Experimental study of improved constructions increasing the efficiency of ball mill protective coatings used in enrichment factories

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Abstract. Nowadays, ball mills are widely used in beneficiation enterprises of the mining industry, cement and similar production plants. As a result of the development of new mines in our republic, the process of extracting minerals in the mining industry is being carried out step by step. Due to the increase in the volume of mined minerals, the need for ore crushing mills is increasing. Taking into account all mentioned the above, in this article, the test results of the improved constructions of the internal protective coatings of the ball mills, which are considered as the main working member of the ball mills used in the enrichment and processing of minerals at the hydrometallurgical plants belonging to "Navoi Mining Metallurgical Combine" JSC and measures to increase the efficiency of mills were presented.

1 Introduction

Currently, in the challenging economic conditions of the world economy, production enterprises are trying to significantly reduce current costs, develop and implement modern technical solutions for production.

Modernization and improvement of equipment is an important and promising way of reducing costs in enrichment plants. The various research works carried out in beneficiation plants are aimed at solving the problems there and are aimed at increasing the efficiency and reducing the cost of production. One of the solutions to these urgent problems is to increase the performance characteristics of the mill coating (armor). Such a solution allows to reduce the downtime of the mill and increase technical and economic indicators.

Protective covers (Armors) - the walls of the mill drum are used as a means of protection in the inner parts of the drum in order to prevent them from being crushed by the impact of balls and ores and the impact of physical forces there, and to ensure the effective trajectory of the ore-crushing ball. These covers are replaced every 6-8 months depending on the hardness of the ores being crushed. Usually linings are made of manganese and chromium steel or cast iron. When loading large-diameter balls, linings made of cast manganese steel are used. For small mills, the thickness of the lining tiles is greater than 50 mm, and for large mills, the thickness of the lining tiles is up to 130-150 mm. The following requirements are

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paid attention to the creation of their effective construction. These are the slowing down of the decay process of the cover surfaces, the simplicity of the technological preparation process and energy efficiency, ease of installation, dimensions, and relatively efficient performance of repair and maintenance work [1-3].

There are several criteria for evaluating the performance of covers, such as mill hours since the cover was installed, mass of ore processed (tons), consumption of cover elements per ton of ore processed, etc. Due to the very low content of metal in ore mined today, a large amount of ore is required to be processed in order to increase the economic efficiency of the enterprise. In today's market conditions, reducing mill downtime by 7-9 days per year (2-3%) can economically justify or exceed the annual cost of replacing the first stage mill lining. This is especially true for beneficiation factories of gold mining enterprises, because the downtime for lost metal in such enterprises is several hundred million soums [4-6].

Over the past thirty years, global experiences show that the use of chromium-molybdenum steel coating is the most effective in mills at the first grinding stage. Many local mining and beneficiation plants use potassium permanganate coating of type 110G13L. However, over time, it becomes very difficult to control the implementation of the annual work plan and does not allow stopping the mills, requiring unplanned work. In this situation, technicians and plant managers begin to look for alternative types and alloys of mill coatings. Sometimes such research leads to negative results, that is, the service life of a new type of cover is less than that used before. Sometimes rubber or rubber metal is purchased instead of metal coating. In this case, we suggest using a new type of “reinforced” manganese steel or a combination of steel with cast iron. In order to save costs, some companies prefer to use a coating of chrome-molybdenum steel called "standard" design. It has a small mass, as well as the height of the plates and risers. The service life of such a coating does not exceed a few months, and it leads to high costs for the enterprise.

2 Materials and methods

According to the structure of the cover surface, it is flat, stepped, wavy, combined, embossed, perforated, heeled, etc. Covers are prepared in the form of plates in special sizes, i.e. according to their introduction into the drum through the hatch, the thickness is 40-50 mm for small mills, and 130-160 mm for large mills, width 300-500 mm, length 350-900 mm and mass is up to 25-1000 kgs.

Covering plates differ depending on the material, profile and installation method. They should be easy to install and replace. Plates for ball mills, which typically use balls larger than 80 mm in diameter, are made of 110G13L manganese steel (Gadfield steel), and for some mills, rubber or ceramic materials.

Embossed surfaces can be used for coarse grinding, and flat or wavy surfaces can be used for fine grinding. In large crushing, the size of the ore is 10-30 mm, and the crushing index is 1-5 mm. In fine crushing, the size of the ore is 1-5 mm, and the crushing index is 0.074-1 mm.

Today, in order to increase the efficiency of ball mills, coatings are made of metal, rubber, rubber-metal, polyurethane, ceramic and magnetic materials.

Metal coverings are considered traditional and have taken precedence over coverings made of other types of materials. Metal coatings are made from manganese steel 110G13L Garfield steel and chromium molybdenum steel, which is now widely used.

This article considers the experimental and test study of the process of determining the strength of improved designs of protective linings of ball mills, used at the beneficiation enterprises of the change in the magnitude of their abrasive fracture in time using the hardness tester EQUOTIP-3 and caliper instruments to measure the degree of abrasive wear of the

lining, directly related to JSC "Navoi Mining and Metallurgical Plant at the enterprise GMZ-2 .

Currently, in the hydrometallurgical plants of JSC "Navoi Mining and Metallurgical Combine" MMS 70x23A, MMS 90x30A, MSHS 3200x4500, MSHS 3600x5000, MSHS 3600x5500, MSHS 4500x6000, MSHS 5500x6500, MSHS 5500x7500, MSHR 210 0x1500, MSHR 3200x3100, MSHR 5500x6500 type ball mills are in operation.

Table 1. Technical indicators of ball mills in operation.

№	Type of mill	Inner diameter of the mill drum, mm	Mill drum length, uncoated, mm	Mill drum size, m^3	Mill drum rotation frequency. rot/min	Power of the main procedure electric motor. kVt	Consum ption capacity, kVt
1	MMS 70x23A	7000	2300	80	13.3	2000	1800
2	MMS_90x30A	9000	3000	160	11.1	4000	3300
3	MSHS 3200x4500	3200	4520	32	19.7	900	720
4	MSHS 3600x5000	3600	5000	45	16.6	1250	1110
5	MSHS 3600x5500	3600	5500	49	16.6	1250	1110
6	MSHS 4500x6000	4430	6010	82	16.6	2500	2200
7	MSHS 5500x6500	5500	6730	140	13,7	4000	2800
8	MSHS 5500x7500	6500	7520	165	13.7	4000	2800
9	MSHR 2100x1500	2100	1500	4.3	24.3	132	0
10	MSHR 3200x3100	3200	3100	22	19.8	630	0
11	MSHR 5500x6500	5500	6500	140	13.8	4000	0

It is important to carry out periodical maintenance and capital repair of operational indicators of ball mills. Every month, the mill is stopped for 12-24 hours and is inspected. From the third month of the technical inspection, the defect inspection process begins.

Currently, nearly 50% of all ball mills used in hydrometallurgical plants belonging to JSC “Navoi Mining and Metallurgical Combine” are MMS 70x23A, MMS 90x30A type mills. Mills of this type are effectively used in industry and have high productivity.

Scientists have been conducting scientific research for many years in order to extend the service life of the mill cover. They offer covers of different materials and different designs and have been working effectively in the mining industry for several years. However, due to the fact that the share of the manufacturing industry in the acceleration of economic growth in the world is very large, it is necessary to further improve the weight of industrial equipment and technologies. This leads to more scientific and technical research and research. Heavy impact mill operation requires frequent mill stoppages to replace protective covers. Reducing the duration of maintenance work, reducing the number of mill stoppages, and increasing the service life of mill linings will increase productivity and lead to more profit. When buying mills in factories and installing them, it is necessary to pay attention to its coatings first. The most time is spent in the processes of technical inspection of mill coatings, disassembly and assembly, and repair.

The structural structure of coatings ensures its short or long-term operation. At the same time, it also evaluates the efficiency of the mill. The operating time of covers and the productivity of the mill are greatly influenced by the frequency of rotation of the mill and the trajectory of the metal balls inside it.

Therefore, in view of the large number of MMS 70x23A and MMC 90x30 type ball mills used in enrichment and processing enterprises, one of the important objects for the mining industry of our Republic, we believe that it is urgent to improve the protective covers of the above-mentioned ball mills.

Before developing measures to improve the construction of protective covers of ball mills, we will conduct an analysis of protective elements of ball mills MMS 70x23A and MMC 90x30. Table 2 lists the types of MMC 70x23A ball mill protective coatings and their main indicators.

Table 2. Types of MMC 70x23A ball mill protective covers and their main indicators.

The name of the protective covers	Material brand	Weight, kg	Number of installations	Total weight
Cover №1	110G13L	842	10	8420
Cover №2	110G13L	800	20	16000
Cover №5	110G13L	596.6	74	22074
Cover №6	110G13L	586	6	1758
Grid (23 - grid)	110G13L	940	20	18800
Grid (18 - grid)	110G13L	925	20	18500
Releasing sector	110G13L	770	10	7700
Right and left elevators	35L	620	20	12400
Corner cover №3	35L	310	20	6200
Corner cover M6001	35L	320	20	6400
Total weight				122852

Types of MMC 90x30 ball mill protective covers and their main indicators are listed in Table 3.

Table 3. Types of MMC 90X30 ball mill protective covers and their main indicators**.**

The name of the protective covers	Material brand	Weight, kg	Number of installations	Total weight
Cover №1	110G13L	748	14	10472
Cover №2	110G13L	1160	28	32480
Cover №5	110G13L	857	104	89128
Cover №6	110G13L	762	8	6096
Grid	110G13L	1230	28	34440
Releasing sector	110G13L	840	28	23520
Elevator	35L	830	28	23240
Corner cover №3	35L	220	28	6160
Corner cover №4	35L	350	28	9800
Total weight				122852

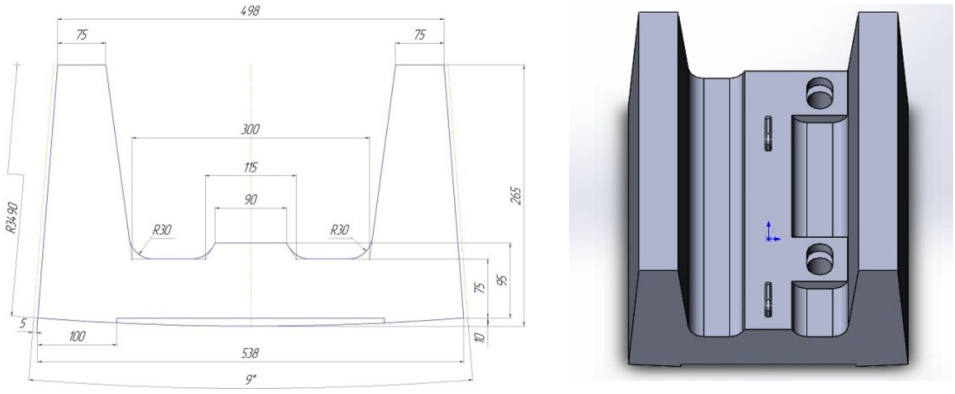
3 Results and discussion

From the above-mentioned Tables 2 and 3, we can see that nowadays the number of ball mill coating of the coating №5 type is more than the others. So we will be able to consider increasing the performance of ball mill coatings in Coating №5 and the related Coating №6.

Figure 1a below shows a basic view of the cross-sectional surface of the coating №5 of the ball mill. This base protection cover is 75mm with two sidewalls offset 5mm from bottom to top, central base is 90mm, base thickness is 75mm, base width is 538mm, and gutters are circular with 30mm radius and total cover height is 265mm. does. The total weight is 596.6 kg. As a result of the rock entering the special grooves of these coatings and the mill balls

hitting it with their own gravity, rock crushing is observed. Figure 1b shows a 3D view of the base plate №5 of the ball mill.

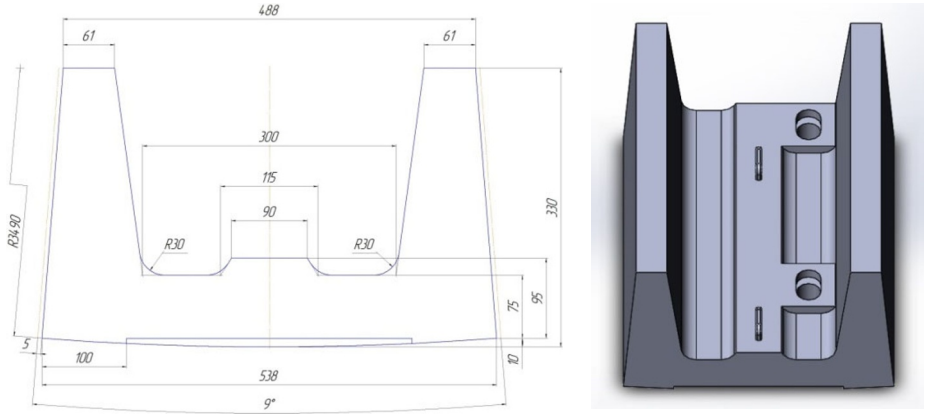
Taking into account the need to reduce the weight of the ball mill and improve the protection elements to ensure the long-term operation of the coating as the main directions for increasing the efficiency of the ball mill, an improved design of the basic coating No. 5 of the ball mill was developed.



a) b)

Fig. 1. A view of the base plate №5 of the ball mill: **a)** basic view of the surface of the cross-section of the cover No. 5 of the ball mill; **b)** 3D view of the base cover No. 5 of the ball mill.

The dimensions of the cross-sectional surface of the newly developed ball mill No. 5 and its 3D view are shown in Figures 2a, b.



a) b)

Fig. 2. A view of the improved cover №5 of the ball mill: a) complex view of the cross-sectional surface of the cover №5 of the ball mill; b) 3D view of improved cover №5 of the ball mill.

This base protection cover is 61mm with two sidewalls offset 5mm from bottom to top, central base 90mm, base thickness 75mm, base width 538mm, gutters 30mm radius, 20mm depth and total cover height It is 330 mm. The total weight is 500 kg.

The main working parts of the above-mentioned basic and improved protective coverings are their side walls, and experimental tests took into account the amount of their abrasive wear as a result of the impact of balls and rocks on their side walls.

Experimental tests were carried out at the MMC 70x23A ball mill at the GMZ-3 enterprise belonging to the Central Mining Department of "Navoi Mining Metallurgical Combine" JSC. During the experiment, the amount of abrasive erosion of the side walls was measured at the beginning of the ball mill coating at 200 moto-hours and then every 500 moto-hours. Based on the results obtained on the basis of experiment-testing, the dependence of the decay of the side walls of the basic and improved protective coverings during the time was created, and this dependence is presented in a graphic form in Figures 3 and 5 below.

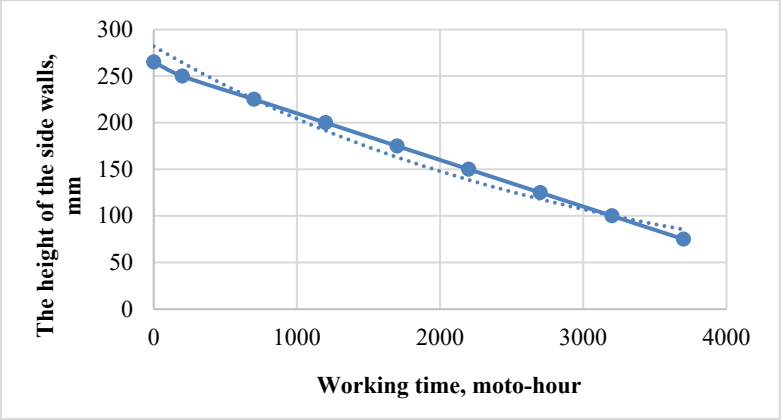


Fig. 3. Connection of the service life of the erosion of the side walls of the base protective cover No. 5 of the ball mill.

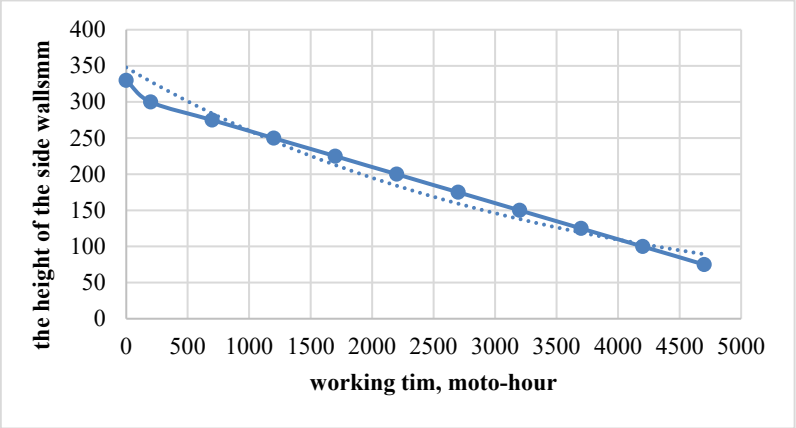


Fig. 4. Connection of the service life of the erosion of the side walls of the base protective cover No. 5 of the ball mill.

From the graphs above, we can see that the allowable abrasive erosion of the sidewall height of the basic protective coating is 75 mm, and the service life before this permissible erosion is 3700 moto-hours, and the service life of the improved construction protective coating is 3700 moto-hours. it was determined to externalize. Graphs of dependence of the height of the sidewalls of the ball mill protective coatings on the service life of the abrasive erosion were established.

4 Conclusion

From the graphs above, we can see that the allowable abrasive erosion of the sidewall height of the basic protective coating is 75 mm, and the service life before this permissible erosion is 3700 moto-hours, and the service life of the improved construction protective coating is 3700 moto-hours. it was determined to externalize. Graphs of dependence of the height of the sidewalls of the ball mill protective coatings on the service life of the abrasive erosion were established.

As a result of the installation of improved protective coatings in ball mills, it is possible to increase the efficiency of the mills by 25-30%. Compared to the basic protective coating, the improved protective coating was found to provide an average of 1,000 moto-hours, which is 27% longer.

In addition, by applying each improved coating, we were able to save 96.6 kg of metal and reduce the mill weight by the same amount. 74 of the protective coating number 5 are installed on the MMC 70x23A mill at the same time, saving a total of 7148.4 kg of metal and reducing the weight of the mill by the same amount. As a result, the consumption of electricity for the mill will be reduced to a certain extent, and we will be able to dwell on this in our next articles.

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