

PAPER • OPEN ACCESS

Grinder with mechanism for disaggregation of pressed materials

To cite this article: A A Romanovich *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **194** 032026

View the [article online](#) for updates and enhancements.



IOP | ebooksTM

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

Grinder with mechanism for disaggregation of pressed materials

A A Romanovich, M A Romanovich, A I Belov

BSTU named after V.G. Shukhov, 46 Kostyukova Street, Belgorod, 308012, Russian Federation

E-mail: bel31rm@yandex.ru

Abstract. The article considers industrial technology and energy-saving for disaggregation of pressed materials with a reduction in energy intensity of the process up to 50%. The technological process is based on the sequential introduction of components in dispersed phases into the feed mixture in the grinding path and at the stage of product separation with certain dispersed characteristics. The increase in the energy efficiency of the line is achieved by the joint operation of the press roller aggregate, which is the development of BSTU named after V.G. Shukhov, and rotor-vortex mills of a very fine grinding of a new design. The machine provides for combining the processes of grinding and disaggregation of the pressed material, thereby reducing the operating costs and increasing the efficiency of using the grinding unit.

1. Introduction.

Currently, many foreign and domestic scientists are engaged in the development and improvement of technologies for obtaining finely dispersed materials. Today, an energy-saving technology for obtaining cement in a grinding complex consisting of two aggregates of a press roll grinder and a ball mill (PRG-BM) has been developed [1-3].

It is known that using the press roll grinder in the technological line of cement grinding provides for increase the productivity of the grinding line and reduce the specific energy consumption. However, the material emerging from the PRG has a structure in the form of a pressed tape, which requires special conditions for its de-agglomeration and final grinding (Figure 1).

The common technological scheme includes PRG, a hammer crusher used to disaggregate the pressed material, and a traditional tube mill for final grinding of the charge, operating in an open or closed grinding cycle [4]. The implementation of this scheme provides for increase the productivity of the ball mill by 30% and to reduce the specific electricity consumption by 15-18%.

2. Main part.

There are also known methods for sectional grinding of materials in which the material is first comminuted by high-pressure working rolls, and then the formed agglomerate is destroyed in a rotating disk feeder or in a centrifugal discharge elevator [3,4], and the grinding is carried out in a ball mill. The above methods of grinding materials increase the productivity of the final unit and reduce energy costs. However, the use of an additional aggregate for the deagglomeration of the pressed material entails an increase in the costs of maintaining and operating grinding equipment.



The company "Humboldt Wedag" developed a method of grinding materials in which deagglomeration and final grinding of the charge is carried out in one unit - BM [5]. The mill in this case has two chambers, the first of which serves to loosen the agglomerate without grinding bodies, and in the second, the final grinding is carried out. However, in the implementation of this method, the grinding unit volume is not effectively used. Therefore, it is advisable to carry out research related to the building the equipment and a method of grinding, which provides for the preliminary crushing and deagglomeration of the charge in one unit.



Figure 1. Clinker material to be grinded: a) - initial product; b) - after treatment in PRG

We have developed the design of the PRG with a device for de-agglomeration of the pressed tape, which provides for combining the processes of grinding and de-agglomeration of the pressed material, thereby reducing the operating costs and increasing the efficiency of the grinding unit (Figure 2).

A press roll grinder with a disaggregation device includes a hopper 2 mounted on the frame conical rolls 1 and a device for de-agglomeration which consists of a jaw mechanism 4 and additional rollers 3.

The unit for grinding anisotropic materials works as follows. In the hopper 2, the raw material is supplied, for example, a clinker which is captured by conical rollers, between which it is destroyed.

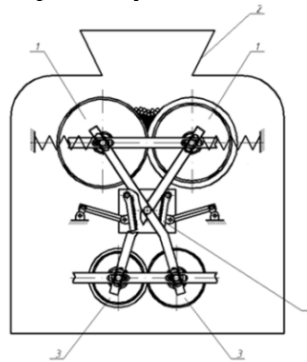


Figure 2. Scheme of press roll grinder with device for deagglomeration of materials

Coming out of the inter-roll space in the form of compressed plates, the material is preliminarily destroyed between two movable jaws and finally between additional rolls of the deagglomeration device.

Additional rolls have an inverse cone with the main conical rolls and thereby an opposite directional effect the material pressed in the rolls, which allows one not only to disaggregate it, but also to uncover the microcracks of the particles. According to the research, depending on the material to be grinded and the mode of its grinding in PRG, about 30% of the finished product contains grain sizes less than 80×10^{-3} mm.

The process of grinding materials is influenced by a number of factors: the pressure of crushing, the conditions for deformation of the destroyed particles, the multiplicity of the application of the

power load, the content of finely divided fractions in the finished product, the technological mode of deagglomeration of compressed particles, and others.

All these factors require more in-depth study to determine the rational parameters of the PRG.

Currently, work is underway to introduce a pilot unit (Figure 3) into a production line for the production of construction mixtures.



Figure 3. Press roll grinder with deagglomerating device

With the purpose of working out the technological modes of operation of the press roll grinder, researches were carried out to study the effect of crushing pressure and the multiplicity of its application on the output indices of the process.

The following materials were used as research materials: limestone organogenic, metamorphic schist fractured and quartzite-sandstone stratified, which had the following initial weighted average particle size: $7.3 \cdot 10^{-3}$ m, $4.9 \cdot 10^{-3}$ m, $1.9 \cdot 10^{-3}$ m, respectively.

The study of the effect of grinding pressure on the fineness of grinding of materials (Figure 4) shows that, regardless of the initial granulometry, strength of particles and other characteristics in the pressure range of $P = 10 \dots 250$ MPa, a decrease in the average particle size, i.e., the pressure factor is an effective technological device that affects the process of material destruction.

When the limiting values of particle strength are exceeded, an intensive destruction of the particles is observed at the initial stage; later (above $\bar{P} \geq (50 \div 100) \text{MPa}$), the efficiency of the fracture process decreases. The latter is due to the densest packing of the crushed particles, and, consequently, to the limitation of their degree of freedom (movement) in the pressed conglomerate at elevated pressures. At the same time, the force influence is perceived to a greater degree not by the particles themselves, but by the pressed sample - the monolith. The concentration of stresses at the contact points of the particles decreases, which leads to a decrease in the intensity of the grinding process.

In this connection, it can be concluded that the effective pressure value when grinding materials is within certain limits. Depending on the initial physicommechanical characteristics of the materials (strength of grains, their anisotropy, granulometric composition, etc.), the nature of the process of their destruction is also different.

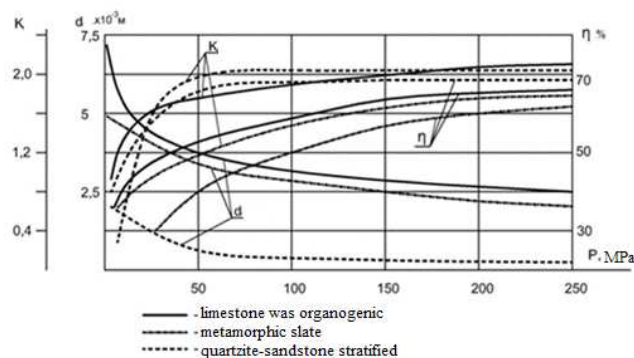


Figure 4. Dependence of the deformation coefficient of the layer of grindable particles (K), The degree of crushing (η) and the weighted average particle size (d) on the crushing pressure \bar{P}

Thus, for anisotropic quartzite-sandstone particles, a more gentle form of the curve is characteristic $d = f(\bar{P})$, which is caused both by the relatively high strength of the grains and by their insignificant initial size ($d = 1,9 \cdot 10^{-3} m$). This is also confirmed by a curve $K = f(\bar{P})$ that has a more gentle character for quartzite-sandstone (for $\bar{P} \geq 50 MPa$). For limestone of organogenic and metamorphic schists, having large sizes of initial grains ($d = 7,3 \cdot 10^{-3} m$ and $4,9 \cdot 10^{-3} m$), the process of intensive deformation (destruction) of grains is observed up to $\bar{P} = 150 MPa$. An analogous regularity for the materials under study is observed in curves $\eta = f(\bar{P})$.

Considering the sufficiently energy-intensive process of grinding materials at high pressures, it is expedient to find ways to reduce energy costs by rational application of the power load.

To do this, we conducted studies of the process of destruction of anisotropic materials in a press matrix with beveled edges at different angles ($\alpha = 10 - 50^\circ$) on the working surfaces of pressing punch (Figure 5).

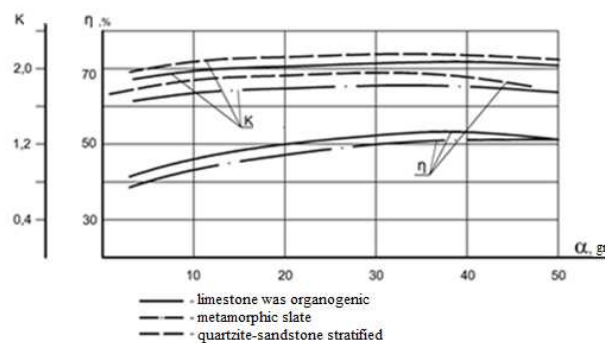


Figure 5. Dependence of the deformation coefficient of the layer of grindable particles (K), the degree of crushing (η) and the weighted average particle size (d) on the angle of the bevel of the working surfaces of punches α . ($\bar{P} = 150 MPa$)

Analysis of the obtained dependences shows that with increasing shear deformations (the angle of inclination of the working surfaces of the punches), the efficiency of the process of particle destruction increases.

Therefore, in the design of PRG, the working surface of rolls having a conical profile have been adopted, that made it possible to realize the volume-shear deformation of the particles. However, as practice shows; increasing the pressure of grinding materials in PRG is not the only way to increase the efficiency of the grinding process.

When using the technological method to increase the multiplicity of the application of the power load (up to 4 to 5 times), the efficiency of the grinding process is significantly increased. This is due to the fact that after the deagglomeration of the compressed particles, some layers of micro-cracks have orientation in the direction of the acting force, which, without significant increase in energy costs, improves the efficiency of the grinding process.

In order to work out the fragmentation modes in the press-roller mill, studies were conducted at a pilot production unit, property of a small innovative enterprise LLC Kompozit, located at the premises of an innovative business incubator of BSTU named after V.G. Shukhov [3-5]. The studies considered influence of the gap between the rollers and shear volume deformation onto the final results of the milling process.

The milling forces in the press roller mill depend on the value of the gap between the rollers, which itself depends on pressure and is a critical factor in the milling process. Studies of graphical dependency $E, N, Q, q = f(\delta)$ (Figure 6) plotted on the results of the experiments, determine that the most rational milling process proceed when the roller gap is $\delta = 5 \times 10^{-3} m$. This is evident from minimum specific energy costs, defining the extreme point of the function and equal to $q_{lime} = 2.56 kW \times h/kg$ for limestone and $q_{cl} = 3.98 kW \times h/kg$ for the clinker.

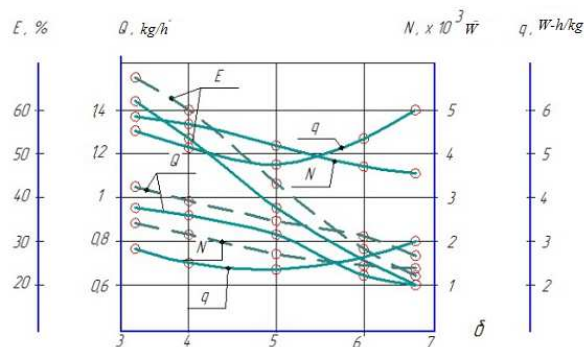


Figure 6. Influence of the roller gap onto E , Q , N , q (materials: – clinker; -- limestone)

In the light of this research and previous studies [4- 5], it has been found out that the most efficient material fragmentation process in the press roller mill with the conical profile of the rollers is at a milling pressure of $P = 150 - 250$ MPa, roller rotation velocity - $V_{av} = 0.8$ m/s and taper ratio - $K = 0.3$, which plays a significant role in shear volume deformation of the materials being milled. These findings will allow reducing significantly electric power consumption during the milling process.

3. Conclusion.

The most effective parameter is the multiplicity of the force effect for fragile particles, in our case – for metamorphic schist and quartz rock.

Thus, the use of the developed PRG provides for:

- reduction of energy costs for the maintenance of equipment, through the implementation of two operations (grinding and deagglomeration) in one unit;
- realization of the process of repeated force action on the crushed particles after their deagglomeration, which is an effective technological method for reducing energy costs and increasing the dispersion of materials;
- removal of more finished product after each stage of its grinding and thereby reduction of energy consumption in subsequent grinding stages;
- improvement of the efficiency of the PRG, using tapered rolls that realize the volume-shear deformation of the material, and the use of a deagglomeration device having a roll with a conical cone.

4. Acknowledgments.

The article was prepared within a development program of the Base University on the basis of BSTU named after V. G. Shukhov.

References

- [1] Romanovich A A, Glagolev S N, Romanovich M A 2016 Technology for the production of nanomaterial with the use of traditional grinding equipment *International Journal of Pharmacy and Technology* **8(4)** 25007-25014
- [2] Romanovich A A, Glagolev S N, Romanovich M A, Babaevskiy A N 2016 The method of computing the efforts of preconsolidation of materials in a roll device *International Journal of Pharmacy and Technology* **8(4)** 25015-25023
- [3] Glagolev S N, Romanovich L G, Evtushenko E I 2013 Innovative activity on the basis of higher educational institutions. Experience BSTU named after V.G. Shukhov *Bulletin of the Belgorod State Technological University named after V.G. Shukhov* **2** 116
- [4] Romanovich L G 2013 Incentives for innovative activity of young scientists on the basis of higher educational institutions in Russia *World Applied Sciences Journal* **25(12)** 1754
- [5] Shonert K, Knobloch O 1986 Crushing of cement on a roll grinder in a layer of material *Zement-kalk-gips* **37(11)** 1-9