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Creation of New Generation Energy-Intensive Tumbling Mill

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Data on the experimental constrained autogenous grinding mill are given. Its construction and advantages are described. The perspective of its industrial application is estimated.

Keywords: MILL, GRINDING, CONSTRUCTION, ADVANTAGES

Introduction

Up to 20% of the country's electricity is consumed by mining-and-processing integrated works, up to 70% of which is used for grinding. Among the reasons for this are: low grinding selectivity and low (0.4-2%) efficiency of the traditional tumbling mills, imperfect technology of enrichment, which usually needs 3-stage scheme of ball milling. Specific power consumption for iron ores grinding is 14–21.7 kW•h/t. The necessary amount of electric power at a plant with capacities of 40 million tons per year is about 800 million kW • h with the annual demand for balls 60 and lining 4 thousand tons. Besides, financial expenses for their payment are constantly increasing due to the clearly defined tendency to increase in the cost of energy vectors. Moreover, steel intensity of the traditional tumbling mills is high and close to 4.3 t/m^3 of the drum effective volume, and their speed is subcritical (0.85 of critical) that provides low engine speeds and their high unit price. Eventually this leads to a decrease in competitiveness of mining-and-processing integrated works, the working cost of concentrate which now is almost 30% higher than world prices.

Consequently, the search and implementation of effective economy of material and energy resources is of strategic importance, directly determining the competitiveness of mining companies.

Results and Discussion

In order to improve the competitiveness of domestic enterprises of mining and smelting complex to the world level it is suggested to improve the enrichment technology and equipment used for grinding, in particular, tumbling mills. This takes into account the main factors determining the level of expenses for energy and material resources. In particular, the aim is to improve the actual process of grinding in the direction of strengthening its selectivity and efficiency in getting the product ready for the enrichment as an effective factor to reduce specific energy consumption. An important factor is the move to constrained autogenous grinding, self-lining of the mill work surfaces that are directly involved in the process of disintegration of raw materials, creating the conditions for transfer of crushing energy, abrasion and spalling in its inner layers. This excludes the necessity to use the balls and corresponding to their wear loss.

One of the ways of increasing efficiency of mills is based on the known ways to reduce the size of mills and create conditions for their work at supercritical speeds what increases the speed of their actuating motors essentially - in1.5-2 times, and almost proportionally reduces their weight, price and size. At the same time efficiency coefficient of the drive is also increased.

The desire to combine the advantages of one design in the above directions to improve constructions and modes of tumbling mills use resulted in the development of a new type of grinding equipment at the NMU - resource-saving constrained autogenous grinding mill (**Figure 1**). When designing the mill the following points were used: increase in the specific output and the transition to autogenous grinding, constrained multi-vector intensive impaction, crushing, abrasion and spalling of raw materials, transfer of the selective destruction of the inner layers of raw materials due to intensification of the effect of transverse segregation per load, self-lining of the mill working surfaces and its increased supercritical speed, optimizing the type and modes

of operation of the mill. Additional increase of the specific output is achieved by placing the intensifier within the rotating drum of the mill, the work surface of which is protected from wearing by large pieces of raw material.

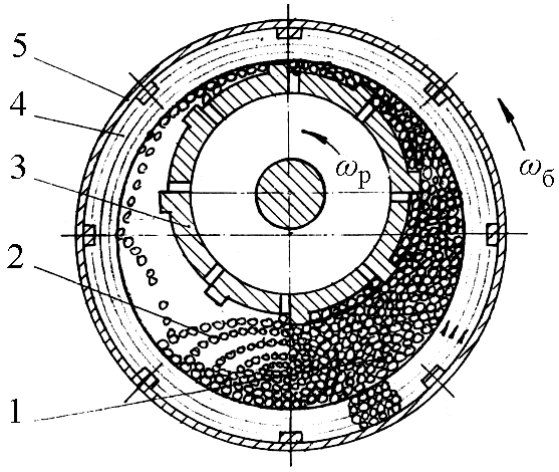


Figure 1. Cross section of the constrained autogenous grinding mill. 1 – inactive wedge-shaped zone; 2 – breaking layer; 3 – rotating intensifier with angulator ω_p; 4 – centrifuging layer; 5 – a drum with angulator $\omega_б$

Complex use of these points provides a more complete disclosure of the useful component, a quick reduce of the specific consumption of metal and energy per unit of final product. This creates conditions for reducing the number of stages of crushing and grinding, processing equipment; the required area and size of workplace become smaller; conditions for increasing the plant power are created.

The potential of selected areas of technology improvement and grinding equipment is confirmed by the results of experimental studies of the process of constrained grinding of various materials. When milling ore containing gold and with strength up to 18 items according to Protodjakonov, the specific consumption of the lining reduced four times and during grinding andesite ore with content of diamonds high safety of their natural shape was settled.

Upon receipt of graphite for the electrical industry specific energy consumption decreased by 81, and during constrained grinding of diopside - 66%. During the constrained grinding of dehydrated chalk the content of classes minus 16, 9 and 3 microns in the finished product was 100, 96.1 and 54% respectively with the specific surface of the finished product 0.83 м2/g. When grinding middlings and talc savings of electricity were 45 and 50%, respectively.

During the wet milling of iron materials of the first stage of ball milling ROF-1 JSC "InGOK" it was established that when the identical rates of enrichment are achieved during 1-stage constrained autogenous grinding compared with 3-stage ball milling the reduction of specific energy consumption is about 23.3%, iron content in the concentrate is 0,85% and the concentrate yield 1.08% higher. And it is only by optimizing the technology of destruction. It was concluded that evenduring 1-stage grinding it is possible to obtain higher quality concentrates with low milling of the original ore. Besides 1-stage constrained autogenous grinding will allow using a shorter, manufacturing scheme with less operations and significantly reduce the cost value of redistribution and concentrate.

Based on an analysis of the results of milling and enrichment and the protocol of technical meeting of experts from JSC "InGOK" and the NMU a technical proposal for an experimental constrained autogenous grinding mill МПС(Р) 1500x1200 with a productivity of original ore ROF-1 JSC "InGOK" 5 t/h was developed. Sketch of the general form of this mill is shown on **Figure 2**.

The mill contains a charging machine in the form of a funnel to feed the source of power and water, as well as spiral feeder with crooked line, which feeds profiles, for the closure of the circulating mill load of sand in the form of a spiral classifier, applied to the box-type storage.

Discharge arrangement of the mill consists of a grid with slots and special curved elevators, which provide reliable operation of the site at supercritical speed of the mill. Mill discharge is transported by the tail journal spiral.

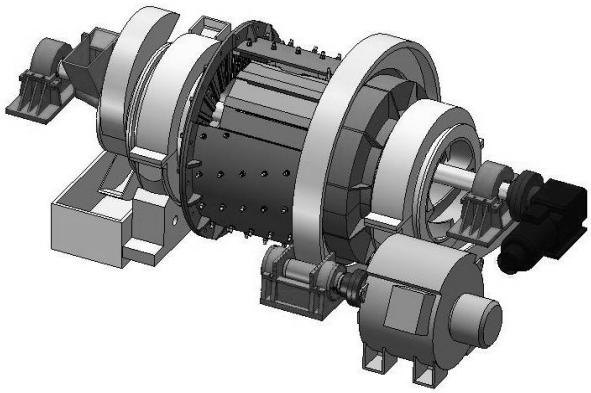
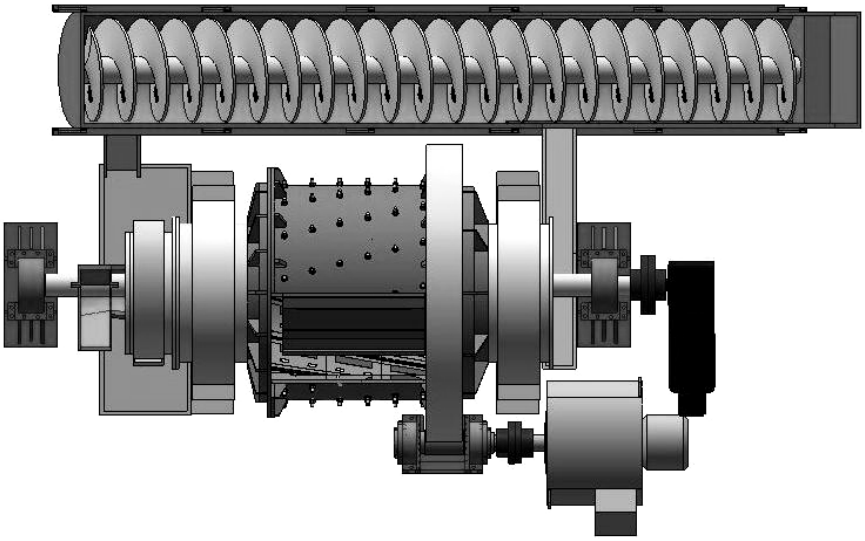


Figure 2. Sketch of the general form of an experimental constrained autogenous grinding mill МПС(Р) 1500x1200

A drive wheel open gear from the synchronous motor is located on the drum. The moment of its moving is passed to the wheel through the under-ring gear, connected with the shaft of the motor through an elastic clutch. Intensifier gear is an individual reducer engine with an asynchronous squirrel-engine.

The intensifier shaft leans against rigidly fixed supports and is connected to the shaft gear motor through an elastic clutch. A special lining, which



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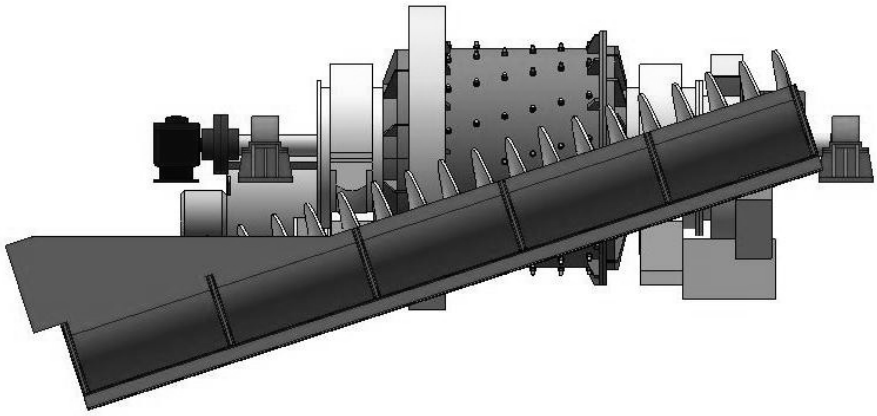

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Figure 3. Plan view (a) and side view (b) of the experimental mill МПС(Р)-1500x1200 with a spiral classifier 1 КСН-7,5 with an inclination angle of 18 ° (angle of the mill drain trench is 10°, classifier trench - 27 °)

intensifies the transverse load inside the mill and selective autogenous material, was installed on the working surfaces. Thanks to these lining profiles uniformity of the mill load during wet grinding is provided.

Technical characteristics of the mill

Productivity according to the original power	up to 5 t/h
Size of the original power	minus 30 mm
Mill speed	41rpm
Weight of the mill without drives	up to 20 t
The drum drive motor	SD2-85/18-12
Drive motor power	132 kW
Nominal motor speed	500 rpm
Engine weight	1540 kg
Danfoss combined motor reducer	VK700-... /D16
Overall dimensions of the mill (including the drive)	5120x2820x2200 mm

During grinding of iron ore of the 1st JSC "InGOK" factory it is expected to save up to 20-23% of electric power, and up to 50-75% of lining. The quality of the concentrate is expected to be 1% higher. The accounting price of the mill without electrical facilities is close to $ 200 000. The mill is well mated with a short spiral classifier 1KSN-1,5 with sand-raking capacity up to 30 t / h (**Figure 3**).

For ironworks the mill may be used as a pilot one in order to obtain bench-mark data for the constrained autogenous grinding mill МПС(Р) of industrial size, for non-ferrous metallurgy and other industries - as the industrial one. It is possible to use the dry method of grinding, with or without grinding bodies.

When determining the prospects for industrial development of the constrained autogenous grinding mill CAG expert judgement of technical and economic advantages of their use for specific enterprises was obtained, in particular, for JSC «Mikhailovsky GOK". It is suggested to use МПС(Р)-3600x3100, adapted to the understructure of replaceble mill МШРГУ-4500x6000. The drive with the existing capacity of 2500 kW was used for the new mill. The use of this mill will provide an annual economic effect of $ 0.85 million with a payback period 1.5 years.

During the evaluation of the advantages of the constrained autogenous grinding of ROF 2 "InGOK" middlings the calculation of the expected economic benefits from the use of МПС(Р)-3600x3100А instead of two replaceble pebble mills МГР-4000-7500. The use of the new mill will provide an annual economic effect of $ 0.86 million with a payback period 3.6 years, even with a 60% increase of the price of 1 ton of a new mill compared to the price of commercial mills (with the same price the economic impact increases to $ 1.25 million and the payback period is reduced to 1.7 years). Also a feasibility study was performed and the expected economic benefits from the use of 2 mills МПС(Р)-3600x3100 instead of the four sections of ball mills used in the JSC "InGOK" were determined, which made $ 2.6 million with a payback period of 2 years.

Conclusions

Nowadays, energy and resource saving based on the intensification and control of grinding equipment is a very urgent problem for the mining industry. Replacement of the outdated tumbling mills for more modern ones leads to the efficient reduction in energy and material expenses. Effective solution to this problem is large-scale implementation of energy-intensive constrained autogenous grinding mills. It is expected to save up to 20-23 % of electric power, and up to 50-75% of lining. Besides, the quality of the concentrate is expected to be 1% higher. Additional savings are achieved by reducing the drive power and its price, reducing the required areas and factory building capacities, reducing the production chain and the number of stages of crushing and grinding.

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Создание энергонапряженной барабанной мельницы нового поколения

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Приведены сведения об экспериментальной мельнице принудительного само-измельчения. Описана ее конструкция и преимущества, оценены перспективы промышленного использования.