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Investigation of Acid Electric-Furnace Slag as a Perspective Raw Material for Ceramic Pigments Production (Report No.3). Research of Slag Preparation Methods

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Different methods of acid electric-furnace slag grinding are studied. The wet-grinding optimized time of studied material in laboratory grinding mill is identified. It provides high fraction output with the size less than 0.25 mm. The obtained product is characterized by predominant silicon dioxide content and comparatively low iron oxide concentration. It can be interesting for production technology of dark blue-green gamut ceramic pigments.

Keywords: ELECTRIC-FURNACE SLAG, GRINDING, GRINDING MILL, FRACTION, MAGNETIC PART, NON-MAGNETIC PART, PIGMENT COMPONENT, CERAMIC PIGMENTS

Introduction

Method of raw materials preparation in ceramic technology has an important meaning and its choice is determined by initial raw material properties, charge composition, and demands lodged to the final product.

Acid electric-furnace slag peculiarity as secondary raw material is their low homogeneity degree in the chemical-mineralogical composition (Report No. 1 and No. 2). Therefore, the correctly chosen recycling method of such materials in many respects will determine qualitative characteristics of the final product; in particular they will determine that of ceramic pigments for production of which they can be applied.

This research is devoted to the study of different methods of acid electric-furnace slag grinding for its preparation to usage in ceramic pigments production.

Results and Discussion

We investigated dry and wet grinding for fine grinding and achieving of high homogeneity degree of electric-furnace slag (Kharkiv) of its averaged sample in laboratory grinding mill. Besides, for dry grinding slag previously underwent drying to residual moisture less than 1.0 %, and wet-grinding was done with adding of water to 33% of humidity.

The results of investigations are presented in the **Table 1**.

It is deduced from the experiments that during grinding of electric-furnace slag sampledue to complex electrometallurgical processes not only dispersion degree increases, but as well slag (pigment) part separates from metallic inclusions.

In particular, it is necessary to mark that the output of pigment component of the investigated slag under 5 h of grinding depends less from the chosen method and equals 92.13 and 91.05 % for wet and dry grinding processes respectively. A small growth of slag fraction with the size < 0.25 mm during wet-grinding in comparison with dry-grinding can be explained by a rather high degree of homogeneity (in the granulometric composition) of initial material and high concentration of b-quartz crystal phase in the composition which possesses high strength (7 points after Mohs scale) against abrasive action of porcelain grinding medium.

The further extension of wet-grinding duration (from 5 to 12.5 h) leads to increase of fine fraction from 92.13 to 96.98 wt. % under corresponding reduction of large fraction from 7.87 to 3.02 wt. %. The optimal grinding time in the grinding mill with

Table 1. Characteristics of acid electric-furnace slag grinding

Slag item	Grinding time, h	Fraction content, wt. %				
		> 0.25 mm			Me/non-Me balance	< 0.25 mm (pigment part)
		Total	Cond. magnetic part (Me)	Cond. non-magnetic part (non-Me)		
Kharkiv slag	5.0*	8.95	6.37	2.58	2.47	91.05
	5.0	7.87	6.17	1.70	3.63	92.13
	7.5	4.45	3.69	0.76	4.85	95.55
	10.0	3.32	2.90	0.42	6.90	96.68
	12.5	3.02	2.69	0.33	8.15	96.98

5* – dry-grinding

Table 2. Fraction content of sample slag pigment part, wt. %

Slag item	Grinding time, h	Grain size, mm		
		< 0.01	0.01–0.05	0.05–0.25
Kharkiv slag	5*	13.67	7.72	78.61
	5	14.12	14.31	71.57
	7.5	36.40	25.71	37.89
	10	39.39	28.85	31.76

5* – dry-grinding

adding of water is 7.5 h. Further grinding is not reasonable because of insignificant increase of fine fraction quantity from 95.55 to 96.68 and 96.98 % (**Table 1**).

The oversize (> 0.25 mm) obtained after grinding underwent further magnetic separation. It was established that with increasing of grinding duration (from 5 to 12.5 hours) there occurs a reduction in the number of both conditionally magnetic (from 6.17 to 2.69 wt.%), and conditionally non-magnetic parts (from 1.70 to 0.33 wt.%) of the studied metallurgical slag. This is because conditionally magnetic part of the recycled material consists not only of pure metal inclusions; it is a combination of well-connected silicate component with different amorphisation degree of amorphous and metal prills. Silicate component and metallic inclusions in less degree significantly dominate in conventional non-magnetic part. The slag part gradually separated from the metal prills, during the further grinding adds to the number of non-magnetic fine fraction, so the content of the latter rises. The process of separating of these phases is quite effective, as evidenced by the significant increase in the ratio of Me/non-Me from 3.63 to 8.15 with increasing duration of wet-grinding from 5.0 to 12.5 hours.

Due to the chemical analysis we revealed high concentration of total iron (Fetotal – 61.5 wt. %) in conditionally magnetic component of sample slag obtained after maximal grinding duration. Such product can be a valuable raw material for steel production, which impose strict requirements for iron-containing raw materials (content of Fetotal at least 50 wt.%).

A further fraction-by-fraction division of the

slag pigment part according to Sabanin's method was performed. The results of this investigation are shown in **Table 2** and **Figure 1**.

The obtained data confirmed the fact established before that the process of wet-grinding of the investigated electric-furnace slag in rather active phase lasts during 7.5 h. The further extension of the duration of milling (up to 10 h) causes an insignificant increase of the fine fraction (<0.01 mm) from 36.4 to 39.39 % due to a corresponding reduction in the proportion of large particles of 0.05-0.25 mm (from 37 89 to 31.76 wt.%).

The results of the chemical analysis of steel slag pigment part, separated after wet-grinding during 7.5 h, showed (see **Table 3**) that it is mainly represented by silica (80.10 wt.%), and also contains a relatively small amount of iron oxides (7.57 wt. % in general). Yield of milled flour is insignificant and equals 0.15 wt. %.

Table 3. Data of chemical analysis of sample electric-furnace slag pigment part, wt. %

Test	Oxide content, wt. %													
	SiO2	Al2O3	Femet	Fe2O3	FeO	TiO2	Cr2O3	CaO	MgO	MnO	ZnO	K2O+ Na2O	П.П.П.	Sum
X	80,10	3,05	0,15	5,56	2,01	0,20	0,18	2,54	1,42	0,68	0,02	0,13	3,96	100

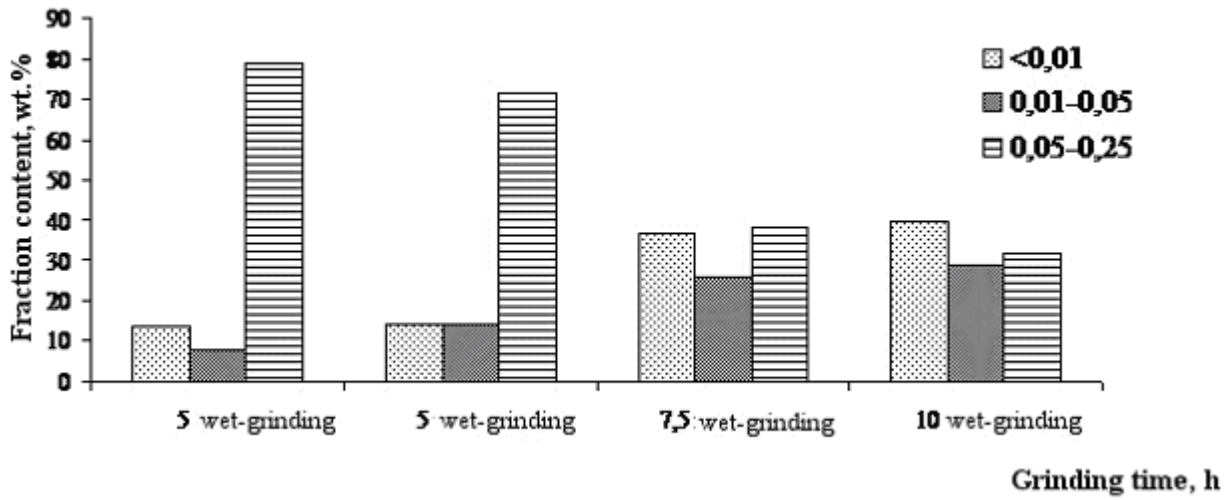

Figure 1. Fraction distribution of pigment part particles of Kharkov slag

Conclusions

Generally the experimental investigations helped to determine

– practicability of acid electric-furnace slag preparations for application in production technology of ceramic pigments by means of their wet-grinding in the grinding mills;

– optimized time of wet-grinding of sample slag, which provides high output rate both pigment part and iron in general in its conditionally magnetic component;

– predominant content of investigated silicon dioxide slag in the extracted pigment part, as well as comparatively low iron oxide which is a very important factor in production of ceramic pigments of bright colours, and blue-green gamut in particular.

References

1. A.V. Zaichuk, YA.I. Belyy, N.A. Minakova et al. *Issledovaniye kislogo elektrostaleplavilnogo shlaka kak perspektivnogo syriya dlya proizvodstva keramicheskikh pigmentov. Soobshchenie 1. Izucheniye granulometricheskogo i khimicheskogo sostava shlaka*, Metallurgicheskaya i gornorudnaya promyshlennost,

2011, № 2, pp. 125-127.*
2. A.V. Zaichuk, YA.I. Belyy, N.A. Minakova et al. *Issledovaniye kislogo elektrostaleplavilnogo shlaka kak perspektivnogo syriya dlya proizvodstva keramicheskikh pigmentov. Soobshchenie 2. Izucheniye granulometricheskogo i khimicheskogo sostava shlaka*, Metallurgicheskaya i gornorudnaya promyshlennost, 2011, № 3, pp. 115 -117.*

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Исследование кислого электросталеплавильного шлака, как перспективного сырья для производства керамических пигментов. Сообщение 3. Изучение способов подготовки шлака

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Изучены различные способы помола кислого электросталеплавильного шлака. Установлено оптимальное время мокрого помола исследуемого материала в лабораторной шаровой мельнице, которое обеспечивает высокий выход фракции размером менее 0,25 мм. Полученный продукт характеризуется преимущественным содержанием диоксида кремния, а также сравнительно невысокой концентрацией оксидов железа и может представлять интерес для технологии производства керамических пигментов сине-зеленого ряда.