The fluidized bed separator

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ABSTRACT
In the production of building materials produces a large amount of harmful substances, poisoning atmosphere and adjacent to the building materials site. One of the biggest polluting the ecology of cities adjacent to industry, is metallurgical industry. One of the most important technological processes is the enrichment, in which the rocks are extracted empty components. In the enrichment of iron ore in the production an increasing proportion consist the anthropogenic waste industries, which pollute the air basin and the huge territory around the factories that dumped these same wastes. This reduces as a space for human life and for the functioning and development of cities. These materials can be applied as construction materials, for example, in the preparation of fine-grained concrete as a mineral powder, and these materials can be applied in the construction of roads, housing, for receiving paint etc.

1 INTRODUCTION
Currently, mining enterprises are mainly used wet scheme of separating raw materials and drum separators [1, 2]. For wet magnetic separation of strongly magnetic ores are used in drum-type separators PBM with a multipolar system of permanent magnets and is available in three versions: with direct-flow, counterflow and semi-counterflow baths [3, 4]. Direct-flow separators are used for materials with the grain size of 6 mm or less, counterflow ones – material fineness 2...3 mm and less, semi-counterflow ones – for material with particle size of 0.3 mm or less [5-7].

The above magnetic separators are separators for wet separation. They have the following negative drawbacks: the presence of water environment with a higher resistance compared to air; water environment has a strong opposition to the movement of magnetic and non-magnetic particles. As result the magnetic particles mix with nonmagnetic ones. When separating weakly magnetic materials is not observed magnetic flocculation (the formation of fortified units by the mutual attraction of the magnetized particles). It causes the need for feeding environment – water (waste water).

The source of waste water and recycled water are the drains dehydrating, washing machines and tailings. Polluting impurities are solids, hardness salts, heavy metal ions and organic substances. Untreated waste water that contains suspended impurities and aggregates, are the cause of the violation of the ecological system with all of its negative effects: shoal and dryen rivers, the vegetation dries, fades surrounding life [8, 9]. Turnover out a huge area, where merge slimes from the enrichment process of iron ore [10]. For the treatment of waste water and impurities has applied mechanical, chemical, physico-chemical and biochemical methods. All this leads to additional costs and cost of finished products.

An alternative of wet method is a dry method of separation. The lack of feeding environment provides significant water savings, there is no need of sewage treatment and eliminates the need for sludges, which occupy a considerable area and negatively affect to the atmosphere and lithosphere [11, 12]. Dry separation is the least energy intensive, as it is based on the natural property of magnetic attraction of ores.
2 METHODS
To improve the efficiency of dry separation tailings is possible due to the overlapping processes of magnetic extraction of ferrous particles and air stirring separating the material [9, 12].

Based on these requirements we have developed and manufactured an experimental installation for studying the process of separation of a two component mixture. Photo of the current installation is shown in figure 1.

The experimental installation consists of the following main components: the belt conveyor 1, the conveyor unloading the magnetic particles 2, the scraper conveyor 3, the transporting tray 4, loading device 5, the stabilization system 6, the control panel 7, the discharge zone of the magnetic particles 8 and the zone of unloading non-magnetic particles 9. The belt conveyor is designed to extract from the mixture of the magnetic particles. Traction circuit inside the belt conveyor along the lower branches of the conveying tape hinged block of magnets. Belt conveyor set at an angle relative to the transporting tray. This situation creates a belt conveyor in relation to moving in the transported tray of a mixture of variable magnetic field from the minimum at the beginning of the extraction to the maximum at an end of the drum. Accordingly, the extraction process of the particles occurs during the period of movement of the mixture under the active section of the belt conveyor in the beginning to extract strongly magnetic particles and decreasing the magnetization of the particles.

![Figure 1. Experimental installation](image)

The transporting tray bottom made in the form of a box. The upper surface of the transporting tray made of permeable to air of the porous material. Passing through the porous material air forms a layer of compressed air between the surface of the porous material and the mixture, with the result that the air passes through the mixture creates the effect of fluidization. Separation of a mixture into fractions in the regime of fluidization increases the mobility of the particles. This increases the probability of their capture by the magnetic field, improves the recovery ratio of magnetic particles that reduces the possibility of occurrence of particles on the partition and coefficient their resistance movement of the particles.

3 RESULTS
Extracting the ability of the separator of the fluidized bed depends on the characteristics of the magnetic system, physical and mechanical properties of the particles of the separated mixture and the geometric parameters of the working area. Recovery ratio of magnetic particles $\eta$ is determined by the ratio of their volumes at the entrance to the active zone $G(x_A)$ and on the way out of it ($x_B$) (figure 2):

$$\eta = 1 - \frac{G(x_B)}{G(x_A)}.$$  

(1)

Extracting the particles in the separation zone causes aerodisperse stream of magnetic particles. They is moved along the working area of the separator fluidized bed at a speed $v$ of the scraper conveyor. The concentration of magnetic particles in this stream are distributed across the height of the working area is very uneven: it sharply decreases from a maximum value in a boiling layer to a minimum value in the zone of deposition to the transport conveyer belt.
Consider a part of the working area of the separator fluidized bed between the cross sections passing through the points $x$ and $x + \Delta x$ (see figure 2). As a result of precipitation of magnetic particles, their concentration decreases from $C(x)$ to $C(x + \Delta x)$. Material balance equation of magnetic particles for the selected part of the working area:

$$G(x) - G(x + \Delta x) = \chi C(x) v_b \Delta x \cos \alpha = \chi \frac{G(x) v_l \Delta x}{h(x) v \cos \alpha}.$$  (2)

Expressing the change volume magnetic particles through its differential, we obtain:

$$G(x) - G(x + \Delta x) = -(G(x + \Delta x) - G(x)) \approx -dG(x),$$  (3)

and dividing the variables in equation (1), we get:

$$\frac{dG}{G} = -\frac{\chi v_l \Delta x}{v (h_t - x \tan \alpha) \cos \alpha}.$$  (4)

Integrated equation (4), we obtain:

$$\ln G_{(x, h_t)}^{(h)} = \frac{\chi v_l}{v \sin \alpha} \left( \ln (h_t - x \tan \alpha) \right)_{x}^{h_t}.$$  (5)

From relation (5) follows:

$$\frac{G(x_h)}{G(x_t)} = \left( \frac{h_t - x_h \tan \alpha}{h_t - x_t \tan \alpha} \right)^{\frac{v_l}{v \sin \alpha}}.$$  (6)

Substituting expression (6) in the formula (1), we obtain a relation for the fractional extraction ratio of magnetic particles:

$$\eta(d) = 1 - \left( \frac{h_t}{h_t + l_t \tan \alpha} \right)^{\frac{v_l}{v \sin \alpha}}.$$  (7)

For incoming in the formula (4) length of the active portion of the working area $l_A$ we obtain:

$$l_A = -\frac{h_t - 1.115 \delta}{\tan \alpha} - \frac{1}{2 c \sin \alpha} l_t \left( \frac{\rho g \cos \alpha}{\mu_0 \chi c H_0^2} \right).$$  (8)

Parameter $l_A$ and the precipitation velocity of particles on the transport conveyer belt $v_1$ (formula 10) takes the form:

$$l_A = -\frac{0.015 - 1.115 \delta}{\tan \alpha} - \frac{\ln(0.183 \cos \alpha)}{52.34 \sin \alpha},$$

$$v_1 = 4.472 \cdot 10^{-4} d^2.$$  (10)
where the particle size \(d\) should be set in microns.

Taking into account formulas (9) and (10) the expression (7) can be rewritten in the form

\[
\eta(d) = 1 - \left[ \frac{0.015}{1.115\delta - \frac{\ln(0.183\cos \alpha)}{52.34\cos \alpha}} \right].
\]  

Comparison of theoretical and experimental values of the full coefficient of extraction of magnetic particles shows that the magnitude of the coefficient of heterogeneity of the distribution of their concentration in the working area of the separator fluidized bed \(\chi\) depends mainly on the thickness of the partial mixture in the initial bound state \(\delta\). As a result of processing of experimental data obtained the following dependence:

\[
\chi(\sigma) = 50\delta^2 - 0.15\delta + 0.0224.
\]  

Substituting the formula (12) in (11) we obtain the final expression for the fractional extraction ratio of magnetic particles in an experimental fluidized bed separator:

\[
\eta(d) = 1 - \left[ \frac{0.015}{1.115\delta - \frac{\ln(0.183\cos \alpha)}{52.34\cos \alpha}} \right].
\]  

From formulas (4) and (5) we can see that the recovery ratio of magnetic particles depends on their physic-mechanical properties (density, size, shape, magnetic permeability), the characteristics of the magnetic system (its size, magnetic field strength, spacing of poles), the constructive-technological parameters of fluidized bed separator (dimensions, tilt angle of the magnetic system, the thickness of the partial layer of the mixture, the speed of movement of the scraper conveyor), but also properties of the air environment (temperature, viscosity).

To confirm the above presented experimental installation we conducted an experimental study. The used material is tails Lebedinsky mining plant. In the course of the experiment changed the following parameters: layer thickness \(\delta\) of the separating material; moving velocity \(v\) of the separating material; the angle of inclination of a belt conveyor \(\alpha\) and the magnetic field strength \(H\).

4 CONCLUSIONS

Figure 3 shows the dependence of the effect of velocity of movement \(v\) of the separating material on the separation efficiency \(\eta\) under different values of the angle \(\alpha\) of inclination of a belt conveyor, a constant layer thickness of the separating material \(\delta = 8\) mm and magnetic field \(H = 40\) kApm Here we can see that all the dependences are of an extreme nature in the studied range of variation of the factors.

Analyzing graphs we can conclude that the maximum value of the separation efficiency \(\eta\) is achieved when the velocity of the separating material \(v = 0.02\) mps, angle of installation of a belt conveyor \(\alpha = 15^\circ\) and \(\eta\) is 85.77 %.

With the aim of improving environmentally friendly production of materials metallurgical production under separation tailings with a high degree of effectiveness proposed scheme dry processing. It is proved that for these purposes can be applied by the magnetic principle of extraction of particles and airs tiring of separating material.

For conducting experiment we designed and constructed experimental installation of fluidized bed separator.

Experimental studies confirm that the proposed in article separator fluidized bed dry separation is more effective in comparison with traditional separators. Efficiency exceeds 90 %.
Figure 3. Dependence of the separation efficiency $\eta$ from of the moving velocity of the separating material $v$ under different values of the angle of inclination of a belt conveyor $\alpha$, a constant layer thickness $\delta = 8$ mm and magnetic field $H = 40$ kApm

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