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Methods to improve efficiency of production technology of the innovative composite cementing materials

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Abstract The article describes the energy-saving technology and equipment for production of composite binding material with up to a 50% reduction in energy consumption of the process due to a synergistic effect in mechanical activation of the raw mix where a clinker component is substituted with an active mineral supplement. The impact of the gap between the rollers on the final performance of the press roller mill was studied.

1. Introduction

Russia has the tenth largest economy in the world, predominantly concentrated in heavy industry, including production of constructional materials and ranks third globally by energy consumption; thus, consuming more energy per unit of GDP than any country among the top ten of the largest energy consumers. In 2005, according to the available data, energy consumption in Russia calculated per production volume was 0.42 kg of oil equivalent (o.e.) per 1 dollar of GDP. At the same time, this indicator does not exceed 0.14 in developed nations, such as Germany, France, Japan, India; in the USA, it is 0.19, while in Canada it is 0.25.

The modern construction industry is based upon processing of vast amounts of non-metallic materials with diverse mineral compositions and physical and mechanical properties (loams, sands, limestone, granite, basalt, quartzitic sandstone, etc.). Such processing is accompanied with significant material and energy costs. Processes of fragmentation and fine milling of materials are among the main operations in both existing and new production processes; such processes consume about 10% of all energy produced globally [1-2]. That is why a reduction of energy consumption in material fragmentation is a current task.

Energy intensity of cement and clinker produced in Russia is about two times higher than the same indicator in the developed nations. Globally, the best values in energy intensity are in the range of 0.09- 0.11 GJ/t. In Russia, this indicator never drops below 0.2 GJ/t.

2. Experimental part

The cited data show that the traditional cement has high-energy intensity and due to a constant increase in price of energy resources with a simultaneous increase in consumption, the task to reduce the energy intensity of binder production is of increasing importance.

Besides, continuing implementation of the national project “Affordable and Comfortable Housing for Russian Citizen” has led to the increased activity of construction and growing demand for dry



construction mixes, with their production currently being at the level of about 3.5 million tonnes per year.

All these factors demanded a new approach to organization and implementation of production of more affordable composite binders and construction mixes using local feed, as well as development of regional energy-saving milling units working with the local feed.

Scientists of Belgorod State Technological University named after V.G. Shoukhov (hereinafter - Shoukhov BSTU) have developed an industrial technology and energy-saving equipment for binder production with a reduction of energy intensity by up to 50% due to a synergistic effect in mechanical activation of the raw mix with replacement of the clinker component with a hydroactive mineral additive. The process (Figure 1) is based upon sequential introduction of the dispersed components into the raw mix at the milling stage and mixing of the components with certain dispersion characteristics.

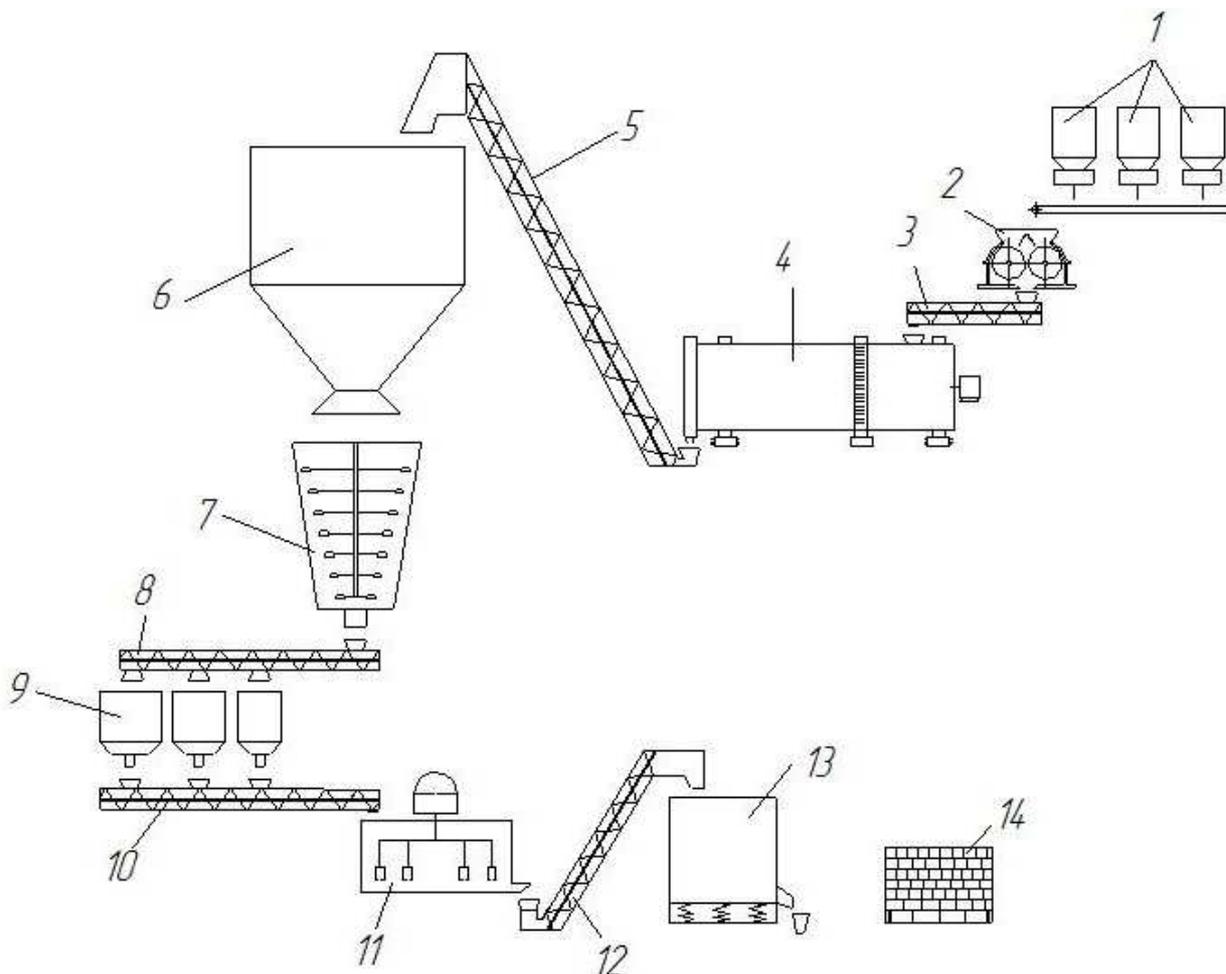


Figure 1. The process scheme of the composite material production: 1, 2, 3 – raw material storage bin; 2 – press roller mill; 3, 5, 8, 10, 12 - feed auger; 4 - dryer drum; 6 – storage bin; 9 - additives bin; 11 - mixer; 13 - packaging machine; 14 - product storage

Increased energy efficiency of the line is attained by means of a joint operation of a press-rolling unit, developed by the scientists from Shoukhov BSTU, and a superfine rotary vortex mill of a new design, whose joint operation contributes to synergistic effect. The composite binder production technology assumes fragmentation of the feed materials to a degree of dispersion characterized with specific surface of 4000...4500 cm²/g.

The technical characteristics of the press-roller grinder (Figure 2) used for preliminary milling are given in Table 1.

Table 1. Technical characteristics of the press-roller grinder

No. item	Technical characteristic	Value of the parameter
1.	Roller dimensions	0.5x0.3 m
2.	Taper rate of rollers	0.3 m
3.	Gap between rollers	$(3-8) \times 10^{-3}$ m
4.	Velocity of roller periphery	0.8 m/s
5.	Installed capacity of roller driver	2x7.5 kW
6.	Maximum backward force	90×10^4 N
7.	Capacity of unit	5-8 tonne/hour



Figure 2. Press-Roller mill

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 OOO Kompozit, located at the premises of an innovative business incubator of Shoukhov BSTU [3]. 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 in its own turn depends on pressure and is a critical factor in the milling process. Studies of graphical dependency $E, N, Q, q = f(\delta)$ (Figure 3) plotted from the results of the experiments allowed determining that the most rational milling process proceeds 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 $q_{\text{lime}} = 2.56$ kW×h/kg for limestone and $q_{\text{cl}} = 3.98$ kW×h/kg for clinker.

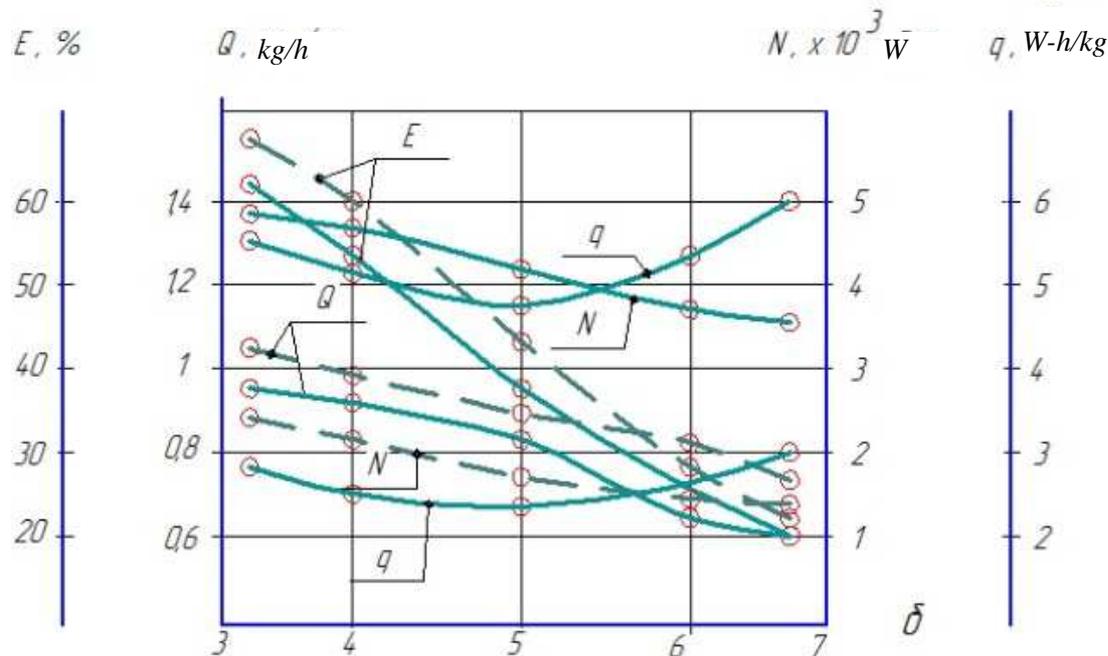


Figure 3. Influence of the roller gap onto E, Q, N, q (materials: _____ clinker; - - - limestone)

In the light of this research and previous studies [4- 7] it was 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 $V_{\text{av}} = 0.8$ m/s and taper ratio $K = 0.3$, which plays a significant role in shear volume deformation of the materials being milled. These findings allow reducing significantly electric power consumption during the milling process.

3. Acknowledgments

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