THE EXPERIMENTAL STUDIES OF THE AUTOMATIC CONTROL METHODS OF MAGNETIC SEPARATORS PERFORMANCE BY MAGNETIC PRODUCT

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ABSTRACT

The objective of this article is to experimentally test for the automatic control of the magnetic separator efficiency of the magnetic product. The developed process depends on the fact that the electromotive force in electric coil located on the pole of the magnetic system of the separation depends on its efficiency with the magnetic product. A functional scheme of the measurement process is given to achieve a magnetic separator by the magnetic product. The theoretical formulas that describe the formation of a pulsed magnetic field in a magnetic separation zone are presented and the magnetic induction of this field is based on the physical variables that characterize the operating system of the damp magnetic drum class. The theoretical reliance of the magnetic induction of the magnetic field in the working zone on the amount of magnetite in the concentrate layer on the surface of the separator drum is determined. The methodology and functional scheme for conducting experimental studies in an industrial environment of an iron ore-dressing factory of the proposed automatic control method is given. The method includes conducting a passive experiment, including the selection of technological samples and their analysis with simultaneous recording of voltmeter readings, which measure the voltage at the output of the electric coil located on the pole piece of the magnetic system of the separator. Mathematical treatment of the results of experimental studies was performed through regression analysis method. The regression equation that connects the size of the electric driving force is obtained in the coil and the magnetic separator performance of the magnetic product is performed. It is concluded that the magnetic separator performance of the magnetic product is sufficiently accurate. The results obtained allow us to develop a system for automatically controlling the performance of a magnetic separator.

Keywords: magnetic separator, magnetic product, productivity, electromotive force, automatic control.

INTRODUCTION

Performance of the magnetic concentration factory by iron ore concentrate determines the performance of the magnetic product of hundreds of magnetic separators operating in the first, second and third stages of enriching sections of the processing plant. Without the automatic control and regulation of this important process variable is impossible to stabilize the operation of the process equipment, operating in the enrichment of the sections in the processing of ores with varying properties. Therefore, development of a method of automatic control of productivity of magnetic separators by magnetic product is relevant.

The main target is to control the separation of iron ore in the wet magnetic dressing process. Osipova, N.V. proposed to make the conclusion of the equations of dependence on the loss of the useful component in the residues and mass fractions of magnetite iron in focusing on the rate of water flow in the separator and the rotational velocity of the drum. A mathematical description is given for some automatic system blocks to control the magnetic separator. The results of its model are displayed in the MATLAB Simulink software package. The operation of the system is studied under the drift conditions of the fixed properties of magnetic separation [1].

A low magnetic separation is usually performed as a pre-focus step to reduce the mass flows in the downstream flow sheet [2].

There are obvious advantages of magnetic separation for bioprocessing applications [3], but it is primarily used only on the laboratory scale, due to the lack of sufficient liter separations, high cost industrial systems and complex design [4].

The National Mining University developed and theoretically justified method of automatic control of productivity of magnetic separators by magnetic product. This method is based on the dependence of the electromotive force induced in a coil placed on the pole piece of the magnetic separator on its performance magnetic product [5] (Figure-1).

The symbols in Figure-1: 1 - a magnetic drum separator; 2 - the magnetic system; 3 - magnetic layer or concentrate product; 4 - electric coil; 5 - magnetic floccules; 6 - voltmeter; E - electromotive force: Φ - is the magnetic flow; - rate of angular rotation of the drum; N, S - north and south poles of the magnetic separator system and floccules.

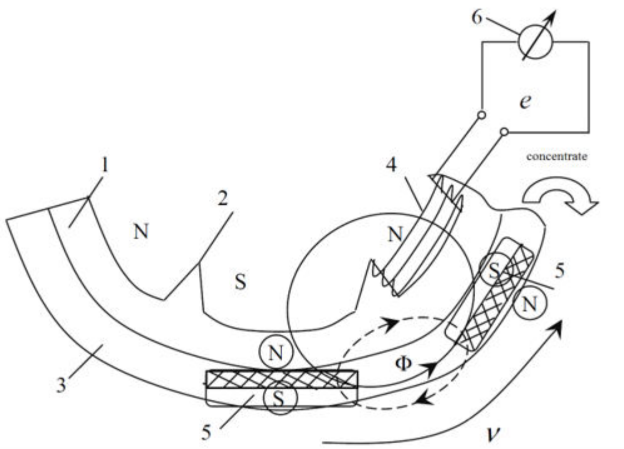

Figure-1. Scheme of the magnetic separator performance measurement method by magnetic product.

When the drum rotates 1 separator (Figure-1) in the concentrate layer 3 is formed of a traveling electromagnetic field [1] with a frequency of pulsating

$$f = \frac{v}{2h} \quad (1)$$

Where v - Separator drum rotation speed, h - step magnetic separator system.

Flocculation 5 magnetic concentrate, moving in a magnetic field of the magnetic separator system, demagnetized and induce an electromotive force in the measuring coil 4, placed on the pole piece of the separator. The magnitude of the electromotive force e is equal to

$$e = -\frac{d\psi}{dt} \quad (2)$$

Where Ψ - linkage.

$$\psi = w \cdot \Phi \quad (3)$$

Where w - the number of turns in the measuring coil; Φ - magnetic flux

The magnetic flux Φ is equal to

$$\Phi = (B_0 + B_M) \cdot S \quad (4)$$

Where B_0 - magnetic induction, created by the magnetic separator system; B_M - Magnetic induction concentrate layer; S - the surface of the pole pieces.

Magnetic induction, induced in the layer of concentrate, it can be represented as

$$B = B_M \cdot \cos\omega + B_0 \quad (5)$$

Where ω - the angular frequency of the magnetic field pulsation

$\omega = 2\pi f$

Expressions given (2), (3), (4), (5), electromotive force, induced in the electric coil, placed on the pole piece, is.

$$e = -w.S.B_M.\omega.\sin\omega t \quad (6)$$

The peak value of this electromotive force

$$e_A = \frac{w.s.v}{2h} B_M \quad (7)$$

Mathematical and physical formulation for the regularity of magnetic field composition separator in working zone and the experimental study to adopt induction of the magnetic field from the part of the iron in separator feeding. Physical and mathematical models were tested to form the magnetic induction in the work area to supply pulp to the separator bath. Experimental results were treated by the least- squares method.

A theoretically proportional relationship was established between the mass of the iron mass in the feeding of the magnetic separator and the magnetic induction of the magnetic field distributed in the buffer feeding area.

Magnetic induction along the vertical separator cylinder generator is measured on the pulp supply axis of the bath of the separator.

The prototype of the system has been designed to automatically control the block part of the iron in the feed separator.

The sensitive component of the automatic control system includes two sets of sensitive elements of the chain magnet installed in the magnetic system bases in the work area to supply the original pulp.

Alsayaydeh, J.A.J. *et al*. developed a method and system for automatic control of part of the mass of iron in the pulp inflowing to enrichment by a magnetic induction signal received in the magnetic separator feed field.

on the principle. For the first time, magnetic induction of the spatially distributed magnetic field in the work area to feed the magnetic separators, measured along the length of the separator cylinder, was found vertically on the pulp supply axis to the separator basin directly

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proportional to the fraction of iron mass in ore [6]. The problem of optimizing the technological compound of iron ore with magnetic separation has been raised. It is introduced to use performance by magnetic product as the optimum standard. Unilateral restrictions should be imposed on the fraction of the iron mass in the concentration and in the residues, as well as on iron extraction for concentration. The results of solving the complex magnetic complexity problem, which includes a ball crusher, are enclosed in a closed loop with a serial spiral work with a set of magnetic separators.

It is proposed to use signals of the sensitive elements of magnetism located in the raw feed areas and concentrate and reject the separation, as a source of information on the large iron masses in the ore concentrate and rejects, respectively.

Basically: Has been established the optimal balance between the consumption of water by the mill and by the classifier. This provides maximum performance for the magnetic concentration assembly taking into account technological limitations.

Has been designed the optimal algorithm for the magnetic concentration complex. It gets better the performance of the complex by at least 5%.

Alsayaydeh, J.A.J. *et al.* concluded that the usage of the industrial separator as a source of information on the large masses of iron in concentration, tails and ore, as well as on the performance of the magnetic product, provides the possibility of practical solution to the problem of automatic optimization of technological complexes of iron ore magnetic separation [7]. It is known that the quantity proportional to the magnetic induction of the magnetic separator on product drum surface. In turn, the magnetic performance of the magnetic separator product determined by the amount of its product in a magnetic drum in the unloading zone. Therefore, it can be assumed that the peak value of the electromotive force in an electrical coil on a pole piece in the discharge area of the separator characterizes its performance by magnetic product. This scientific hypothesis requires experimental verification.

Magnetite is one of the most widely used iron oxides in a variety of research and industrial fields. Its ease of separation by magnetism attracted great interest to be used as a supporting material for various noble metal catalysts. Sungjun Bae *et al.* reported for the first time that polycrystalline magnetite can exhibit a significant catalytic activity towards the reduction of p-nitrophenol by sodium borohydride, while three other single-crystal magnetite samples show a slight effect on stimulation [8].

The purpose of this paper is a representation of results of experimental studies in industrial conditions of automatic control method of the magnetic separator productive capacity according to the electromotive force value, induced by running magnetic field of magnetic separator in the coil placed on a pole piece of separator magnetic system in the zone of concentrate discharging.

The concept of electromotive force maybe introduced in various ways of theoretical electromagnetism. The multitude of alternate expressions for the electromotive force is often the source of confusion. We summarize the main ideas, adopting a pedagogical logic that proceeds from the general to the specific. The electromotive force of a "circuit" is first defined in the most general terms. The expressions for the electromotive force of some familiar electro dynamical systems are then derived in a rather straightforward manner. A diversity of physical situations is thus unified within a common theoretical framework [9].

An interesting approach to the relation between work and electromotive force, utilizing the concept of virtual work, is described in [10]. Of course, the list of references cited above is by no means exhaustive. It only serves to illustrate the diversity of ideas concerning the concept of the electromotive force. The subtleties inherent in this concept make it an interesting subject of study for both the researcher and the advanced student of classical Electrodynamics

MAIN PART

Experimental studies were carried out in conditions of Lebedinsky concentration Plant of Public Joint-Stock Company “Iron Ore Enrichment Works”. Diagram of the experiment shown in Figure-2.

The original ore arrives to the mill 1 MC20-1-23 wet grinding of ore bin 2.

The mill is set in motion by a synchronous electric motor 3 and operating in a closed loop with a spiral classifier 5. The degree of filling the mill with ore φ controlled using radiotracers filling 6. According to the testimony of the secondary appliance 7, preset value of the degree of filling stabilized by the automatic control system boot, which includes boot regulator 8 and vibratory feeder 9.

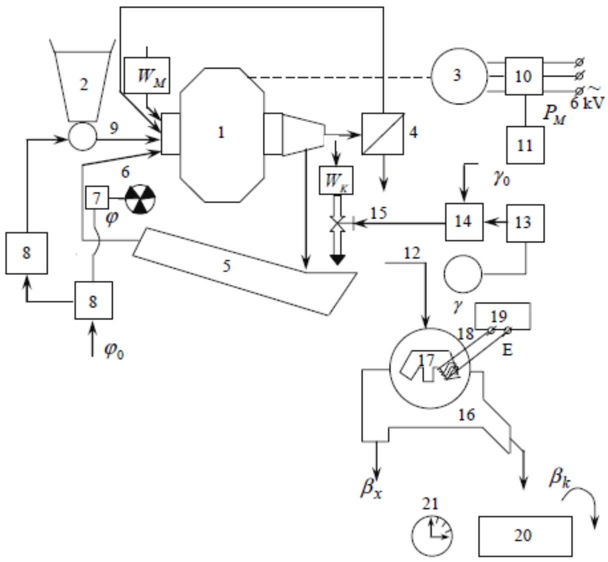

Figure-2. Scheme of the experiment.

The active power of the drive motor of the 3 mills was measured by a power converter 10 and a secondary

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instrument 11. Classifier drainage density γ measured by radioisotope density meter 12 and secondary instrument 13, stabilized by the regulator 14 and the control valve 15 water flow in the classifier 5. Ore pulp is fed to a magnetic separator type 16 PBM-PP-120/300. Water flow to the mill and classifier was controlled by flow meters W_M and W_K .

On the pole piece of the magnetic system 17 of the separator 16 is placed an electric coil 18. The electromotive force induced in the coil E was measured with an electronic voltmeter 19. The separator capacity of the magnetic product was measured using measuring capacitance 20 and chronometer 21.

During the experiment, the concentrate of magnetic separator 16 was held sampling and sample analysis was performed for the mass fraction of magnetic iron in the concentrate. Volumetric flow of pulp to the measuring capacity.

$$W = W_B + W_T = \frac{Q_B}{\gamma_B} + \frac{Q_T}{\gamma_T} \tag{8}$$

Where Q_B, Q_T, W_B, W_T - respectively, mass and volumetric consumption of water and solids; γ_B, γ_T - respectively, the density of water and solid.

From the expression (8), considering that $W = \frac{V}{t}$, where V - volume of measured capacity; t - capacities filling time, determine the performance of the separator for magnetic iron.

$$Q = Q_M = B_K \gamma_T \left(\frac{V}{t} - \frac{Q_B}{\gamma_B}\right) \tag{9}$$

Where B_M - mass flow of water to the mill; B_K - mass water flow in the classifier.

The experiment was carried out for three shifts. Technological samples of the concentrate were taken in the steady state and the time of filling of the measuring tank was recorded. According to the formula (9) calculated values and electronic voltmeter 19 measured values of electromotive force E. As is well known [11], the presence of a time-varying magnetic field implies the presence of an electric field E as well. Osipova N. V. found solution to a topical scientific–technical problem-automation of wet magnetic separation control in iron ore processing. The automatic control allows stabilization of iron content of concentrate at a preset level at the minimum loss in tailings. The author marked advantages and disadvantages of the earlier developed methods and offered a new approach based on using two subsystems ensuring stabilization of magnetic iron content of concentrate and iron loss in tailings. The research of the developed model efficiency allows recommending it for the commercial introduction at processing plants of operating mining and processing works [12]. Osipova N. V et al. dealt with the problems of using modern information technologies to improve the safety of mining operations in methane-mining mines. To analyze and forecast the development of complex gas-dynamic processes, depending on a variety of heterogeneous factors, it is suggested to use complex platform solutions [13].

The electric separation of the friction depends on the different electrical properties of the metal. Under the influence of friction and collisions, the particles have an opposite electrical charge. Then, under the influence of the high voltage electric field, using the different electrical and mechanical forces working on these metals, the path of the molecules is different. The particles are then sorted [14] [15]. When the charged small powder coal particles enter the high voltage electric field, they act on the air drag force, longitudinal drag force, electric field strength, gravity, etc. [16]. The experimental data are presented in the following table.

Table-1. Experimental data on the dependence of electromotive force on the performance of a magnetic separator.

No	Electromotive Force, Q , Kg/s	Magnetic Iron Separator Capacity, E, B
1	17.2	1.2
2	17.6	2.3
3	18.3	2.1
4	19.2	4.5
5	19.4	2.7
6	20.4	5.3
7	20.7	5.1
8	20.8	6.2
9	21.6	6.3
10	21.9	7
11	21.8	8
12	22.4	7.9
13	22.3	8.8
14	22.4	8.1
15	22.9	9.2

Dependence regression equation $E = f(Q_i)$ calculated on the computer using the table processor EXCEL and is presented in Figure-3.

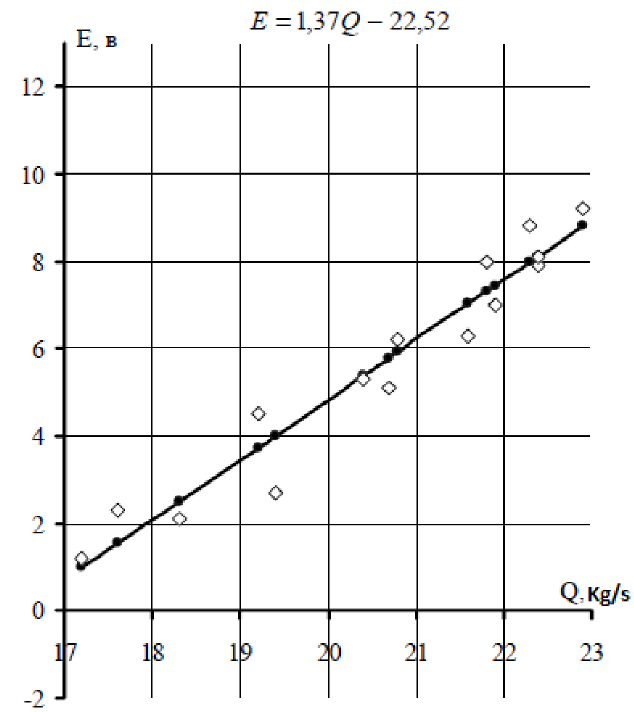

Figure-3. Regression equation of the electromotive force (E) of the performance of the separator for the magnetic iron Calculation Results: Regression Equation $E = 1{,}37Q - 22{,}52$; coefficient of determination $r^2 = 0{,}94$; correlation coefficient $r = 0{,}97$.

Analysis of the equation (Figure-3) indicates the presence of a linear relationship between the electromotive force induced in an electric coil placed on the pole end of the magnetic system of the separator and its performance on the magnetic product.

PROSPECTS FOR FURTHER RESEARCH

Consist in the development and study of an automatic control system of magnetic separator performance on a magnetic product for wet-flow counter current separators and dry enrichment magnetic separators.

CONCLUSIONS

The project's objectives have been successfully achieved by experimentally test a fulfilment of the process of automatic control of magnetic separator efficiency by magnetic product

Particularly to the case of this journal article, most of the relevant details to the general theory of design and implementation have been also introduced throughout this article.

In the nutshell, this paper is focus on the magnitude of the electromotive force induced by the traveling electromagnetic field of the magnetic separator in an electric coil, placed on the pole tip of the magnetic system of the separator in the concentrate excretion zone, it is possible to judge the performance of the semi-current magnetic separator on the magnetic product.

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