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Modernization and Development of the Ball Mill Electric Drive Control System

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ABSTRACT: In this article, we will look at the general issues related to the creation and use of controls for variable induction ball mill motors. The automated operation of the electric drive of this mill fulfills the following important requirements: conversion of electrical energy into mechanical energy, which is necessary for the implementation of this technological process; management of processes to improve product quality with a degree of optimization according to a number of criteria, for example: ensuring maximum productivity, accuracy and quality of the work process. Minimal energy consumption of materials, etc. Specific control tasks are diverse and are determined by the nature of the technological process.

In addition, the function of an automated electric drive is all integrally connected with the need to regulate the values that characterize the movement of the electric drive, the speed of the moment, position.

I. INTRODUCTION

In the process of automation of the electric drive of a ball mill, the implementation of this function of the working body is possible only through the use of an electric drive controller. Transmission variators used today to control mechanical or hydraulic vehicles, hydraulic couplings, etc. are often technically and economically impractical.

An electric drive is understood as an electric drive that provides speed or torque control in a given range with the necessary accuracy. In most cases, the control system of a variable electric drive must also provide a given nature of transient processes[1].

When changing the speed of the moment or other cards and above the electric drive, the use of an adjustable electric drive as part of technological machines and units is associated with one of the following circumstances. Mills of various designs are widely used in the mining and processing industry in the production of fine materials and other technological processes.

Consider the grinding process using a cement ball mill as an example. A mill of a similar design is used in the production of cement for the preparation of pulverized coal, initial components of paints and others.

II. SYSTEM ANALYSIS

The basis of the mill is a drum filled with half its volume with bodies, the grinding bodies are cast iron or steel balls[2,3].

The drum rotates by an asynchronous electric motor through a mechanical gearbox when the drum rotates, freely moving grinding bodies grind the material loaded into it by impact and erasure and crushing.

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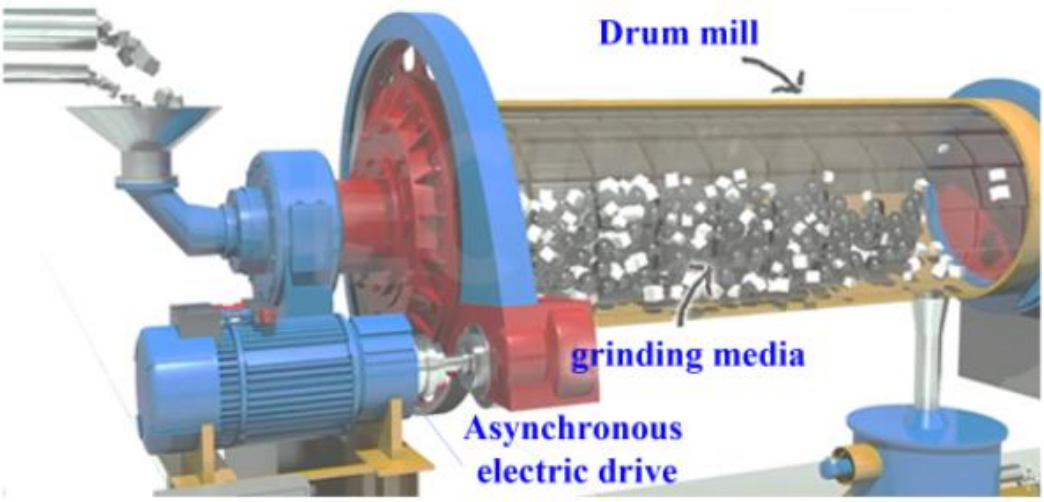

Fig. 1. The scheme of direct start-up of the electric drive of a ball mill

To obtain the final product with the specified dimensions, closed-cycle mills are used. The material crushed in the drum enters the separator in the separator, a fraction of the finished product of the required size is extracted from it. With the help of an aspiration system, larger particles are directed from the new drum for additional grinding[4].

III. INPUT DESIGN

Thus, from the bulk, we grind its material, particles of the required size are continuously extracted.

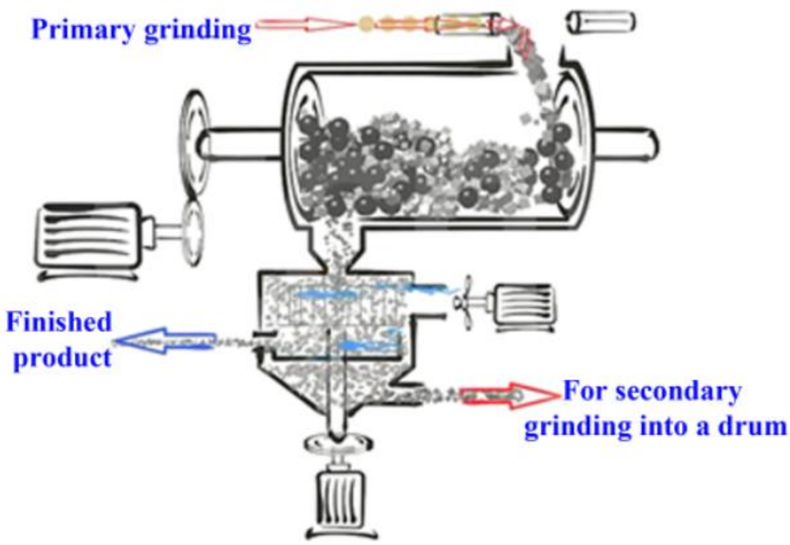

Fig. 2 Functional diagram of a ball mill

Controlling the fineness of grinding is carried out by changing the amount of the loaded source material, changing the deflection angles of the separator blades by displacing the armor plates at the drum outlet. The fineness of grinding also depends on the drum rotation speed.

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Disadvantages in the operation of a drum ball mill: heavy start-up and, as a result, high starting currents, voltage dips in the power grid, rapid wear of the gearbox during direct starts, high repair costs, replacing gears, complexity, reconfiguring the mill to the required fineness of grinding.
Controlling the speed of the drum rotation using mechanical devices is expensive and difficult high power consumption[5,6].

IV. OUTPUT DESIGN

To eliminate the above disadvantages, we will install DELIXI frequency converters in the electric circuits of the electric motors of the separator drum and fan, and connect remote controls (R-Controls) to each frequency converter.

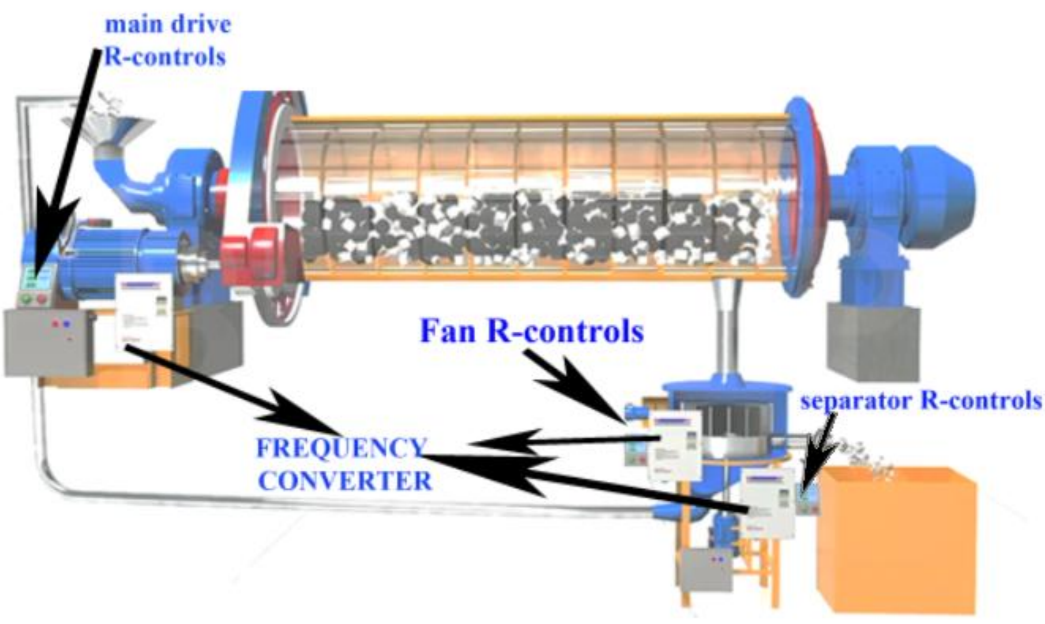

Fig. 3. Diagram of the speed control of the electric drive of the ball mill

The required value of the drum rotation speed to maintain the specified parameters of the grinding process are set from the remote control of the main drive. Direct control of the speed of rotation of the mill drum allows obtaining the required particle size of the grinded product; when the mill is started, the drum drive frequency converter smoothly accelerates the mill to a given nominal rotation speed.

V. ESSENTIALS OF PERFORMANCE

The currents of the electric motors of the drum, separator and aspiration fan during acceleration increase smoothly and do not exceed the nominal values.

The required speed of rotation of the separator and the fan is set by the corresponding remote controls, the speed control of the separator and the aspiration fan allows to obtain the product fractions of the required size without dust[7].

The use of DELIXI frequency converters to control the mechanisms of the drum ball mill allows you to simplify the process of starting the mill and reduce the starting currents, select the optimal parameters of the mill for grinding the material to any required size, simplify the reconfiguration of the technological process to produce products of another range without stopping the mill by setting the required speed value.

Expand the functionality of the mill by operating at speeds higher than the rated speed, increase the service life, reduce equipment repair costs and reduce power consumption.

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VI. DIAGRAMMATIC REPRESENTATION

When using a frequency converter in an electric drive of a drum mill, the following advantages are obtained.
reduction of the speed of rotation of the electric motor by 20 percent;
allows you to obtain an energy saving effect of up to 50 percent, while this effect can also be supplemented with various additional functions that have a frequency drive:
for example, one such feature is automatic optimization;
energy consumption due to a special algorithm for working with an electric motor;
this function allows you to additionally save up to ten percent;
electricity due to significant energy savings obtained with the help of cleanliness control, they pay off very quickly, usually within up to 1 year.
In this article, we examined the main features of frequency converters and their advantages[7].

VII. RESULTS

We estimate the value of economic efficiency achieved by controlling the speed of the electric drive using a DELIXI frequency converter (price from a warehouse in Moscow 18850 dollars. with VAT) for an electric ball mill drive with a capacity of 400 kW.

Energy savings can be up to 45% when adjusting the speed of rotation and automating the operation of the ball mill electric drive using a frequency converter. As a result of calculations, we assume that the savings will be 20%, but in practice this figure can reach 40%. Taking this into account, the energy savings for 1 year for an electric ball mill drive with a nominal power of 400 kW, operating 9 months (71280 hour) a year, will be:

$$B = 6480 \times 400 \times 0.2 = 518400\, kW \times h$$

Let's determine the price of electric energy that is saved – 0.033 dollars/kWh

$$C_{efficiens} = 518400 \times 0.033 = 17107.2\ dollars$$

We take the size of the coefficient λ for 1,2. Calculate the payback time of the factory-wide frequency converter ESQ-500-4T4000G 400kW , the price of which is $C_{converter}$ =18850 dollars:
In monetary terms, at the cost of 1 kWh = 0.043 (electricity tariff for industrial and equivalent consumers with an attached capacity of > 750 kVA, 2021 year).

VIII. CONCLUSION

When determining the cost-effectiveness of using a frequency converter at facilities, the following factors are taken into account:
a) energy savings (20 % or more);
b) reducing the cost of routine maintenance;
c) increase in the life of the electric motor (1.5-2 times).
Below is a simplified formula for calculating the payback period of frequency converters:

$$T_{\text{payback}} = \frac{C_{\text{converter}}}{\lambda \times C_{\text{efficiency}}}$$

Where: $T_{payback}$ - payback period in months; $C_{converter}$- the cost of the converter;
$C_{efficiency}$-the cost of the saved electricity per month.

$$T_{\text{payback}} = \frac{C_{\text{converter}}}{\lambda \times C_{\text{efficiency}}} = \frac{18850}{1.2 \times 17107.2} = 0{,}91\,\text{month} = 27\,\text{days}$$

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IX. SCOPE

Ball mills are used in mining enterprises and in the crushing of large minerals of lead enterprises. These mills are the optimal solution for adjusting the speed of electric angles, improving productivity and quality of production.

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