

Conference Paper

Technical Solution for the Disposal of Solid Slag from Metallurgical Plants with Production of Abrasive Powders

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Abstract

This article considers a technical solution to the production of abrasive powders according to the standard ISO 11126 from copper slag and nickel slag with the use of air classification. Justification of the selection of air classifier for the process of classification of copper slag is performed. The results of laboratory studies on the effect of the consumption concentration on the quality of the separation of slag particles in apparatus with an inclined louver lattice with reverse air suction are presented. This article then discusses the dependence of the material separation boundary on the air flow rate through the classifier's louver. Based on the theoretical calculation, an industrial apparatus with a capacity of 50 t/h on initial raw materials was developed, laboratory tests were industrialized, and the results of industrial tests were shown. Industrial testing was carried out and the results of are shown.

Keywords: granulated slag, disposal, abrasive powder, granulometric composition, consumption concentration, air classifier, screening.

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1. Introduction

At present, the most common raw material for the production of abrasive blasting powders is granulated slag of copper-smelting and nickel production [1]. Slag granules have high Mohs hardness and sharp angular shape. Copper slag and nickel slag contain quartz only in bound form, which makes it environmentally different from quartz powders. Since the relative density of slag granules is higher than that of most abrasive materials, it has a higher kinetic impact energy. Abrasive is not a metal alloy, so it complies with ISO 11126 [2]. The initial abrasive particle size distribution is between 0.1 and 3.5 mm. However, according to ISO 11126 the maximum grain size shall not exceed 3.15 mm and the minimum fraction content minus 0.2 mm shall not exceed 5 %.

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2. Technology

Granulation of copper slag and nickel slag is usually done by mechanical crushing (spraying) of mineral melt in water. In order to obtain the required abrasive fraction, it is necessary to dry the raw material and sort it.

The main method of dry separation of bulk materials by grain size is screening [3, 4] – the separation of the raw material by grain size on the screening surface with calibrated holes. Screening efficiency is affected by the size of the screen holes. When the raw material passes through the screen, only a certain number of grains passes through each hole and this number is constant, and this phenomenon does not depend on the size of the holes. It is well known that fine screening requires dozens of times more production floor space and, taking into account the significant abrasive wear of fine screens, is hardly feasible for the purpose of dry separation. The most efficient use of screening is determined by the size of the boundary grain of at least 1–1.5 mm.

An alternative method of fine screening is pneumatic classification – separation by weight and shape using the aerodynamic characteristics of the grains in the air stream. Numerous studies [5–8] show high efficiency of air classification on the boundaries of less than 1 mm. Available experience of industrial application of air classifiers for granulated slag screening [9, 10] has revealed the most suitable separator design - an apparatus with inclined louver lattice with reverse air suction [11] (see Figure 1). A distinctive feature of the apparatus is no sealing of the raw material loading unit and unloading unit of coarse material, meanwhile the fine product is deposited initially in the settling chamber built in with the classifier and then in the cyclone.

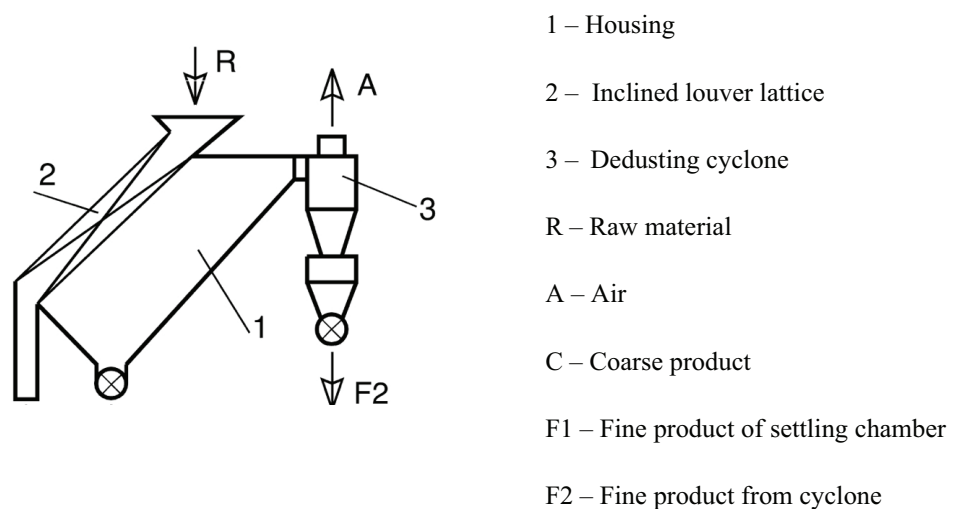


Figure 1: Classifier diagram

3. Experiment

When designing an industrial classifier, it is important to know not only the ‘sharpness’ or clarity of the powder separation on a given boundary of separation, but as well its energy efficiency, directly related to the specific load on the initial feed. In order to define this parameter (the ratio of the material consumption to the air flow rate), an experiment was carried out in which the consumption concentration of the initial copper slag was varied in the range from 1 to 7 kg/m³.

From the obtained data (see Figure 2), it follows that the classifier works stably up to a concentration of 6 kg/m³ with an efficiency of about 60% according to the Eder–Mayer criterion [12]. Slag (Table 1) with a grain size of less than 5 mm was fed into the classification.

TABLE 1: Initial granulometric composition of slag

Fraction size, mm	> 3.0	2.5-3.0	1.6-2.5	0.8-1.6	0.5-0.8	0.2-0.5	0.2-0.0
Fraction content, %	12.24	9.63	21.54	34.60	14.51	2.71	1.15

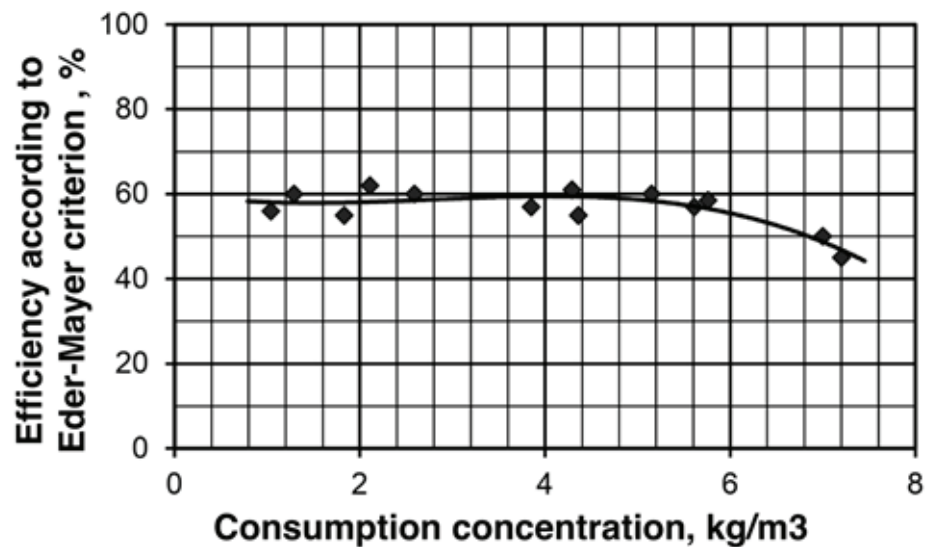


Figure 2: Change in separation efficiency due to consumption concentration

Knowing the initial granulometric composition, the given capacity of the initial supply, efficiency and separation boundary, it is easy to calculate the basic dimensions of the industrial classifier [13]. In order to select the fan, it is necessary to know the influence of the air flow rate on the boundary grain (see Figure 3).

According to the method [13], a mathematical model of the process of separation of copper slag on the boundary of 500 microns with the capacity of the initial supply

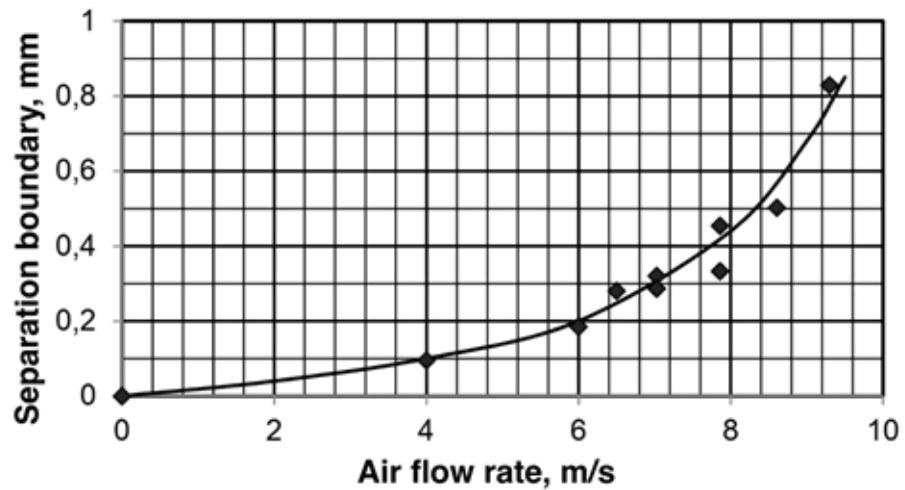


Figure 3: Dependence of the air flow rate on the material separation boundary

of 50 t/h was produced, the predicted regime characteristics (Table 2) and the basic geometric dimensions of the apparatus were determined.

The approximate size of the industrial classifier screen is 900×2000 mm with a flow cross-section of 25 %, the required air flow rate at the boundary of 500 microns is 9000 m³/h.

TABLE 2: Predicted performance characteristics of the copper slag separation process

Flow rate (w), m/s	Separation boundary (x ₅₀), microns	Coarse product				Fine product			
		Yield, %	Residue (%) on screen (mm)			Yield, %	Residue (%) on screen (mm)		
			0.2	0.5	0.8		0.2	0.5	0.8
8	430	90.78	99.97	98.12	84.99	9.22	59.79	19.38	3.13
9	680	81.13	99.99	99.38	91.35	18.87	79.12	37.44	8.02

4. Industrial Testing

Based on experimental studies and calculations using the classification process model, an industrial unit for producing abrasive powders was designed and implemented in 2018 at the Karabash Abrasive Plant LLC with a capacity of 50 t/h. The technological scheme of the plant is shown in Figure 4. The results of the classification process for copper slag at the industrial plant are as follows: the yield of a large dedusted product is 83%, the residual content of 0–0.5 mm fine fraction is not more than 3.5%, the actual separation boundary is 0.45–0.50 mm at 8–8.5 m/s air flow rate through the screen and separation efficiency is 55–57%.

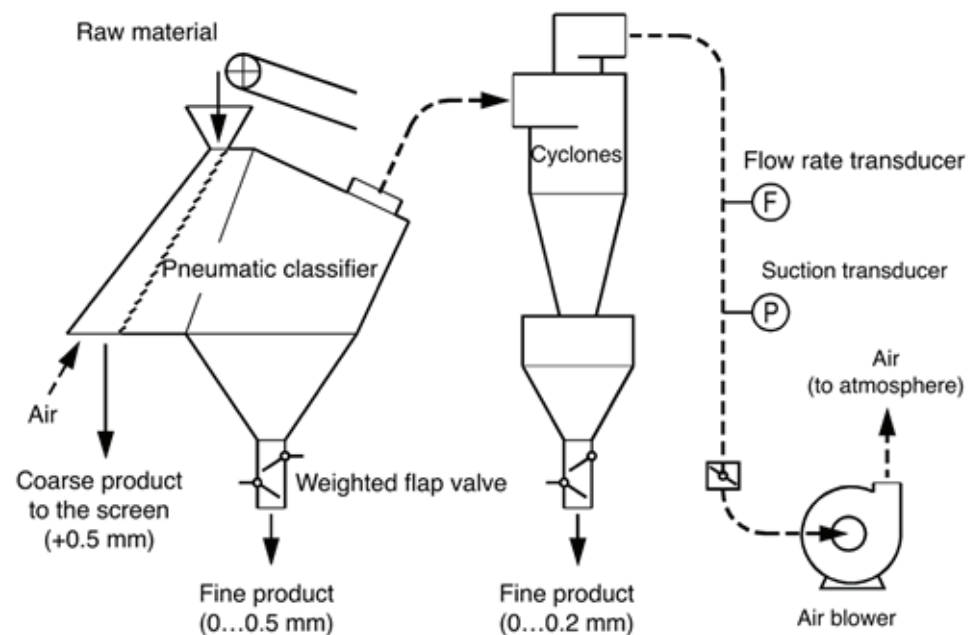


Figure 4: Technological scheme of the plant

The initial copper slag after drying in the drum enters the pneumatic classifier, where the fine fraction 0–0.5 is blown out. After the classifier, the coarse fraction of +3.5 mm is screened on the screen.

Thus, it can be concluded that the main parameters of the industrial apparatus for separation of copper slag quite accurately correspond to the developed experimental calculation model of the pneumatic classifying process.

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