abrasives cause a little bit more effective destruction, but taking into account that density depends on type of abrasive and more dense ones are more expensive as a rule it is not rational to rely on this indices when selecting an abrasive. In mining the most useful according to complex of various reasons is quartz sand [2, 3]. Dependence of effectiveness of the process on averaged particle's size is negative parabolic function, in other words with the increase of a particle's size effectiveness rises to some turning point and then decreases.

Technical parameters of the AWJ are standoff distance, traverse speed and attack angle. Standoff distance affects in a similar way to particle's size. Effect of traverse speed exponentially decreases with increase of its value. Influence of the attack angle depends on a type of destructed material either ductile or brittle. For ductile materials the most effective angle is about 20 degrees, for brittle – 90 degrees [7]. Almost all rocks belong to brittle materials [3].

To the parameters of hydro system delivered water pressure (made by pump), water density, orifice diameter and orifice flow coefficient. Comprehensively they have been taken into account in indices of water flow velocity. By the way according to [7] neglect geometry of instrument could be neglected in computations if it is known that satiation of a water stream with abrasive is in optimal mode. So the value of velocity of abrasive water jet in this case would be half of water flow velocity value. Efficiency of the process is in direct proportion to water pressure. Influence of other parameters of hydro system is out of much interest.

Above was described the example of excluding and not taking into account geometry of an instrument. It is important because there is not sure understanding of processes inside instrument and their influence on effectiveness of overall technology. The most commonly used indices of efficiency of 'interi-

or' processes in instrument are velocity of abrasive water jet. Besides could be necessary to determine density of abrasive water jet and concentration of particles in it. Reliable description of the forming and propagation of abrasive water jet with out on represented indices is one of the most important and interesting scientific challenges of the AWJ. To solve these problems nowadays are trying by the way of consideration abrasive water jet as a multiphase flow of water, abrasive particles and air [8].

But much more significant is to give a theoretical description of destruction as a complex of various tasks. Among them interaction between particle and surface of destructed material, determination of surface's shape after particle's impact, determination of volume of carried away material after particle's impact and summation a lot of such volumes in order to compute depth of cut or wearing, estimation of the possibility macro and micro cracking, conditions of cracks' origin and directions of their following propagation and how cracking affects indices of destruction efficiency with AWJ et cetera. Most of them are rather complicated individually.

Meet these challenges in the most advanced way possible with application to them of structural-temporal approach of fracture mechanics [9]. It considers destruction as erosion, which consists of simultaneously taking place deformations such as elastic and bound deformations and cracking. In reference to mining separately have been solved tasks of mathematical description of bound deformations [10], microcracking [11] and even their combination but only for sole particle's impact and in quite idealistic case [12]. In case of successful fulfillment of other described challenges it could be possible implement the AWJ in advance works conjointly with mechanical tool (fig. 1) in area of hard rocks where at present is used blasting method.

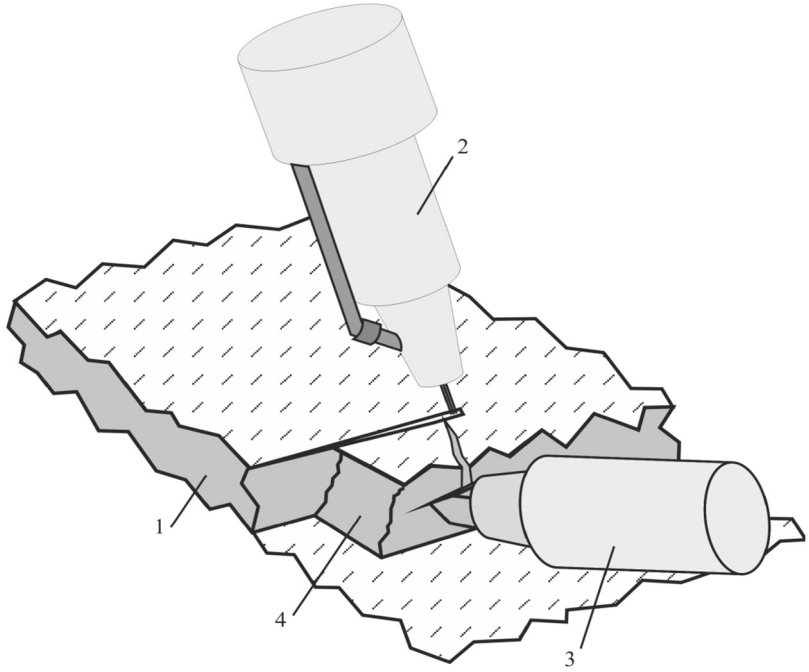

Figure 1 – Scheme of combined destruction of hard rock with AWJ and mechanical tool [3]: 1 – rock; 2 – AWJ; 3 – mechanical tool; 4 – pillar midlevel

Summary. In the paper there are represented features of waterjet technologies regarding mining, emphasized advantages of the AWJ, considered reliable knowledge about the technology, denoted most relevant challenges of it and marked directions in which their solutions could be found.

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