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SCIENCE OF MINING MACHINES

Variation in Energy and Production Data of Pneumatic Percussive Machines in the Uplands

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Abstract—Under study is a production system composed of a power motor, compressor, pneumatic percussive machine and a treated medium. Based on the generalized theoretical and experimental data, the author relates productiveness of pneumatic percussive machines, energy intensity of rock breakage in the uplands with the rare atmosphere and elevation of the machine work site above sea level. The obtained results offer a reason-why approach to selection of the pneumatic percussive machine parameters for operation in the uplands.

Keywords: Motor, compressor plant, pneumatic percussive machine, rock breakage, uplands, atmospheric pressure, efficiency, productiveness, energy intensity.

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INTRODUCTION

Pneumatic percussive machines are widely used in mineral mining, e.g jackhammers and concrete breakers, hand drills and hard rock drills, DTH hammers and hammer attachments for ripping and crushing. Blow energy of these machines, depending on the model can be from tens to thousands joules.

Performance of pneumatic machines—capacity and energy intensity—is governed by the value compressed air pressure from stationary or movable compressed-air plant. When such machines operate in the uplands, due to lower air density, performance of the machines differs essentially from the ratings of normal conditions [1].

Currently in the Kyrgyz Republic, some mineral deposits are being developed at the altitudes from 2 to 4.5 thousand meters above sea level. According to the rating scale of the International Civil Aviation Organization [2], in the standard atmosphere, relative variation in air pressure with altitude is given by:

$$\frac{p_h}{p_0} = \left[1 - \frac{0.0065h}{288.15}\right]^{-5.2561}, \tag{1}$$

where p_0, p_h—respectively, air pressures at sea level and at altitude h, m.

In conformity with this formula, at the altitude from 4 to 4.5 thou m, air pressure is $(0.608 - 0.570)p_0$, which is almost half normal pressure at seal level. This fact can essentially affect capacity and energy impact of pneumatic machines [1]. Thus, it is necessary to study effect of highland conditions on performance of pneumatic percussive machines in terms of upland deposits in Kyrgyzstan.

Actual pressure measured at working sites at Kumtor deposit located at altitude of 4–4.5 thou m was from 442 to 467 mm hg [3], which corresponds to 0.620–0.587 MPa at a latitude of 41–42°. These values differ from the calculations by (1) by 2–3%, which implies applicability of the formula in the further analysis of the altitude and air pressure correlation. It is worthy of noticing that in the altitude range from 0 to 4 thou m, the relation (1) is close to linear and, to an accuracy of 2% at the most, can be approximated by the function:

$$\frac{p_h}{p_0} = 1 - 10^{-4} h. \tag{2}$$

Let us consider a system composed of drive motor DM, compressor C, percussive machine PM and rock R to be broken (Fig. 1). The motor, compressor and percussive machine are characterized by energy input N and efficiency η, and rock is characterized by fracture energy consumption q understood as energy required to fracture unit volume of rock.

1. INFLUENCE OF UPLAND CONDITIONS ON COMPRESSOR PERFORMANCE

It is assumed that energy source is an AC asynchronous electric motor which drives the shaft of a piston-type compressor. Depending on the motor type, its efficiency η_1 under rated loading is 0.8–09. When the actual and rated load ratio is changed from 0.5 to 1.25, efficiency alters insignificantly [4] and, thus, its value can be assumed constant. Then the compressor shaft energy input is: $N_1 = N\eta_1$ (N—energy input from main).

The output N_2 of the compressor is governed by polytropic air compression [5–7]:

$$N_2 = m(m-1)^{-1} p_a Q \left[\left(\frac{p_1}{p_a} \right)^{\frac{m-1}{m}} - 1 \right], \tag{3}$$

where m—index of polytrope; p_a—inlet air pressure of the compressor; Q—compressor capacity; p_1—output air pressure of the compressor.

The ratio p_1 / p_a depends on the compression chamber size and is constant for a given compressor. For instance, for a compressor generating compressed air pressure $p_1 = 0.7$ MPa in normal air conditions, $p_1 / p_a = 7$.

In conformity with (2), at the altitude h, the compressor output pressure p_{h1} is:

$$p_{h1} = p_{01}(1 - 10^{-4} h), \tag{4}$$

where p_{01}—output pressure of the compressor under normal air pressure.

Aimed to estimate supplied power of the compressor in the upland conditions, some assumptions are admitted. A compressor capacity only depends on the speed of its shaft and on the size of the compression chamber, and is independent of pressure, moisture content and temperature of air [5]. The polytrope index m in the test ranges of temperature and pressure is also constant. It follows from (3) that, subject to these assumptions, the compressor output is directly proportion to air pressure.

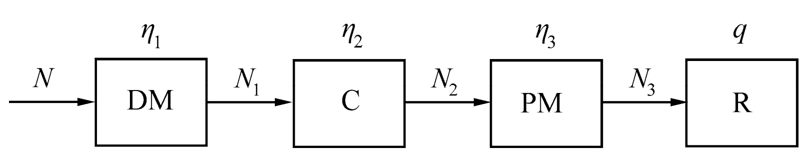

Fig. 1. Chain of energy transformation.