MODERNIZATION AND REPAIR OF EQUIPMENT

Reengineering of the ball mill drive at the Novotroitsk Plant of Chromium Compounds

A. V. Nefedov · R. E. Ishmukhametov · N. A. Chichenev · I. I. Basyrov · Y. O. Lyubchenko · E. E. Balakhnina

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Abstract
The Novotroitsk Plant of Chromium Compounds specializes in the processing of chromite and dolomite ores, which are delivered to the first workshop of the grinding department, where they are crushed and ground in a ball mill. Operational experience has shown that the failure of the ball mill installed in this workshop leads to unplanned downtime due to failure of drive components, which accounts for 11.3% of the nominal operating time of the workshop. In order to increase the reliability of the technological equipment, it is proposed to replace the existing electric drive, which includes an obsolete 4A series electric motor and a special reducer, with a modern R167DV280V4/BVG122 motor-reducer, which transmits the rotation to the mill drum through a gear coupling. The development of the new drive has simplified its design and reduced the labor intensity of maintenance and repair. This technical solution increases the operating time between repairs, thus reducing operating costs. Calculations show that the implementation of the project solutions will lead to a 0.02% reduction in the cost of processing 1 ton of ore, a 1.37% increase in production profitability, and a 1.29% increase in sales profit. The additional investment does not exceed 3.4 million rubles and will be recovered in less than 3 months.

Keywords Beneficiation production · Crushing and grinding processes · Tube ball mill · Electromechanical drive · Geared motor

Introduction

At present, metallurgical enterprises pay considerable attention to reengineering of existing equipment, implementation of new advanced technologies, full automation of metallurgical processes with the help of powerful computer systems, improvement of work organization, and qualification of employees [1–6]. Considerable attention is also paid to the identification of bottlenecks in the operation of primary technological equipment and the collection of data for the development of organizational and technical measures to reduce unplanned downtime [7–11]. One of the key issues in the metallurgical industry is increasing the reliability of equipment, which is achieved by modernization or replacement of obsolete technological machines and units [12–16].

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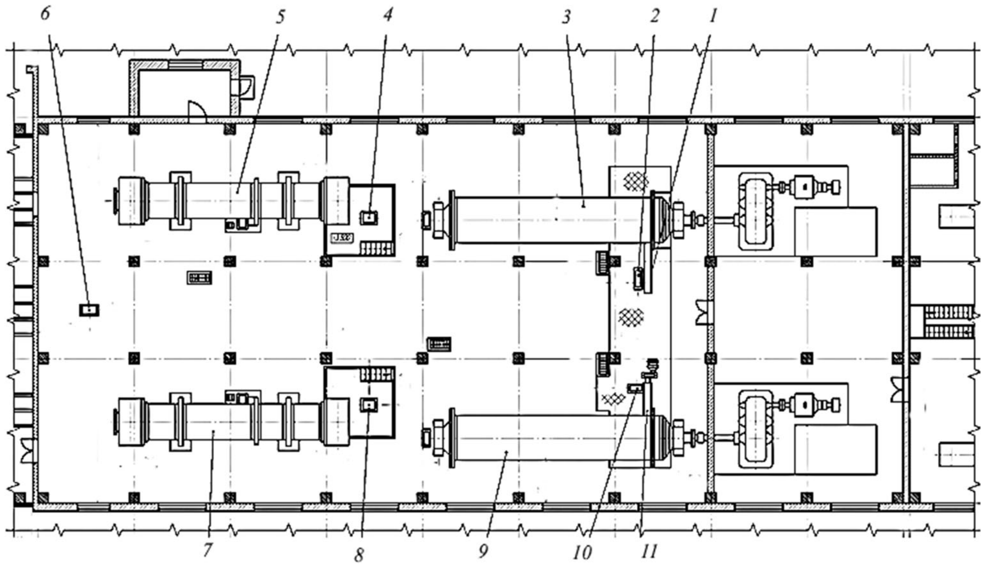

Fig. 1 Layout of equipment: *1, 11*—screw conveyors; *2, 4, 6, 8, 10*—elevators; *3*—tube ball mill for chromite grinding; *5, 7*—drying drums; *9*—tube ball mill for dolomite grinding

Materials and methods

This article examines the reengineering of the ball mill at the Novotroitsk Plant of Chromium Compounds (NPCC) to increase the productivity of the existing equipment.

The Novotroitsk Plant of Chromium Compounds is specialized in the processing of chromite ore [17]. Chromite and dolomite ores are delivered to the first workshop of the NPCC grinding department in open wagons, which are unloaded to the raw material storage area by a grab crane. The raw material is then transported to the receiving hopper where it is fed into a jaw crusher via a trough feeder. After crushing the large pieces, the ore is conveyed to a drying drum and then transferred by elevator to an intermediate hopper from which it is fed by trough feeder to the dry grinding mill where the chromite and dolomite ores are ground (Fig. 1). The material from the ball mill is conveyed to the next elevator and finally to the storage hopper.

Currently, the grinding department operates a SMM2061 ball mill with the following specifications:

- capacity: 25 t/h;
- drum diameter (internal): 2600 mm;
- drum working length: 13,000 mm;
- drum rotation speed: 20 min^{-1}.

The drive is provided by an electric motor of the type 4A200L8UZ, now discontinued, with a power rating of 22 kW and a speed of 750 min^{-1}, and a special reduction gear with a ratio of 37.5.

Physical and moral aging leads to unplanned downtime due to drive component failures, which account for 11.3% of the nominal operating time of the workshop.

The general appearance of the tube ball mill for chromite grinding prior to reengineering is shown in Fig. 2. Chromite ore is continuously fed into the conical throat of the loading trunnion, which is lined with internal spirals to direct the movement of the ore. After loading, the ore moves into the working chamber of the mill drum where it is repeatedly subjected to the grinding action of the grinding media (steel balls), resulting in comminution. The ground product is discharged through the hollow trunnion into the discharge chute funnel. The kinematic diagram of the tube ball mill drive is shown in Fig. 3.

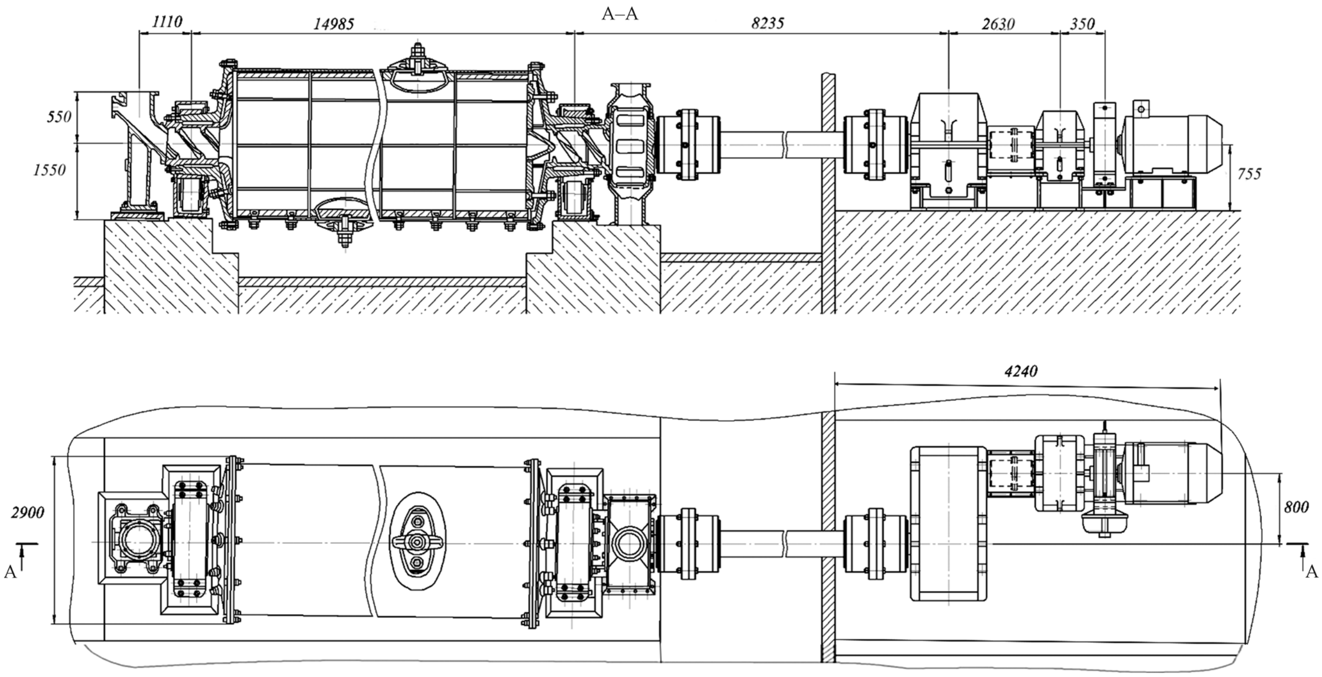

Fig. 2 Ball mill before reengineering

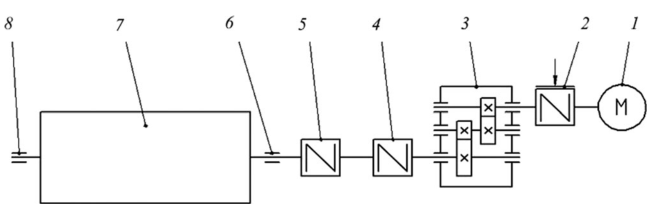

Fig. 3 Kinematic scheme of the ball mill CMM2061 before reengineering: *1*—electric motor; *2*—brake coupling; *3*—reducer; *4, 5*—gear couplings; *6, 8*—bearing assemblies; *7*—mill

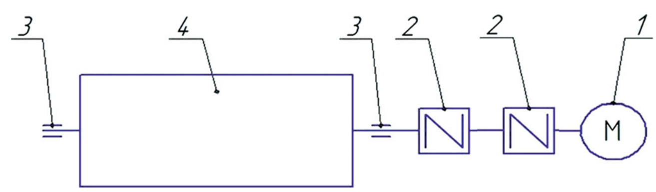

Fig. 4 Kinematic scheme of the ball mill drive after reengineering: *1*—geared motor; *2*—gear couplings; *3*—bearing assemblies; *4*—mill

Results and discussion

Due to the increased demand for NPCC products, it is necessary to increase the productivity of the equipment, including the power of the electric drive and the speed of the ball mill drum. Experience with ball mills shows that productivity can be increased by 10–15% without changing the drum design. This technical solution will allow NPCC JSC to increase the production of sodium chromate by increasing the amount of solid chromite and dolomite ores crushed in the crushing department of the first workshop, which will reduce the production costs.

To achieve this, it is proposed to replace the existing electric drive, which includes an obsolete 4A series electric motor and a special reducer, with a modern R167DV280V4/BVG122 geared motor, which transmits rotation to the mill drum through a gear coupling. The kinematic scheme of the proposed drive for the tubular ball mill is shown in Fig. 4, and the technical data of the geared motor are given in Table [18, 19].

The drive is mounted on a frame which is a welded sheet metal structure. The general appearance of the CMM2061 tube ball mill after reengineering is shown in Fig. 5. A gear coupling, commonly used in machine building, is used to connect the transmission shaft between the output shaft of the geared motor and the mill drive shaft.

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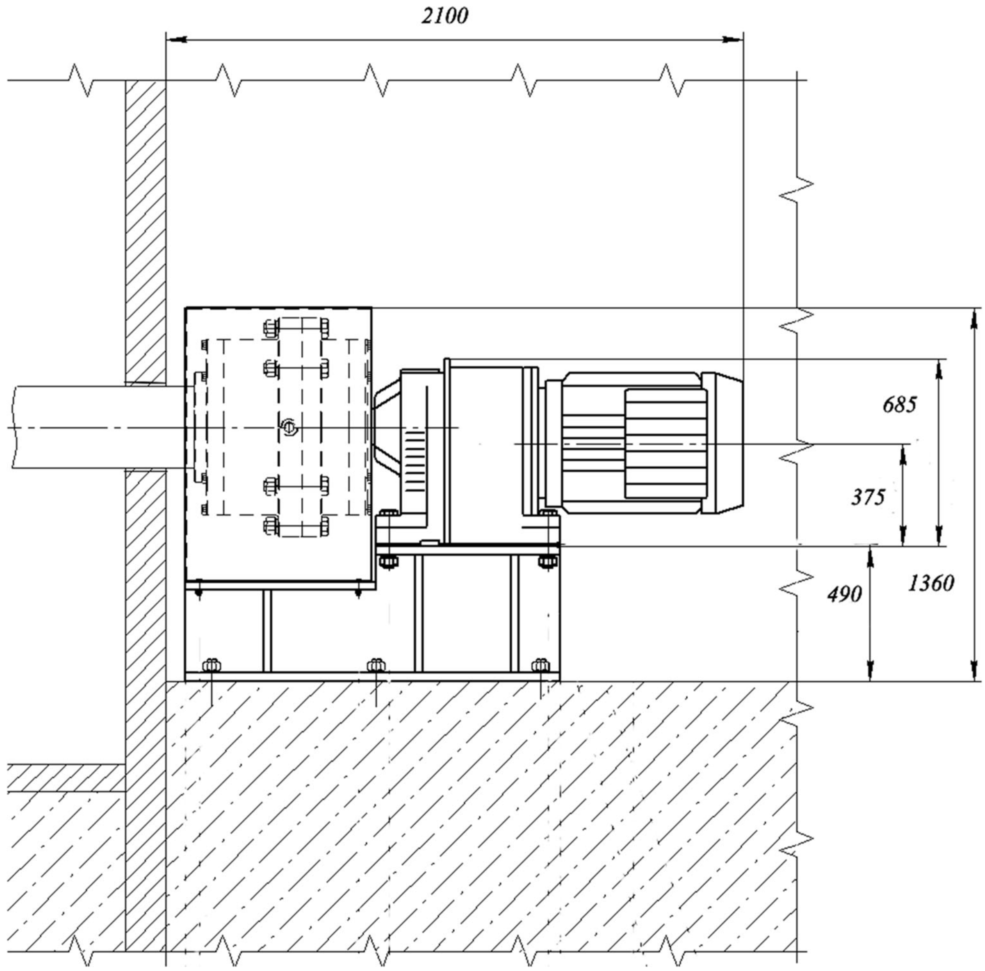

Fig. 5 General view of the drive section of the ball mill after reengineering

Table 1 Technical specifications of R167DV200 L4 geared motor

Characteristic	Value
Power, kW	30
Rotation speed on the slow-speed shaft, min^{-1}	22
Torque, N·m	13,100
Gear ratio of the reducer	67.40
Diameter of the output shaft, mm	120

According to GOST R 50895-96, the coupling is selected on the basis of the largest diameter of the ends of the shafts to be connected, and then the coupling strength is verified [20]. If the diameter of the output shaft of the geared motor is $d_{out} = 120$ mm (Table 1), a type 1 coupling with a nominal torque $T_{nom} = 16{,}000$ kN·m, a bore diameter of 120 mm, sleeves of design 1, climatic design U, and category 2 *Coupling 1-16000-120-1U2 GOST R 50895-96* is selected. The maximum torque on the connected shafts generated by the geared motor (Table 1) is $T_{work} = 13{,}100$ N·m, which ensures the strength of the coupling.

In order to assess the economic viability of implementing the modernized drive for the tube mill, an investment cost estimate was prepared. It was determined that the total investment, including additional costs for purchase and installation of new equipment, would amount to approximately 3.4 million rubles.

The expected economic benefit from the implementation of the new drive is related to the reduction in capital and routine maintenance time, which has resulted in a 3 t/h increase in ball mill productivity. The proposed drive upgrade will reduce the cost of processing 1 ton of ore by 0.02%, increase production profitability by 1.37% and increase selling profit by 1.29%. Given the current production volume, these improvements have a significant economic impact. The cost of implementing the proposed equipment will be recovered in less than 3 months from the start of operations. These metrics demonstrate the economic viability of the developed project.

Conclusion

The modernization of the drive for the tube ball mill simplified its design and reduced the labor required for maintenance and repair. Replacing the old drive, which consisted of an electric motor and a gear reducer, with a new drive, consisting of a geared motor and a gear coupling, increases the time between repairs and thus reduces operating costs. Calculations show that the implementation of the project solutions will lead to a 0.02% reduction in the cost of processing of 1 ton ore, a 1.37% increase in production profitability, and a 1.29% increase in sales profit. The additional investment does not exceed 3.4 million rubles and will be recovered in less than 3 months.

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Authors and Affiliations

A. V. Nefedov[1] · R. E. Ishmukhametov[1] · N. A. Chichenev[2] · I. I. Basyrov[2] · Y. O. Lyubchenko[2] · E. E. Balakhnina[2]

✉ A. V. Nefedov
cosnovotr@rambler.ru

R. E. Ishmukhametov
peretz_97@mail.ru

N. A. Chichenev
chich38@mail.ru

I. I. Basyrov
basirovilnur@mail.ru

Y. O. Lyubchenko
gorbatyuk54@bk.ru

E. E. Balakhnina
autobusred@yandex.ru

[1] Novotroitsk Branch of NUST MISIS, Novotroitsk, Russian Federation

[2] NUST MISIS, Moscow, Russian Federation