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Construction of the electromagnetic mill with the grinding system, classification of crushed minerals and the control system.

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Abstract: The article presents the construction of an innovative electromagnetic mill, which in comparison to traditional solutions provide a significant reduction of energy consumption and higher technological performance. The device is equipped with a control system, measuring grinding quality or analyzing the operating status of the mill. Direct control of the grinding process is implemented in industrial controllers (PLC) and is supported by the optimization algorithms that run in the supervisory control system (SCADA).

Keywords: ***mining operations, mineral processing; control and optimization; measurement, sensors; electromagnetic mill; control system; shredding; grinding; grinding media***

1. INTRODUCTION

Shredding of the raw material is an operation widely used in many industries, from mineral processing, the chemical industry, construction, food and pharmaceutical industries. This determines different expectations about the degree of fragmentation and properties of the product after crushing.

The yield of the grinding product is closely dependent on the type of feed and parametrs of grinding process. Considering the case of a particular material, the final efficiency of grinding is affected by the moisture content of the feed and its particle size as well as grinding media to feed ratio. Therefore, a direct comparison of various types of mills to each other is difficult and its yield is difficult to estimate. It is worth mentioning that parameters such as efficiency and energy consumption in various types of grinding plant, because their knowledge is essential to the initial assessment of the suitability of the mill and crusher at the specific application.

Conventional grinding of mineral raw materials is carried out by material removal by the grinding media. In the classical drum mills – ball or rod – the movement of the grinding media is caused by the rotation of the cylindrical working chamber filled with grinding media.

A disadvantage of such mill is a high energy consumption and interchangeable parts such as lining and grinding media. Such solution results in low efficiency of the process due to the high loss of energy supplied to move the grinding media, which is only slightly reflected in the actual grinding process. It is difficult to control the shape of the grains, which often results in low technological value of the obtained product.

The ability to control the size of the feed and grinding media, on going analysis of grain size and the operating status of the mill and recycle flow will allow the full and far more effective mechanical activation of produced grains with specific physical and mechanical properties (size, shape, surface area and energy surface properties) as well as a significant increase in grinding efficiency and a reduction in energy consumption by 50%. Heat losses in the working chamber can be used for simultaneous drying and heating the material, what results in increased milling capacity.

2. CONSTRUCTION OF THE ELECTROMAGNETIC MILL

Electromagnetic mill is a device in which the ferromagnetic grinding media are moved by deliberately generated rotating electromagnetic field as an energy carrier. The basic elements of the mill are inductor of rotating magnetic field and placed in its axis tube, serving as a working chamber (Wołosiewicz-Głąb, Foszcz 2015, p. 225). The working chamber is approximately 20% filled with ferromagnetic grinding media. Electromagnetic mill was little-known grinding machine used the most in laboratories rather than in industry. Such limitation of applications derives from the very low productivity and low efficiency of this type of mills. Low technical-motor parameters influenced by improper design assumptions lead to very large energy losses in the inductor windings of a rotating magnetic field. One of the advantages of the electromagnetic mill is the the ability to enhance many of technological processes by grinding in the area in which the ferromagnetic rods (grinding media) of suitable selected length to diameter ratio rotates moved by rotating electromagnetic field. The mill operates efficiently in terms of both high-hydration content and low humidity. 30%

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decrease of milling efficiency occures in case of material with a moisture content in the range of 15% to 30%, especially if it has a high viscosity as well (Wołosiewicz-Głąb, Foszcz 2015, p. 227).

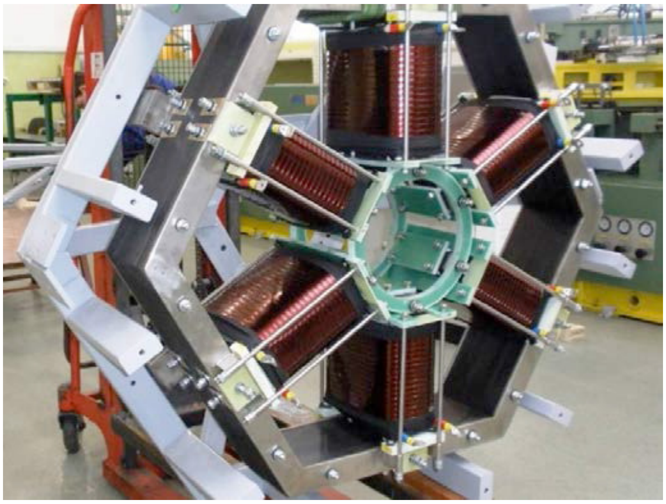

Fig. 1. Magnetic inductor developed by ELTRAF company

Fig. 2. Electromagnetic mill working chamber (visible grinding media).

Unlike in case of conventional mills (balls, cylpebs or rod) the mill housing is stationary while the grinding (or mixing) takes place in the working chamber, inside which some small ferromagnetic elements – called grinding media are moving. Their movement is caused by the action of the vortex electromagnetic field (Wołosiewicz-Głąb, Foszcz 2015, p. 9931). The effectiveness and efficiency of the process carried out in the mill is dependent on the proper selection of the physical parameters of the structure and process parameters such as flow rate of feed (residence time), particle size of the input, the speed and intensity of the rotating electromagnetic field, temperature, humidity, and other parameters of the workpiece (e.g. lithological composition). Desired grain size of the product determines the technological requirements of individual technologies, eg. for copper ores below 75 microns, for zinc ore less than 100 microns, raw materials for cement production below 90 microns, high-quality mineral fertilizers less than 10 microns (Sidor, Foszcz, Tomach and Krawczykowski 2015). A basic condition for industrial use of electromagnetic mill is its continuous operation. Grinding media should be selected for the particle size of the particulate material. In case of large grain size variation of the material, a blend of different size grinding media are being used. Any change in the size of the grinding media adapts to the physical properties of the ground material and the final fineness of the ground product. Defined requirements for grinding systems and classification, about the reduction of grinding energy consumption, the optimal grain size, grain shape and their surface properties show that there is a need to design a modern fine griding system with recirculation of particles which do not meet quality requirements. To make this solution competitive, system should be universal for possible all kinds of raw materials, configurable using a measuring and control system as well as a dedicated HMI / SCADA software. Such requirements impose a need for mills with a unique operating principle and the wide possibilities of parameterization of its work.

2.1 The structure of the technological system

The concept assumes the vertical position of the working chamber of the electromagnetic mill, which is loaded from the top by the auger conveyor and from the bottom the stream of transport air with suitably humidified is provided.

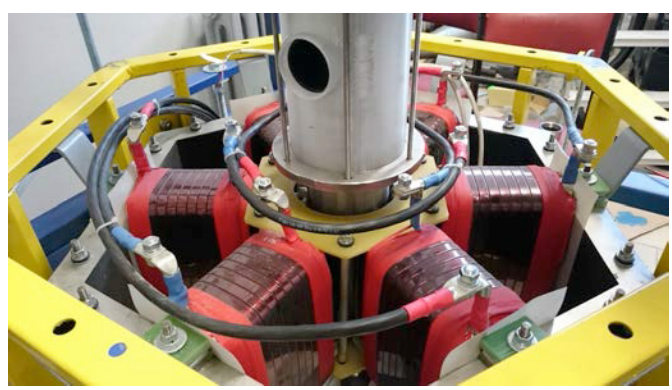

Fig. 3. Working chamber and electromagnetic field inductors.

Over the working chamber there is an integrated preliminary classifier, which forms internal recycle. The material is received from the top of working chamber and goes to the preliminary classifier. Unmilled material returns along with the feed from the top of the working chamber and the material of suitable particle size is entrained upwards into the accurate classifier. To ensure adequate air flow speed for transportation and accurate classification, between the initial and the exact classifier there is an adjustable plague of additional air. Accurate classifier separates the stream of material to the final product stream and the recycle stream. Providing a pneumatic separation, the recycle stream is sent again to the mill. However, due to small particle size in the recycle, to force the next passage through the working chamber, recycle stream is fed from the bottom of the