The grinding clinker pressure process study

A Romanovich¹*, E Amini², I Apukhtina¹, E Pahomov¹

¹BSTU named after V.G. Shukhov, 46 Kostyukova Street, Belgorod, 308012, Russian Federation
²K. N. Toosi University of Technology, Tehran, Iran

E-mail: AlexejRom@yandex.ru

Abstract. The article describes the grinding process by pressure in order to study the effect of pressing on the fineness of grinding at its different granulometry. Experimental studies have been conducted to study the compressible layer height effect on the clinker grinding fineness, taking into account the initial granulometry.

Introduction

The most energy intensive process in cement production is the fine clinker grinding and additives. Many scientists, both in our country and abroad, have been engaged in increasing the grinding equipment efficiency [1-2]. One of the promising ways to reduce energy consumption is its step-by-step materials grinding with the coarse grinding stage removal beyond the ball mill limits to a roller press [3-4].

However, the grinding pressure process is poorly understood. The article studies the pressing influence on the clinker fineness at its different grain sizes and height of the compressible layer. The Belgorod cement plant clinker, which has the following mineralogical composition, was taken as the material under study: C₃S - 66%; C₂S - 13.2%; C₃A – 47%; C₂A – 14%. The studies were conducted on a hydraulic press PSU-50 with a measurement accuracy of 4 MPa in a cylindrical mold with diameter of 4×10⁻² m. The experimental studies result carried out are presented in the graphical dependencies form in Figures 1-3. The conducted studies (Fig. 1) allowed to establish that with an increase in the pressing, the residue on the R₀₂ and R₀₀₈ screens decreases. This process most effectively occurs at a pressure of from 30 to 90 MPa. With an increase in the initial particle size of the clinker grains, the fineness of grinding at a fixed pressure increases. This is explained by the fact that with an increase in grain, the specific strength and the contact area per unit volume decreases [5].

Further experimental studies were devoted to the compressible layer height influence study on the clinker grinding fineness with regard to the initial grain size distribution (Fig. 2). The studies for clinker with a height of embankment from 10×10⁻³ to 40×10⁻³ m, with a constant pressing pressure of 50 MPa have been conducted.

Graphic analysis of Fig. 2 made it possible to establish that with an increase in the initial clinker layer height, the grinding process efficiency decreases, but remains fairly high. This indicates that the materials grinding is carried out not only on the grains interaction surface with the punch, but also inside the layer. It also indicates the possibility of establishing in the specified range the gap between the press rolls used for the practical implementation of the preliminary grinding of clinker. It is known
that during pressing, elastic expansion negatively affects the density of the material [6], and grinding is a process of inverse pressing.

Figure 1. The pressing effect on the grinding fineness at different granulometry of clinker: (10 ... 7) $\cdot 10^{-3}$ m (1); (7... 5) $\cdot 10^{-3}$ m (2); (5 ... 3) $\cdot 10^{-3}$ m (3); - residue on sieve R008: - residue on sieve R02

On this basis, experimental studies were conducted to study the compaction pressure effect at different initial clinker granulometry on the elastic expansion value. The studies were conducted on a bench installation (Fig. 3). The amount of elastic deformation was recorded using two micrometers of the indicator type with a measurement accuracy of $0.01 \times 10^{-3}$ m.

Figure 2. The effect of the compressible layer height on the clinker grinding fineness with different initial granulometry: (10 ... 7) $\cdot 10^{-3}$ m (1); (7... 5) $\cdot 10^{-3}$ m (2); (5 ... 3) $\cdot 10^{-3}$ m (3); sieve residue R008: sieve residue R02

Micrometers located on both sides of the press forms. According to the indicator type micrometers indicators arithmetic mean, graphical dependencies were built. This analysis found that the elastic expansion value for clinker increases with increasing pressure.

Based on our research, we have developed a grinder design that improves grinding degree and productivity. The materials contain a significant part of the fine fractions ($0 ... 5 \times 10^{-3}$m). The grinder includes a device for loading the charge into the PRG (Figure 5) [78]. The device provides partitioned loading and uniform distribution of the charge across the rolls’ width. The device works as follows:
The ground material of poly-fractional composition (for example, clinker) enters perforated inclined partitions 3, 4, interconnected in its upper part by a hinge (Figure 5, view A).

**Figure 3.** Bench installation: 1 - pressing punch; 2 - the basic bearing; 3 - stop; 4 - movable pressing punch with a conical working surface; 5 - press matrix; 6 - stationary pressing punch; 7 - thrust bearing; 8 - bolted connection, 9 micrometers

**Figure 4.** The pressing pressure effect on the clinker elastic expansion at different initial granulometry: (10 ... 7) ⋅ 10^{-3} m (1); (7... 5) ⋅ 10^{-3} m (2); (5 ... 3) ⋅ 10^{-3} m (3); - residue on sieve R_{008}: - residue on sieve R_{02}

Eccentric rubberized rollers 7, 8 get a rotation through the material layer from the rotating rolls, 1,2, using the side plates 5,6. The side plates are rigidly fixed with partitions 3,4 and provide their oscillatory movements. This intensifies the separation process and materials supply. Large material fractions from partitions 3 and 4 through channels 11 and 12, the cylindrical surface of the rollers 9, 10 are fed to rolls rotating towards each other 1,2. Eccentric rollers 7, 8 ensure the alignment of the coarse-grained layer of clinker along the rolls’ width and ensure its uniform flow into the roll-over space.
Small fractions of the material with greater strength compared to large grains fall inside the layer captured by the rollers. This leads to an increase in the degree of grinding of large particles. Material freezing on the walls is excluded due to oscillatory movements of the side plates 5 and 6.

In layer-by-layer grinding, the middle layer of the fine fraction, characterized by the densest particles packing, provides a damping effect on the easily milled large fractions of the material. The destructive forces increasing from the side of the rolls provide a more uniform density (degree of grain deformation) throughout the entire thickness of the layer, which increases the efficiency of the grinding process and the productivity of the unit due to the possibility of increasing the layer thickness of the material being crushed. The uniform distribution of the material across the rolls’ width due to eccentric rollers will increase the rolls service life.

![Diagram](image)

**Figure 5.** A device for loading the charge into the press - roller grinder.

With an increase in the perforated partitions 3.4 inclination angle, the flow value of the material passing through the holes in them will also decrease. Thus, the degree of its classification will also decrease, but the clinker layer thickness, which has large particles, which, passing between the rollers and eccentric rubberized rollers, will raise the side plates 5,6. This will lead to a decrease in the guides inclination angle, and, consequently, to an intensification of the classification process, i.e. The fractionation self-regulation process has been carried out.

**Summary**

Experimental studies have shown that with increasing pressing pressure, the grinding fineness increases and the most intensively the clinker grinding process takes place within 30 ... 90 MPa. A change in the crushed layer height from 10 to 40 \( \cdot 10^{-3} \) m does not significantly affect the grinding fineness. This indicates the grinding materials process inside the layer under pressure, including due to the different grains’ strength. Elastic expansion increases with increasing pressure and depends on the initial grain size distribution. However, the increase in the elastic expansion value is decreased with an increase in the initial grains’ value.
The grinder design with the device for loading the charge, which allows to increase the grinding degree and the unit performance when grinding materials containing a significant part of small fractions (0 ... 5 x 10^{-3} m). This design use allows the layer-by-layer material flow: from the rolls side - large fractions, in the middle of the layer - smaller, stronger ones. In layer-by-layer grinding, the middle layer of the fine fraction, characterized by the densest packing of particles, provides a damping effect on the easily milled large fractions of the material. The destructive forces increasing from the side of the rolls provide a more uniform density (degree of grain deformation) throughout the entire layer thickness, which increases the grinding process efficiency and the productivity of the unit due to the possibility of increasing the layer thickness of material being crushed. The uniform distribution of the material across the roll’s width due to eccentric rollers will increase the rolls’ service life.

References
[1] Romanovich A A, Romanovich M A, Belov A I, Chekhovskoy E I 2018 Energy-saving technology of obtaining composite binders using technogenic wastes (Journal of Physics: Conf. Series) 1118 012035.
[2] Romanovich A A, Kolesnikov R S, Romanovich M A 2018 Study of device for precompaction and uniform supply of materials to working bodies of aggregate (Materials Science and Engineering: Conf. Series) 042052.
[3] Malov P N, Tarabanov N S 1968 On the effect of elastic consequences on the properties of pressed carbon materials (Chemistry of fuel) 1132-133.
[4] Valkevich V L, Fmedlider G I, Fortunatov T V 1970 Dispersion and elastic expansion of oxide granular masses during pressing (Refractories) 45-48.
[5] Popilsky R Ya, Kondrashev F V 1988 Pressing ceramic powders (Metallurgy) 27-28.
[6] Romanovich A A 2011 Study of the effect of the speed of rotation of the rolls on the output indicators of the grinding process and the development of recommendations for improving the wear resistance of their working surfaces (Bulletin of BSTU named after V.G. Shukhov) 4 71-73.
[7] Pirotsky V Z 1986 Improving the technology and technology of grinding Portland cement clinker: evaluation of the effectiveness of grinding systems 90 3-23.
[8] Romanovich A A, Romanovich M A, Chekhovskoy E I 2018 The calculation of the effort required to create directional movement of the shale materials in the press roller unit (Bulletin of BSTU named after V.G. Shukhov) 8 131-137.

Acknowledgements
The work is realized in the framework of the Program of flagship university development on the base of the Belgorod State Technological University named after V.G. Shukhov, using equipment of High Technology Center at BSTU named after V.G. Shukhov.