Classification of hydraulic borehole mining technological processes during pay zone development

2015 IOP Conf. Ser.: Earth Environ. Sci. 24 012004

(http://iopscience.iop.org/1755-1315/24/1/012004)

Classification of hydraulic borehole mining technological processes during pay zone development

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Abstract. Relevance of the work is defined by the need of solid mineral deposits development by hydraulic borehole mining. The main advantage of the method is that the extraction of minerals could be carried out in difficult geological conditions, excluding tunneling of mine workings and quarries construction. The article presents a generalized and systematic classification of hydraulic borehole mining technological processes during pay zones development. According to the classification three groups of technological processes were defined: main, auxiliary and hydraulic borehole cutting head monitoring. The main technological processes are: rocks fracturing, suction and lifting of the slurry to the surface, delivery of the slurry to the slurry pump. Auxiliary processes include: cleaning of intake ports of slurry retrieval device, drilling of pilot hole and maintenance of mining chambers roof sustainability. To hydraulic borehole cutting head monitoring processes refer: operation modes control, tripping operation and rotation.

1. Introduction

The whole complex of hydraulic borehole mining (HBM) could be divided into four technological processes [1]: well drilling (construction); pay zone development (minerals extraction); slurry processing; pre- and post-works – producing of working agents, facilities construction, assembling-disassembling, mine reclamation and etc.

One of the most time-consuming HBM process is cutting of particles from the formation to create slurry of liquid and rock material and delivery of the slurry to the surface. For more deep and systematic view, a classification of HBM technological processes during pay zone development was created (figure1), at that, 3 groups of technological processes are defined: main, auxiliary and hydraulic borehole cutting head monitoring.

2. Materials and Methods

Main technological processes are realized throughout the whole process of minerals extraction. To these processes refer: rock fracturing by a jet of pressurized water (cutting of minerals from the formation), suction and lifting of the slurry to the surface, delivery of the slurry to the slurry pump.

Rock fracturing during HBM process could be realized by the following methods: hydrodynamic (water jet, hydropercussion and depression), mechanic and their combinations [2].

Suction and lifting of the slurry to the surface could be done through: discharging process, displacement process, mechanical process and their combinations. At that, discharging could be created by airlifts, hydraulic elevators (jet pumps) and vortex unit. [2].

Delivery of the slurry to the slurry pump could be realized by means of directed or free flow.

The following could be referred to the directed flow:

– discharging, created by airlifts, jet pumps and vortex device;
– displacement, created by back pressure in extraction chamber and working agents;
– water jet, created through application of pressurized water jet produced by special water jet pumps[3].

Free flow of slurry is provided by specially formed bottom of the cone chamber. The cone form of the chamber could be created due to the angle of natural repose or due to the application of water jets with specially placed jet nozzles. [4].

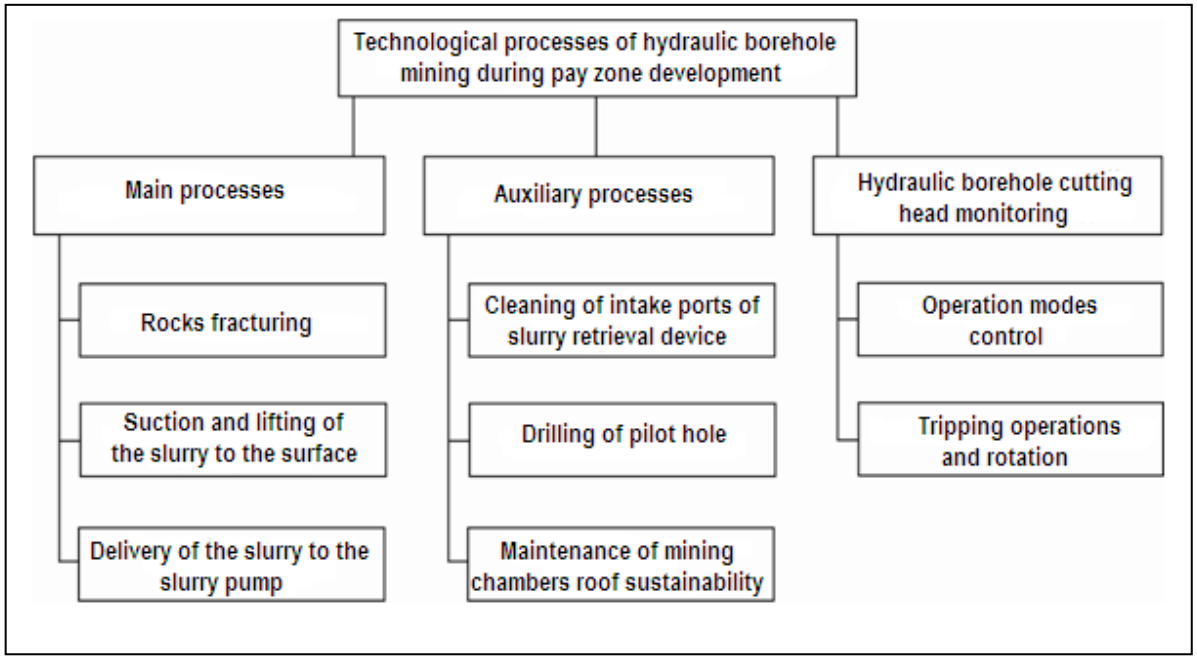

Figure 1. Classification of hydraulic borehole mining technological processes during pay zone development

Auxiliary technological processes are realized in case of necessity during the process of mineral extraction, namely: cleaning of intake ports of slurry retrieval device, drilling of pilot hole and maintenance of mining chambers roof sustainability.

Irregularity of rock fracture, heterogeneity of formation, roof caving and insufficient slurry dilution during HBM lead to constant clogging (blocking) of slurry retrieval device intake ports. The following methods could be applied for cleaning of slurry retrieval device intake ports:

– hydrodynamic, which in its turn is divided to:
  - water jet - realized with the help of special gumming nozzles, forming jets directed to the intake [5];
  - water impulse - created by hydraulic bumps in bottom-hole zone, which in its turn are produced by airlifts, hydraulic elevators, hydrodynamic generators, explosions, airguns, acoustic guns as well as by raising/lowering and rotating of hydraulic cutting head.
– mechanical, realized by shells, blades, pins and other destructive element which are the parts of hydraulic cutting heads [6];
– pneumatic, realized via injection of compressed air into the intake port through special downhole pneumatic units (gas accumulating high pressure caps) [7]
– mixed method.

Drilling of pilot hole could be fulfilled by hydraulic cutting head without replacing of drilling assembly, which allows increasing of working productivity due to quick transformation from the one

process to another. This technological process could be realized according to three technological schemes:

- drilling of pilot hole during extraction [6, 8, 9];
- drilling of pilot hole and further extraction [10, 11];
- drilling of pilot hole with casing and further extraction [10, 11].

Mining chambers originate during pay zone development by HBM method. At that, if the roof is made from a weak rock it may collapse. Following methods could be used to provide mining chamber roof sustainability:

- construction of artificial roof (mine working support) [12, 13];
- applying of special systems for pay zone development, namely: trapping [14]; successive working out of mine sectors [15], cut-and-fill mining [15], creating of back pressure in chamber by working agents (water, compressed air) [6, 16]; creating of chamber with the diameter not exceeding the dome of natural collapse [12];
- mixed method.

Technological processes of hydraulic borehole cutting head monitoring are the processes for cutting head operating during minerals extraction, namely: operating mode control, tripping operations and rotation.

Operating mode control of hydraulic borehole cutting heads could provide three modes of operation: combined operation of jet drilling and slurry retrieval units, jet drilling unit autonomous operation, slurry retrieval unit autonomous operation. The following technologies could be used to control the operating mode: valves, open-close channels for supplying of working agents [10]; separate channels to supply working agents for jet drilling and slurry retrieval unit [11], turn on and turn off of working agents supply [9].

Joining of hydraulic borehole cutting heads during HBM process could result in difficulty of tripping operations and rotation. It is explained by the fact that hydraulic borehole cutting heads have special double pipe column which require nonstandard casing connection. This results in inability of rotary drilling. Besides, there is a small distance between the cutting head and the casing string. When the cutting head is rotated from the surface it increases the risk of cutting head locking and unscrewing of casing pipe bottom. The mentioned problems could be solved by:

- reducing of pipe number in the construction of hydraulic borehole cutting heads [10, 17];
- applying of downhole hydraulic engines based on turbodrill or screw motor construction [8], or Segner turbine [17].

3. Conclusion

The presented classification, organize and generalize the information concerning technological processes for pay zone development by HBM method. The classification data will significantly simplify the method of choosing and improving of solid minerals deposits development by hydraulic borehole mining technology.

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