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Significant damages of core diamond bits in the process of rocks drilling

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ABSTRACT

Technology of rotary drilling with diamond bits requires expert knowledge and experience. Drilling modes i.e. combination of pressure on the bit, the rotational speed of the bit, and the quantity and quality of lavage has a decisive influence to achieve maximum drilling speed with minimum consumption drilling bits with diamonds. Optimal setting of the operating mode of technological parameters pressure force, speed and lavage is a fundamental prerequisite to achieving maximum productivity and overall streamlining of the drilling. When talking about the use of diamond bits the careful handling is necessary since assembly operations till drilling process. The shedding of diamonds from the cutting rim and related premature wear, destruction of the entire drilling tool results in inefficient drilling and high cost of labor and drilling tools. This paper deals with the dynamic faults of diamond core bits in drilling of selected rock. We analyze the causes and consequences of developing these faults. The frequency spectra of vibro-acoustic signal of drilling tool with water flush, without water flush, with the bit for drilling of the rock and without bit no-load are presented. Obtained knowledge about the failure causes contributes to the prediction of possible emergency conditions, to the prevention of the operating mode faulty setting. The paper points out possibilities for efficient use of the drilling process from both energetic and economic point of view.

1. Introduction

Technological development in the mining industry and geological exploration is very fast, especially in drilling techniques. Technical development of deep drilling naturally goes towards modernization, innovation and optimization of the economic and energy resources. In the development of drilling techniques we can observe two main tendencies. On the one hand there is an effort to achieve the highest possible performance in speed and depth [1,2]. On the other hand there is an effort to obtain the most perfect rock specimens in order to abstract the details about geological, engineering and hydrogeological characteristics of the rocks. The choice of method for deep drilling depends on its purpose, diameter and drilling depth, the type and geomechanical properties of drilled rock, and last but not least on technological progress and drilling tools. When excavating wells in hard rock the rotary core drilling with diamond bits is crucial. The main advantages of core drilling are the ability to extract the core with intact rock structure and the ability to excavate under any inclination [3–5]. Accordingly, based on scientific knowledge and assumptions about the geomechanical properties (abrasiveness, strength) of rock we then consider how drillable the rock is. For hard rocks like andesite and limestone, which are the subject of our research, the most suitable is rotary core drilling with diamond bits. Working mode is in high speed revolutions, the plain water is used for water flush. The advantages of this

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technique are deep wells with small diameter and possibility to drill under any inclination. Additionally, diamond core bits are largely resistant to abrasion and speed of the drilling progress is greater compared to other drilling technologies.

2. Specification of core drilling process by diamond bits

By monitoring the drilling process we have enough information about the impact of adjusted rock drilling operating mode. Working mode represents synergistic effect of the main technological components of the drilling process. The main control variables are the pressure force F (N) of the drilling tool on the bottom of the well, the drilling tool rotation speed n (rps), water flush flow per time unit ($m^3 \cdot s^{-1}$) and the quality of the water flush which is determined by its physico-chemical parameters. All of these components are independent of each other; during drilling they can be individually regulated. Knowledge of drilling mode is the basis of knowledge for the rock core drilling process with diamond bits. For these reasons in practice we can find drilling and embossing kits with pre-defined operating mode by the manufacturer. At best, it sets the mode based on the average geomechanical properties of the rock or experience (heuristics).

From a systemic point of view, rock drilling process can be simply understood as a system with the following control variables as inputs (Fig. 1):

- revolutions of the drilling tool n (rpm or rps),
- pressure force F (N),
- volume of lavage of the drill with water Q ($m^3 \cdot s^{-1}$).

The outputs of the system are controlled (or state variables):

- speed of drilling v ($m \cdot s^{-1}$),
- torque M_k ($N \cdot m$),
- specific work of separation w ($J \cdot m^{-3}$),
- work capability of the tool $\varphi = v/w$ ($m^2 \cdot s \cdot kg^{-1}$),
- acoustic or vibro signal.

Where w and φ are state variables of the process, which are not directly measurable in real conditions. The process of disintegration affects additional state variables:

- properties indenter (drilling tool),
- geomechanics properties disintegrated of the rock mass.

In the process of rocks disintegration occurs power consumption distribution:

- disintegration of rock,
- conversion of substantial part power consumption to heat,
- tool abrasion,
- vibration of drilling rigs,
- vibro-acoustic of rock disintegration.

Specimens of two types of rock i.e. andesite and limestone were drilled under laboratory conditions on a test stand, in experimental measurements of the core drilling process (see Fig. 2).

The experimental drilling stand is constructed for horizontal drilling with the core diamond bits. It offers the possibility of the automatic regulation of measured output variables namely revolutions (rpm) and pressure force (N). In the automatic mode the drilling stand is fully controlled via PC. The revolutions (rpm) and pressure force (N) are entered by software (program) in automatic mode. These variables are maintained on constant level via drilling stand. Currently, the drilling stand consists of three basic parts: controlled propulsion of the drill bit, a series of sensors and control system Twido that communicates with a PC. The computer records desired output data. Vibro-acoustic signal of drilling stand is measured by the system ADASH 3900-II. The sampling frequency of the measured signal is $f_s = 18{,}000$ Hz. Experimental drilling was realized for each of the selected rocks, where it was

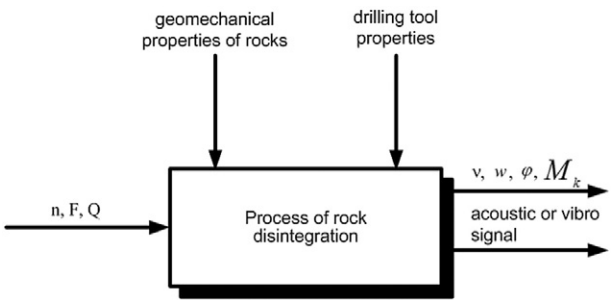

Fig. 1. Principle scheme of the rocks disintegration process.