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INCREASING THE MINERS SAFETY IN THE UNDERGROUND COAL MINING

With the deterioration of mining and geological conditions of coal seams and increasing the longwalls load, various emergencies are increasingly occurring. Moreover, the analysis of the circumstances and causes of accidents indicate that increasingly their main cause is the human factor. However, this is not always the worker's fault. Sometimes it is difficult for miner to assess the situation in the workplace due to the presence of many distracting and masking factors, as well as his psychophysiological condition. Heavy and stressful working conditions, personal fatigue "provoke" the miner to simplify operations by disregarding the requirements of safety rules. Therefore, it is important to establish the interconnection between the level of miners injuries in coal mining and their physiological capabilities during of making the production operations.

Really, at implementation of productive process operations the mortgage of safe mining is accordance of power-hungriness of works to physical possibilities of miners. These possibilities can be estimated by the energy expenditure of the miners organisms. According to the amount of energy expenditure to perform certain operations over a period of time, we can set the intensity of energy expenditure of the body and assess the difficulty of work for a particular worker. That is, the total energy expenditure of the worker (E_T, kcal) when performing the operation or their combination, constituting a certain production cycle with a duration of t is determined by the expression (Nehrii et al. 2017)

$$E_T = \sum_{i=1}^{n} (N_i t_i), \tag{1}$$

where t_i - the duration of the i-th operation (sub-operation), min., and the weighted average energy expenditure for the production cycle (N_T, kcal / min.) taking into account the forced breaks, will be (Nehrii et al. 2017)

$$N_T = k_w \sum_{i=1}^{n} (N_i t_i) \Big/ \sum_{i=1}^{n} t_i , \tag{2}$$

where k_w - the coefficient of working time density.

The energy expenditure of the human body in different studies was determined in different ways: by determining the reduction of energy resources of the organism; by measuring heat production; by the magnitude of the oxygen demand; by determining the amount of work spent on the implementation of production operations; by heart rate. The most universal is the method of determining energy expenditure by heart rate, because it is faster, simpler and allows to quickly determine the condition of the worker.

According to the results of studies presented in (Zolina et al., 1983) and (Research Report, 1994), a linear dependence of energy expenditure of miners on heart rate, which has the form (Nehrii et al. 2017)

$$N = 10{,}4(HR - 71{,}6) \qquad W \tag{3}$$

(R^2=0,9; $t > t_{cr}$ (22,08>2,06); $F > F_{cr}$ (225>4,24))

To verify this dependence and determine the difficulty of the miners in performing certain operations, observations were made on the miners with the fixation of their physiological and ergonomic characteristics. 643 heart rate measurements were performed during various operations by different miners. Then from expression (3) the current energy expenditure was determined, and from expression (2) - the average value of energy expenditure of the miner's body during the performance of a particular operation. It was found that the heart rate of miners varies from 76 to 168 beats/min. (on average from 81 to 145 beats/min.), and, depending on the type of work performed, the energy expenditure of their organisms varies from 46 to 1003 watts (on average from 91 to 760 watts).

Comparison of the energy expenditure of miners with work schedules showed that the underground workers of the main professions during the shift experience increased physical activity. The body's total energy expenditure often reaches or exceeds acceptable values long before the end of the shift. They show earlier signs of fatigue. The total energy expenditure during the works was determined from expression (1) and compared with the allowable (290W) and optimal (174W) values of energy expenditure of the organism, which are regulated in the normative document (State sanitary norms and rules, 2014).

To assess the difficulty of work, an indicator was adopted (Nehrii et al. 2017)

$$k_в = \frac{N_T}{290}, \tag{4}$$

where 290 is the conditional limit of the difficulty of continuous work without rest for able-bodied men, W.

In cases where $k_в \geq 1$, working conditions are harmful (State sanitary norms and rules, 2014), otherwise - the worker performs his duties in a safe environment. Comfortable working conditions will be in the case when energy consumption will not exceed 174 W ($k_в$<0,6).

The study of accidents data at the mines of the Pokrovsky and South Donbass coal districts, consideration of work schedules related to an accident, allowed to establish the patterns of miners injuries during the main production processes.

Determining the energy expenditure of the miners' bodies affected by the production cycle operations that preceded the occurrence of the adverse event, led to the conclusion that before the injury, the performers worked in hazardous conditions due to the difficulty of work.

The comparison of accidents and the coefficient of severity of work, calculated from expression (4), indicated that most injuries were received at $k_в$>1 (mostly $k_в$ was in the range of 1.04-2.41). All

operations were regulated by the work organization schedule and were performed in strict compliance with it. That is, the implementation of regulated work was accompanied by injuries to workers. In this case, one of the ways to reduce the level of injuries may be by reduce the loading on the person by changing the improvement of the work schedule and optimize of the operations process. To do this, we can increase the duration of breaks for compensatory rest or increase the number of workers on labor-intensive operations. Then a break for compensatory rest is required for the duration of work t_w (min.) And can be determined from the expression (Nehrii et al. 2017)

$$t_r = \left(\frac{N}{4{,}2} - 1\right) t_w . \tag{5}$$

Thus, it was found that accidents can be associated with employee fatigue, when the physical capabilities of miners do not correspond to the energy intensity of production operations that make up the work schedule. Therefore, it is necessary to further study the physiology of miners to ensure safe working conditions.

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EVALUATION OF MATERIALS FROM THE EXCAVATION OF THE OUENZA HEMATITE DEPOSIT (NORTH-EAST ALGERIA) BY GRAVIMETRIC ENRICHMENT

Abstract

Quarries and mines that exploit hematite ore Fe_2O_3 usually have a large quantity of waste rock with low iron content, stored in the slag heaps of quarries or mines without enrichment. This work consists in finding solutions to this product to make it more or less usable in industries. As an example of use, the Fe_2O_3 content in the clinker after grinding and homogenisation varies between 1 and 8%. Africa. After chemical and mineralogical analysis of the whole product, the large percentage of existing chemical elements is the hematite ore Fe_2O_3 which has a low iron concentration. To improve its iron content, it must be treated by chemical and hydro mechanical