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EXPERIMENTAL RESULTS OF DEMAGNETIZED MAGNETITE CLASSIFICATION

The paper presents experimental results of the classification of a magnetized and demagnetized suspension of magnetite concentrate and shows a high degree of its demagnetization in a pulsed mode.
Keywords: magnetite, demagnetization, classification.

During the enrichment of magnetite quartzite grains of magnetite need to be milled to a particle size less than 50 μm in order to be disclosured. This process is carried out in ball mills with central discharge in three stages. The presence of the finished class in grinding zone reduces the speed of the process, leads to undesirable overgrinding of magnetite grains and, as a consequence, increases the cost of enrichment of magnetite quartzite. Discharge of the finished class is performed by external devices, such as spiral classifiers at the first stage of grinding and hydrocyclones at the second and third stages. The value of the circulating load coefficient of the mill, which in existing enrichment schemes exceeds 200%, depends on the efficiency of the classifying devices. The efficiency of classification of the magnetite particles with fineness of 50 microns with hydrocyclones ГЦ-500 does not exceed 80%, without taking into account their magnetic flocculation.

After each stage of grinding magnetic separation is applied, it leads to the magnetization of magnetite particles as magnetite has residual magnetization. Magnetic flocculation, occurring in suspension of magnetized particles, increases the effective size of magnetite suspension particles, which further decreases the classification efficiency and increases the coefficient of the circulating load.

Furthermore, magnetite with fineness less than 74 μm is widely used in coal preparation as a weighting agent for dense-media separation. Magnetic flocculation of the weighting particles leads to faster delamination of suspension, which increases the lower limit of the enriched coal size and enhances error of separation.

In general, it can be assumed that the residual magnetization of magnetite plays a negative role in the enrichment of minerals and its reduction, or demagnetization, is an urgent task.

In most cases, special devices are used for the demagnetization, their concept is shown in Fig. 1. Structurally, it is a tube of non-magnetic material on which the sections of specially designed electromagnet are situated, which provides a smooth reduction of the induction of alternating magnetic field during the magnetite particles movement through the pipe in the direction shown by arrow, while the solenoid is constantly connected to an AC power source. Degaussing occurs according to the hysteresis curves. To reduce the power consumption, capacitor is connected in parallel to the solenoid, providing currents resonance at mains frequency. Q-factor (quality factor) of the formed oscillation circuit must be over 10, so the coils are made of expensive copper. For example, weight of the coil with the pipeline diameter of 450 mm reaches up to 500 kg.

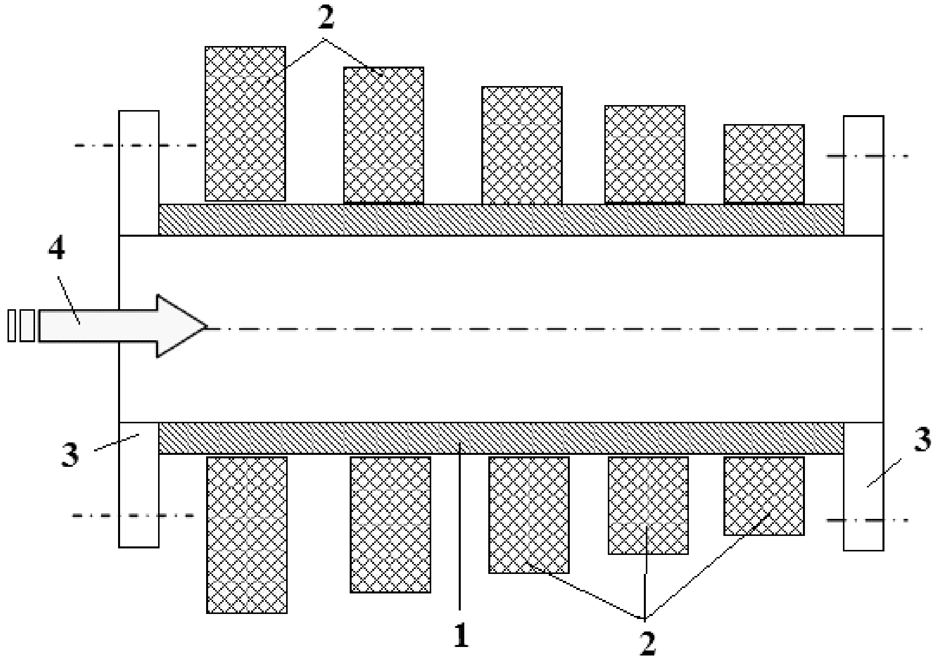

Fig. 1 – Demagnetizing apparatus. 1 – a pipe from a non-magnetic material; 2 – coils of electromagnet; 3 – flanges; 4 – magnetite slurry flow direction

It is energetically and constructively advantageously to carry out degaussing in a pulsed mode. In that way in a simple solenoid coil damped oscillations of the current are excited, and the number of oscillations must be greater than 5, which is provided by the respective quality of the oscillatory circuit. In this case, all the particles inside the solenoid and in the places, where the maximum magnetic field strength is more than the residual magnetization of the particle, undergo demagnetization.

Laboratory facility for magnetite suspension degaussing was designed and constructed. An integral part of the facility is a coil of simple construction, where damped oscillations are excited and through which a magnetite suspension passes. The outer and inner coil diameters are 20 mm and 12 mm respectively, and its length is 130 mm. The solenoid is a three layers winding of copper wire with a diameter of 1.2 mm and comprises 300 turns. Its inductance is 220 μH and active resistance – 0.5 Ω.

Damped oscillations in the solenoid are excited by a generator, its circuit diagram is shown in Fig. 2. The generator operates as follows. At the initial time thyratron U1 is closed and the capacitor C1 is charged to a voltage of source E1 through the charging inductance L1, discharging inductance L2 and the coil L3. The inductance L1 is much more than the inductance L2. When a control pulse to the electrode G of the thyratron U1 is received, it opens and the capacitor C1 is discharged through the discharge inductance L2, thyratron U1 and an oscillating circuit consisting of a capacitor C2 and solenoid L3. As the polarity of the voltage on the thyratron changes, it closes, and in the oscillator circuit C2 L3 damped oscillations are excited by the stored therein during C1 discharging energy. The application of a thyratron produces voltage pulses of a few kilovolts at the duration of rising edge of the pulse less than 1 μs. In this setting the capacitance of the capacitor C2 was 109 nF, and the amplitude value of the voltage in the resonant circuit was equal to 3600 V. Graphically change of the magnetic field induction in the center of the solenoid in time is shown in Fig. 3.

The study of the suspension demagnetization was carried out with magnetite concentrate of Mining and Processing Plant “Poltavskiy” (Poltava GOK) after flotation. Pre- magnetized in a constant magnetic field with induction of 0.35 T and stirred suspension of magnetite with a solid content of 350 kg/m^3 was passed through a glass tube with inner diameter of 6 mm, which was located inside the solenoid.

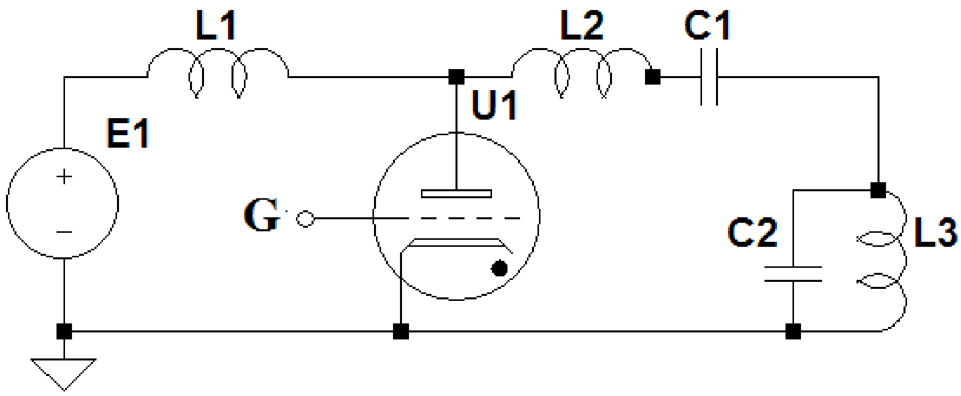

Fig. 2 – Schematic diagram of the pulsed generator of damped oscillations with the thyratron

Submission of a suspension in the tube was implemented through the funnel. Volumetric flow rate of the slurry was 1.5 10^{-5} m^3/s, the speed of its movement in the solenoid was equal to 0.53 m/s. Thus, residence time of the particles of magnetite inside the solenoid was 245 ms. The cycle time was 120 ms, so every particle of magnetite was exposed demagnetization during the passage through the solenoid at least twice.

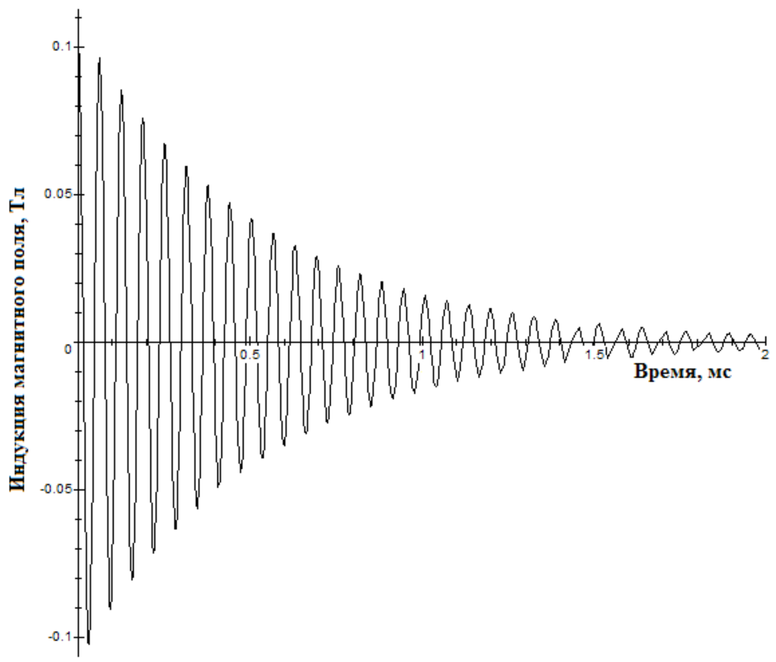

Fig. 3 – Dependence of the magnetic field induction in the center of the coil in time

The study of classification of magnetized and demagnetized magnetite suspension, prepared from Poltava GOK concentrate, was performed on a laboratory model of hydrosizer shown in Fig. 4. The content of magnetite in concentrate was equal to 69%, and the content of less than 50 microns particles – more than 94%. Premagnetizing of suspension was carried out in a constant magnetic field with induction of 0.35 T.

Hydrosizer is a transparent plastic tube having an inner diameter of 23 mm and height of 320 mm. In the lower part of the tube, above the nozzle of pure water supply, grid with a mesh size of 40 microns is mounted to equalize the flow rate of water in the transverse section of the tube and to remove the underflow.

To remove an overflow product circular chute, provided with nozzle, is mounted on the upper part of the tube. Initial suspension flows coaxially to the middle of the tube. The change of the rate of the pure water upstream is carried out by changing the pressure of water, supplied to the lower part of the apparatus. Particles with a soaring rate less than a flow rate, falls into the overflow product, and the rest – into underflow product.

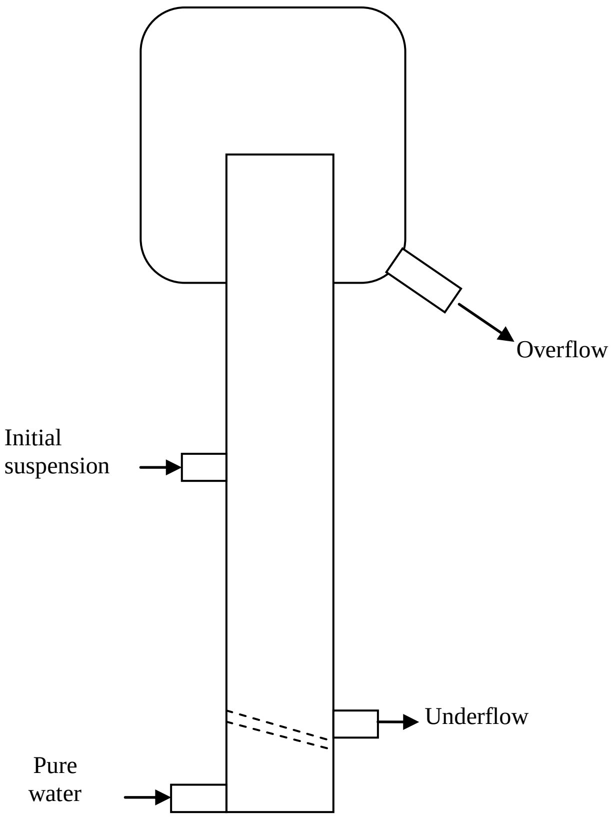

Fig. 4 – The scheme of laboratory hydrosizer

The research results are shown in Tables 1 and 2.

Table 1. – The critical size of minerals depending on the flow rate in hydrosizer.

Mineral	Density, kg/m^3	Flow rate, mm/s	Calculated size of the boundary grain, µm
magnetite	5400	17,4	85,2
		6,63	52,6
silica	2700	17,4	137,1
		6,63	84,6

Таблица 2. – The distribution of magnetite suspensions during the separation in hydrosizer.

Calculated size of the boundary grain for the magnetite, µm	Product yield, %			
	Magnetized		Demagnetized	
	Overflow	Underflow	Overflow	Underflow
85,2	51,2	48,8	93,1	6,9
52,6	23,1	76,9	79,7	20,3

The suspension was classified at two upstream rates. As can be seen from Table 1 at a rate of 17.4 mm/s virtually all magnetite and silica particles should fall into the overflow product, but after magnetization of slurry the yield of the overflow product was 51.2%. With nearly all the silica particles are carried into the overflow (with the exception of a small amount of beans entrapped in magnetic floccules), we can conclude that more than a half of the magnetite particles forms floccules larger than 85 microns. After demagnetization the yield of overflow product was more than 93%, indicating fairly complete demagnetization of magnetite particles.

At a flow rate of 6.63 mm/s more than a half of the magnetite and all silica particles should fall into the overflow, but as a result of magnetic flocculation less than 20% of the magnetite particles falls into the overflow product. As follows from Table 2, after demagnetization the quantity of magnetite with particle size of less than 53 microns that falls into the overflow product is 3.75 times greater than in case of magnetized magnetite, which also indicates a sufficiently complete demagnetization of magnetite particles.

Thus, putting the demagnetization apparatus before the operation of classification of the ground product will significantly reduce the circulating load of the mill, so the application of the pulsed demagnetization of magnetite method in the flow chart of the magnetite quartzite enrichment will improve its overall efficiency and reduce energy costs.

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