

Changing Lining Technology at the SAG Bauxite Mill at Hydro Paragominas

Tiago Silva¹, Ederison Rego², Diego Monteiro³ and Esterison Silva⁴ and Antonio Lisboa⁵

1. Mechanical engineer

2. Process engineer

3. Specialist mechanical technician

4. Engineering manager

Hydro Bauxite & Alumina, Paragominas, Brazil

5. Sr. Technical Sales Support – Mill Lining

Metso Minerals, Belem, Brazil

Corresponding author: tiago.silva@hydro.com

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Abstract

This work was carried out on the premises of the Hydro Paragominas Bauxite Mine, located 70 km from Paragominas city in the state of Pará, Brazil. The Paragominas plant is responsible for processing and sending bauxite pulp through a pipeline over 244 km extending to the Hydro Alunorte refinery in Barcarena city also in the state of Pará, Brazil, the main equipment responsible for the production of this pulp are the mills. As a result of cooperation between the maintenance, process and industrial operation engineering sector of Hydro Paragominas and the company Metso Minerals, a customized specification project and optimization of the SAG mill body liners was developed. Previously, the SAG mill linings (162 pieces) were manufactured in steel alloy and due to the comminution process, several parts broke, causing lost production, increased costs and exposure of maintainers to risk. The project aimed to mitigate coating breakages throughout the set's useful life campaign, which is an average of 3 years. To achieve this, the material technology was changed from steel alloy to a hybrid coating (Hardox500 and special rubber), the angle of attack was changed from 20° to 25° and the pieces were unified, which reduced the number of pieces from 162 to 54. With these modifications, “zero” liner breakage throughout the useful life was achieved resulting in OpEx savings of 540 kUSD/year, an increase in the feed rate in the mill of 29 t/h which represents a gain of 6.69 MUSD/year and a reduction in risk exposure in the individual coating replacement activity. The coating replacement frequency was previously monthly and was reduced to only occur in Overhaul stops every 3 years, in the risk matrix the risk level went from 12 to 2. The project exceeded all expectations for product application.

Keywords: Comminution milling, Liners maintenance, Reliability and operational guarantee, Safe operation, Performance improvement.

1. Introduction

Mineração Paragominas is an important part of Hydro's strategy as a global provider of innovative and sustainable aluminum solutions. Mineração Paragominas is responsible for the bauxite mine, which is located approximately 70 km from the municipality of Paragominas, in the northeast of Pará, on the Miltônia 3 Plateau. It currently has approximately 1 400 company employees and around 800 outsourced employees.

The mining operation began in March 2007 and currently moves around 16 million tonnes of ore per year, generating 11.4 million tonnes of bauxite annually, which is transported by a mine pipeline, the first in the world to transport this type of ore.

In Paragominas, bauxite removal goes through the processing stage, which consists of crushing, grinding and classification. The processed ore is mixed with water, forming a pulp that is pumped through a pipeline to the Alunorte refinery, in the city of Barcarena, where the bauxite is refined, transforming it into alumina, a raw material for aluminum.

Grinding is the main process for obtaining ore for granulometric adjustment and separation of silica from bauxite, in Figure 1 shows Plant 1 and Figure 2 shows Plant 2 of Mineração Paragominas.



Figure 1. Plant 01



Figure 2. Plant 02

2. Objective

In Brazil, SAG mills usually use steel alloys as the construction material for their coating, however, due to the problems that were occurring in the operation of SAG mills at the Mineração Paragominas unit, it was necessary to seek an alternative solution to solve the problems of cracks and coating breaks (shown in Figure 3).



Figure 3. Cracked linings

3. Linings Development

Hybrid coatings (metal + rubber) are now commonly used in the industry and Hydro's engineering team assessed three Chilean suppliers of hybrid coatings [2]. Based on technical and commercial criteria, the company Metso was chosen to develop the most suitable coating for the Mineração Paragominas type of operation. A multidisciplinary team from Hydro, consisting of a mechanical engineer, a process engineer, an operations engineer and a maintenance operator, monitored the entire development process.

The type of material selected for the coatings was made of action alloy and it became hybrid (Hardox500 metal + special rubber). The physical geometry was also optimized and the angle of attack went from 20° to 25° [2]. The high and low plates, previously manufactured separately, were unified forming a single piece, as shown in Figure 4. In addition the central ring was unified with the feed and discharge rings, which reduced the number of lining rings from three (feed, central and discharge) down to two lining rings (feed and unloading). The new design meant that every 6 coatings became 2 coatings, with a reduction of close to 30 % of the total lining weight [1]. There was also a reduction in the number of fastening elements by 33 % due to the unification of the parts, shown in Table 1.

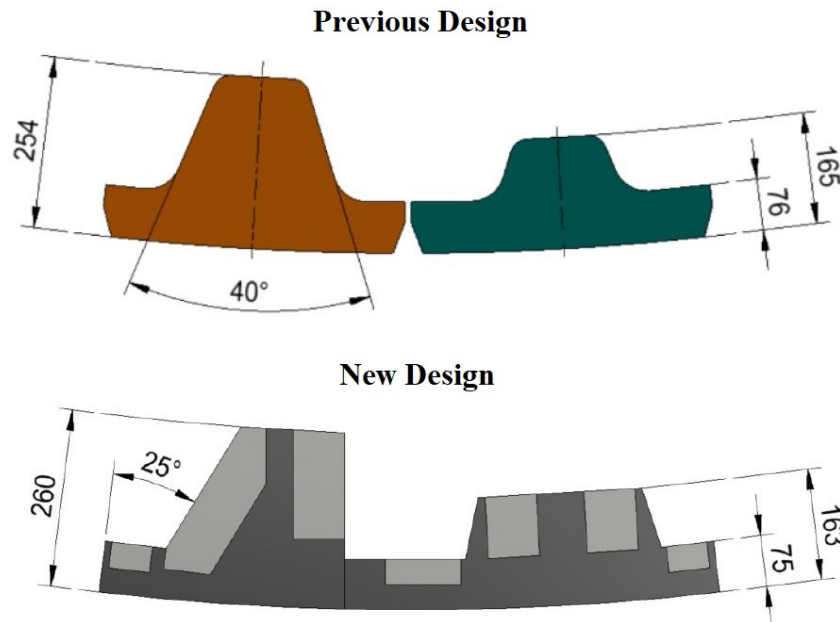


Figure 4. Previous Design and New Design

Table 1. Parts reduction table

	Metal Cylinder 3 rings			Poly-Met Megaliner 2 rings		
	(current)			(proposed)		
	FE	ME	DE	FE	ME	DE
Unit weight [kg]	1 154	1 154	1 154	1 237	-	1 194
Quantity pieces [un]	54	54	54	27	-	27
Total quantity [un]	162			54		
Variation quantity [%]	-			67 %		
Total weight [kg]	93 474			63 637		
Weight variation [%]	-			29.80 %		
Quantity of screws set	486			324		
Screw variation [%]	-			33 %		

Trajectory simulations of the grinding bodies were carried out during the lining design and development. The purpose of the comminution of the ore was to optimize the grinding and disaggregation of the silica from the bauxite, to give an operational gain for the downstream process. An example of the simulation carried out by Metso engineering [1] and validation by Hydro's engineering team is shown below in Figure 5.

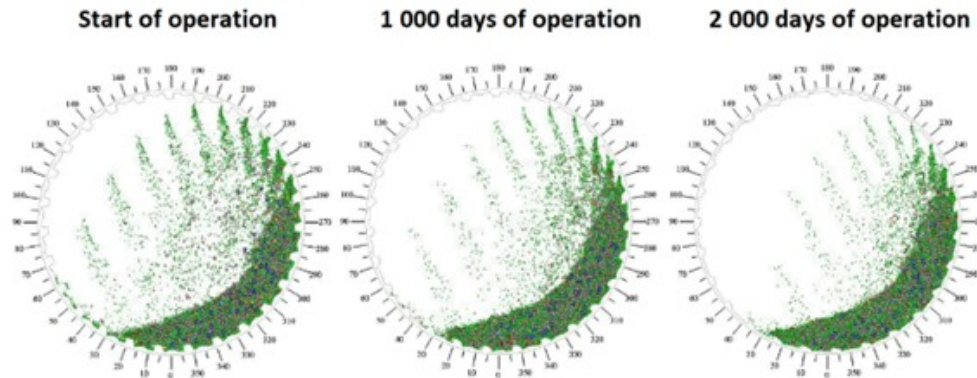


Figure 5. Process Simulation

A component of the new coating model is that it had an exclusive fixing system, fixing pieces are inserted on the outside of the mill.

The screws are easy to remove and well protected against dust, corrosion or mechanical damage in general. This means that during the installation and removal of the cladding screws, workers are not in the danger zone.

Liners are placed only by the plate handler operator. Guide markers and the liner positioning system facilitate assembly, which also provides a better working position and working environment. Workers can stand on a stable platform outside the mill while they torque screws. The new coatings that are made of rubber, do not fuse together due to the impact of the balls and it is easy for the plate handler operator to remove old coatings. Generally, gravity is sufficient to remove coatings with the exception of the first row, where a tool is used to remove the coatings.

In summary, the new design had the following advantages:

- Lower coating weight. The density of rubber is lower than that of metal, as seen in Figure 5.
- Increased loading capacity for ore and/or grinding media. The mill is lighter, allowing for a greater load capacity, as seen in Figure 8.
- Improved useful life and less wear due to the hybrid material of rubber and steel.
- Predictable maintenance service life. There have been no liner breaks throughout the campaign.
- Lower risk of breaking and “Peening”. The rubber cushions the impact of the balls, as seen in Figure 4.
- Lower energy consumption. Due to the lower weight, the power required by the engine decreases.

4. Results Achieved

The results obtained were very positive, and the expected improvements were achieved including reduced maintenance costs, reduced maintenance downtime, improved mill productivity and reduced risk related to maintenance worker exposure to hazards.

Starting with maintenance costs, during the last campaign with the previous liner, 354 505 USD was spent on coatings throughout the campaign to maintain the mill and operation, which is equivalent to half the value of the coating overhaul, which in its last purchase was 725 824 USD [4]. To perform this work 58 maintenance orders were generated and 198 780 USD was spent on labor for these repairs. There was a total of 11 corrective stops generating 31.3 hours of maintenance at the MO-123-01 Mill throughout the campaign from 02/23/2017 to 02/02/2023, which consists of 32 865 tonnes of feed in the SAG corresponding to 983 393 USD in Loss of Profit. A summary of the projected and achieved savings in the campaign after the installation of the hybrid coating is shown in Figure 6 below [4].

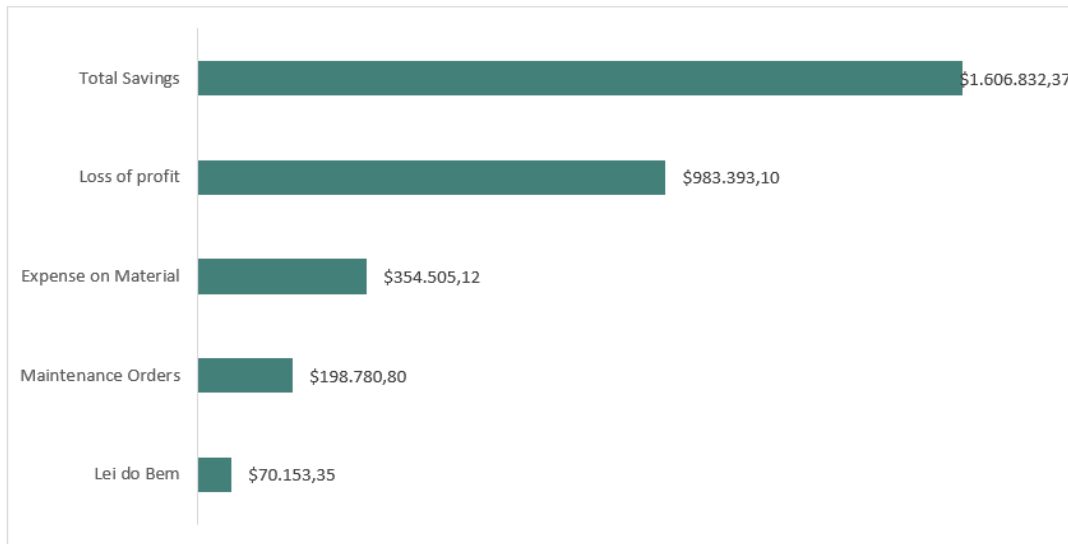


Figure 6. Earnings graph

Among the various tax incentives that are in force in Brazil, the Lei do Bem (Law nº 11,196/2005) offers the opportunity for companies, from all sectors, to reduce their tax costs as a basis for spending on RD&I. The Mills cladding modification project obtained the benefit base: 766 703 BRL (139 512 USD by Sept. 2024) – after analyzing the expenses, we arrived at this base value for calculating the benefit. Additional exclusion (60 %): 460 022 USD – amount that is reported to the Federal Revenue through the ECF, the net benefit for the Mineração Paragominas (15.25 %): 70 153 USD – real benefit for the company. The benefit achieved by the project represents around 40 % of the total benefit determined by the Mineração Paragominas.

As shown in Table 1, going from 162 pieces of coatings to just 54 pieces inside the mill provided a reduction in downtime to replace the coatings, which fell from 124 hours to 78 hours of the total time (i.e. 2 days less) as the downtime is directly linked to the number of parts to be replaced by the plate handler.

Another considerable gain was evident in the process and operation of the mill throughout its first year of operation, where it was evident that the change in the profile of the linings brought a gain in productivity and increased the plant feeding capacity [3] by 29 tonnes per hour (Figure 7). As shown in Table 2, this increase in feeding capacity provides a potential gain in increasing production of around 150 000 tonnes of bauxite per year. This increase in production is potential because Mineração Paragominas production is largely dependent on the ability of the downstream Alunorte refinery having the capacity to receive this increase in production, as shown in Table 2.

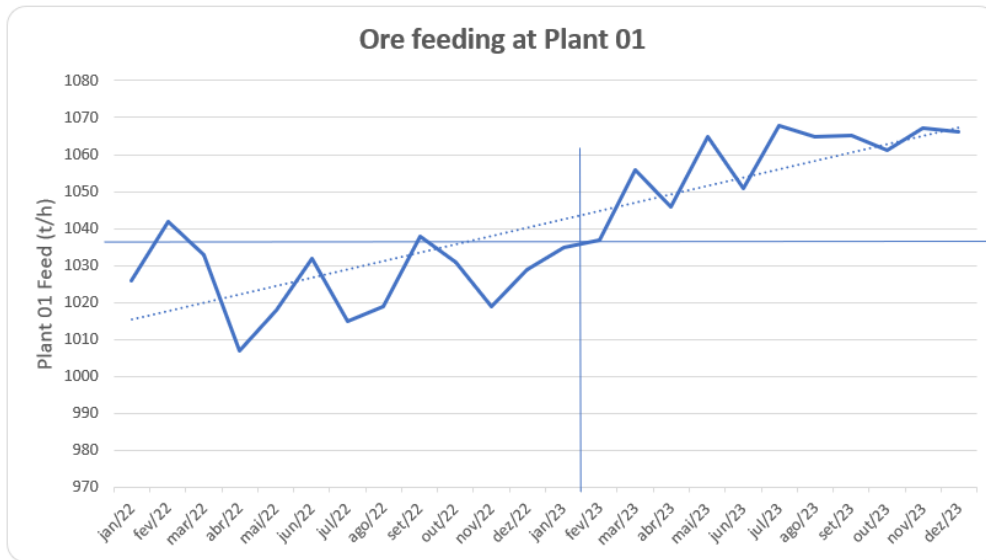


Figure 7. Average ore feed at the Plant.

Table 2. Calculation of potential ore feed gain at the plant with increased ore feed

Equipment	MO-123-01 – SAG Mill 1
Additional ore feeding at SAG (t/h)	29
Operating hours per year	8 760
Mass Yield	67 %
Operating Yield	88 %
Value of Bauxite Produced (BRL/t)	223.3
Potential Production / Year	149 782
Value in Potential Production	6 689 263 USD

The other gain with this change in technology was the reduction in the exposure of maintainers to risk when carrying out this task. The new design features the screw fixing from the outside of the mill, which meant that there is no chance of an accident in the event of a failure of the mill lifting equipment. Figure 8 shows the before and after of how the screws were placed in the coverings. The other maintenance safety benefit was that the interventions that used to be monthly are now only carried out at the end of the covering useful life.



Figure 8. Before and after the improvement in linings

By mitigating the risk in the replacement activity and significantly reducing the frequency of execution of this activity from monthly to three-yearly (36 months), the risk level in the risk matrix was reduced from 12 to 2 as shown in Figure 8. The risk level was validated by the Hydro occupational safety team, confirming the great improvement in the safety of all maintainers helping drive towards the Hydro target of zero accidents.

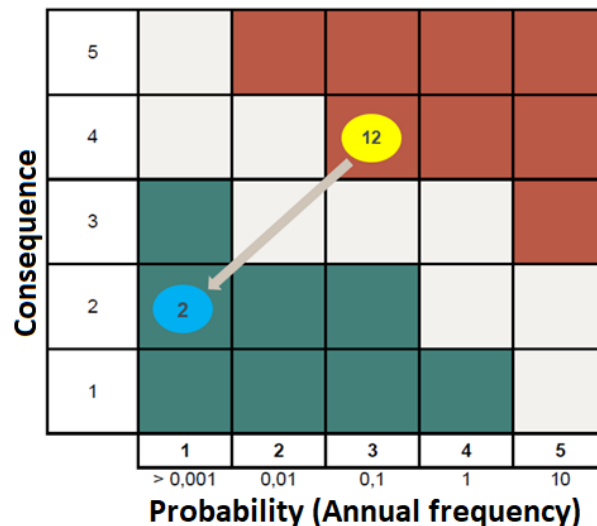


Figure 9. Activity risk matrix

5. Conclusion

After 1 year of operation, it can be concluded that the technology change was a success, in addition to being the first SAG mill in Brazil to have hybrid liners (Hardox500 and special rubber), the results achieved exceeded what was expected for this technology change, as evidenced in topic 4.

For this development to be successful, the Hydro team first applied the pillars of BABS (Hydro's management system) to build and apply this improvement, using change management as the basis for structuring the project and Hydro's vision applied to the scope of the project. With the pillars of values, care: we always aim to mitigate the risks of employees who work in the maintenance and operation of the Mill, collaboration: the project has always been done in "8 hands" Engineering, Maintenance, Operation and Process, always aiming for the best context for all disciplines and courage: in installing the first hybrid coating with 100% external fixation on a SAG Mill body in Brazil.

The entire project was carried out in conjunction with the partner company Metso, which supported the Hydro team and provided all the materials, as well as using the technical standards that govern Asset Management, aiming for the standardization and physical integrity of assets.

6. References

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