COMPARISON OF USE EFFICIENCY OF DIFFERENT TYPES OF DENSE BALL LOAD DURING THE GRINDING OF PORTLAND CEMENT CLinker

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Abstract. The authors of this article carry out a comparative analysis of the effectiveness of using several types of dense ball packaging for cement production. This analysis is based on the study of the degree of influence on the kinetics of the clinker grinding process in the open cycle mill of different assortment of balls without the use of the milling intensifier and in the case of its use. The possibility of refusing the use of an intensifier in the case of rational selection of grinding bodies.

Clinker is characterized by a small amount of grinding, so the process of its grinding is associated with a large energy cost of 45 ± 5 kWh / t cl. [1]. As is known, the productivity of a cement mill is limited by the aggregation of the particles of the ground material, by adhering them to grinding bodies and armored, thereby reducing the efficiency of the grinding process in the grinding unit, which is accompanied by an increase in the specific consumption of electricity [2].

This circumstance makes it necessary to find ways to reduce the specific electricity consumption of cement mills and increase their productivity. In this paper, the application of some of them has been considered: the use of a dense spherical packing (PSU) [3] and an intensifier of grinding [4].

The aim of the work was to study the influence of different types of dense ball charge on the disperse characteristics of clinker, such as the specific surface and residue on the screen No. 008, and also to assess the degree of their effect on these parameters in the presence of a grinding intensifier, which was used by "Lithoplast 4I" Polyplast Novomoskovsk.

The investigations were carried out at the clinker of the Oskolcement plant. The clinker of the fraction 10-0 mm without addition of gypsum to it was fed to the GIPROCEMENT mill of 0.5 × 0.28 m. The weight of the feed material in all the experiments was 4 kg.

The material was crushed in the first chamber for 10 minutes, in the second for 15 minutes and 10 minutes. Through these intervals of clinker grinding time, samples were taken to establish the specific surface area and the total residue on a standard No. 008 sieve. The specific surface was determined by the air permeability method.

The particle size distribution of Portland cement clinker, milled in a mill for 35 min, was determined on a laser particle analyzer ANALYSETTE 22 NanoTec plus from FRITSCH.

The whole process of grinding passed in one chamber of the mill. In the first chamber, a constant range of balls was always loaded: Ø74 / Ø54 with a 2: 1 ratio of balls (φ = 0.2, mass of grinding bodies 55 kg), then after 10 min of clinker grinding from the mill, this ball charge was extracted, and another assortment of balls was loaded, corresponding to the second chamber: Ø60 / Ø17 = 1: 2 or Ø40 / Ø17 = 2: 1.

In the case of combined loading, the material was frayed in only one chamber for 35 minutes, with sampling at the above time intervals.

The studies were started with a combined loading: Ø74 / Ø54 / Ø40 / Ø17 = 1.3: 0.4: 2.2: 1.0; φ = 0.2, the mass of the balls is 55 kg, the power capacity is 13.75. After 35 minutes of grinding, the specific surface area of the clinker is 329.4 m2 / kg, the residue on the No. 008 screen is 7.1%, the content of the fraction is 5-30 μm = 68.9%.
In the case of using a tight ball packing with diameters of balls Ø60 / Ø17, a mass of a grinding load of 55 kg, $\varphi = 0.2$ and an energy capacity of 13.75 after the same time interval, the indicated parameters have the following values: $S_p = 345.49 \text{ m}^2 / \text{kg}$, $R_{008} = 1.34\%$, 5-30 $\mu \text{m} = 74.15\%$.

The use of a treadmill Ø40 / Ø17, having a mass of grinding bodies of 80 kg, a load factor of 0.3 and a power-bearing capacity of 20, leads to the following results: $S_p = 411.28 \text{ m}^2 / \text{kg}$, $R_{008} = 3.94\%$, 5-30 $\mu \text{m} = 69.59\%$.

At this stage of the research from the data obtained (Table 1), it seems that the rational assortment of grinding media is a tight ball packing Ø60 / Ø17, because it makes it possible to obtain a material with a residue on a standard sieve No. 008 5 times less than when using a combined load and 3 times less, compared to a tight ball load Ø40 / Ø17. By the content of the fraction of 5-30 $\mu \text{m}$, all three samples have approximately the same value.

### Table 1. Effect of assortment of milling bodies on disperse characteristics of Portland cement clinker

| Assortment of grinding load | The ratio of fr. 5-30 microns to fr. 0-5 microns | Specific surface, $\text{m}^2 / \text{kg}$ | Residue on screen No. 008, $\%$ | Content of fr. 5-30 $\mu \text{m}$, $\%$ |
|---------------------------|---------------------------------------------|---------------------------------|----------------------------|-----------------|
| Combined load             | 4.7                                        | 329.4                           | 7.1                        | 68.9            |
| PSN Ø60/Ø17               | 5.1                                        | 345.5                           | 1.3                        | 74.1            |
| PSN Ø40/Ø17               | 4.7                                        | 411.3                           | 3.9                        | 69.6            |

Then, the previous experiments were repeated, but with the addition of the grinding aid (0.1% by weight) to the second chamber, it was not first introduced. With the combined loading, the additive was introduced into the mill after 10 minutes of clinker milling, in order to enable us to further compare the results obtained. The data of the carried out researches are resulted in tab. 2.

### Table 2. The cumulative effect of the assortment of grinding bodies and the grinding intensifier on the disperse characteristics of Portland cement clinker

| Assortment of grinding load | The ratio of fr. 5-30 microns to fr. 0-5 microns | Specific surface, $\text{m}^2 / \text{kg}$ | Residue on screen No. 008, $\%$ | Content of fr. 5-30 $\mu \text{m}$, $\%$ |
|---------------------------|---------------------------------------------|---------------------------------|----------------------------|-----------------|
| Combined load             | 6.6                                        | 377.3                           | 1.4                        | 87.9            |
| PSN Ø60/Ø17               | 5.9                                        | 358.8                           | 0.2                        | 83.3            |
| PSN Ø40/Ø17               | 5.4                                        | 394.1                           | 2.4                        | 85.5            |

The addition of the additive to the combined charge leads to a decrease in R008 of approximately 80%, an increase in the specific surface area and the content of fr. 5-30 $\mu \text{m}$ approximately by 14.5% and 28%, respectively.

The addition of the additive to the grinding chamber with a trough Ø60 / Ø17 is only accompanied by a 85% reduction in the total residue on the No. 008 screen. Change in the specific surface area and content of fr. 5-30 $\mu \text{m}$ is not significant.

The same result is given by the replacement of the camera Ø60 / Ø17 on the camera Ø40 / Ø17: only a decrease of R008 by 39% is observed. The remaining parameters hardly change.

From this it can be seen that the input to the grinding mill intensifier reduces the total residue on the No. 008 sieves by 80%, in case of using only a combined load in the second chamber or a Ø60 / Ø17 camera.

All the results obtained in the course of this work are given in general form in Fig. 1 and 2.
According to the results of the research, it is established that the camera Ø40 / Ø17 is inferior to the camera 60 / Ø17 in the residue on the control screen No. 008, in the case of clinker grinding in the mill for more than 25 minutes, at an early stage they have the same efficiency. In the production of ordinary cement, the use of both types of dense ball packing is expedient in the absence of a grinding intensifier.

If we accept the value of the specific surface in the range of 300 - 320 m²/kg as the criterion for the readiness of the product, we can make a comparative assessment of the effectiveness of using different types of assortment of balls. The mill's productivity in this case will depend on the time it takes to achieve the specified fineness of grinding.

So, in case of using a tight ball packing with diameters of balls Ø40 / Ø17, this will take 25 minutes, in all other cases - about 30 minutes. This leads to the important conclusion that the use of the grinding intensifier does not always lead to an increase in the productivity, and in the case of a competent selection of the range of grinding load, it is no longer necessary to use it for the production of ordinary cement.

The carried out researches prove expediency in continuation of researches on studying of influence of an assortment of grinding bodies on kinetics of process of grinding clinker in a ball mill. The paper shows that rational selection of grinding bodies allows to obtain cement with high dispersive characteristics, without the use of grinding intensifiers, which ensures a reduction in the cost of the cement produced by the enterprise, as well as an increase in the mill's productivity and a decrease in the specific consumption of electric energy.

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