Performance of an Impact Crusher used as an Alternative to Produce Anode-Covering Crushed Bath during Autogenous Mill Refurbishment

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Abstract

This work presents the performance of an impact crusher used to produce 300 tons daily of crushed bath for anode covering. The impact crusher has been tested for 10 months consecutively in the Sohar Aluminum smelter, beating the initial original equipment manufacturer (OEM) specifications and life expectancy.

The impact crusher was initially selected as a short-term compact alternative to temporary replace an aging and defective autogenous mill during its change-out for a similar model. The study describes the contingency plan carried out to prepare for the changes during actual production cycles, the performance tests and setting, the maintenance schedule, the improvement in terms of operation, the learning curve in terms of inlet product acceptance and final product size.

The use of the impact crusher as an alternative was a real success. Unlike an autogenous mill, it permitted to test various setting to increase the crushed bath particle size in simple ways. The crusher proved reliable, and it even enabled to process every source of bath materials from the bath of the pots, butts, crucibles, basement, and dross consistently with light preventive maintenance schedule.

Keywords: Autogenous mill, Impact crusher, Crushed bath size.

1. Autogenous Mill Condition Legacy & Replacement

Sohar Aluminium smelter was designed with a facility to crush bath for anode covering and for crushing of tapped bath. The breaker function, an autogenous mill (AM), is to crush 250 to 300 t of bath daily to supply the potrooms with bath at a certain particle size. Figure 1 shows the AM. The granulometry of the bath covering the anodes, and its consistency are both critical for the crusting behavior, the pot heat balance [1] and the control of the liquid bath level, as pointed out by Taylor [2] and Gudmundson [3]. As per Aluminium Pechiney specifications, the optimum granulometry of the anode cover bath once crushed must be for less than 5 % , smaller than 0.75 mm and for at least 50 % , greater than 3.15 mm. The crushed bath granulometry plays a role in protecting the anode against the air oxidation, regulating the heat losses above the top of the anode, forming the desirable crust on and around the anode, scrubbing the fluorides emission, contributing to the liquid bath level adjustment, as well as the covering operation quality and velocity [4].

Figure 1. Pictures of the 2013 autogenous mill.

At the beginning of its operation, the presence of heavy pieces of aluminum trapped in the tapped bath damaged the AM before a detection system was implemented. In 2013, it was decided to replace the gravity breaker with a new one, for this reason. Unfortunately, the improvement did not last long. The new AM has also run into increased frequent and recurrent problems. Persistent vibration issues and miscellaneous failures are summed up in Figures 2-4. A motion amplification recording system was applied to identify the reason of the failures. The foundation itself was in cause and had to be replaced.

The decision was taken to replace it with new foundation in 2021. The duration of the project was estimated at 18 months with the international context linked to the covid situation.

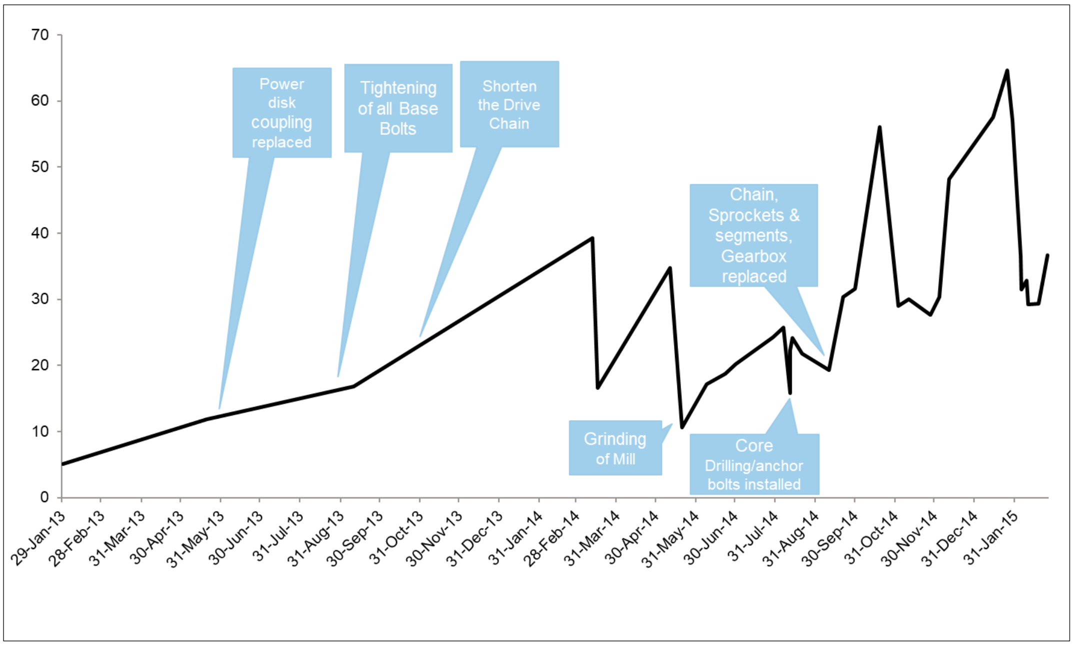

Figure 2. Summary of failures and issues of the AM from January 2013-January 2015.

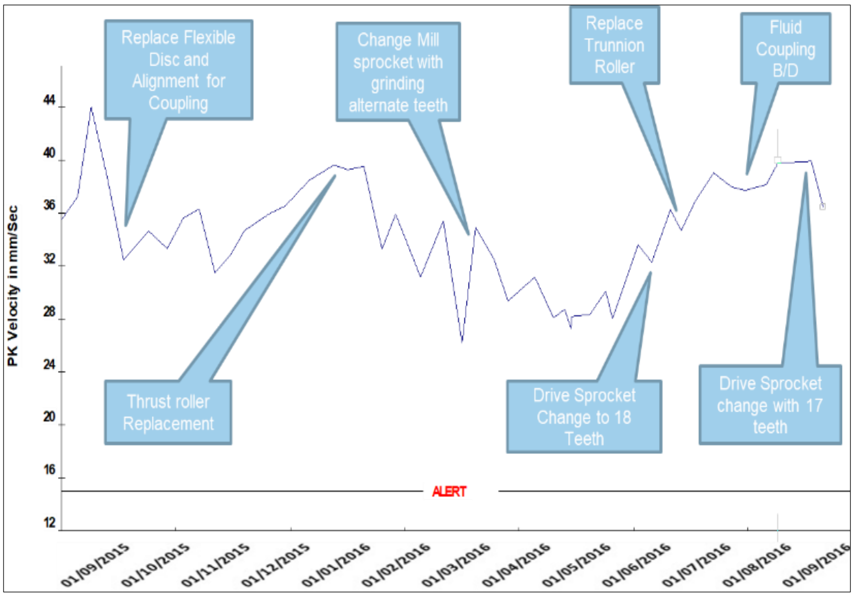

Figure 3. Failures and issues with the AM from January 2015 to January 2016.

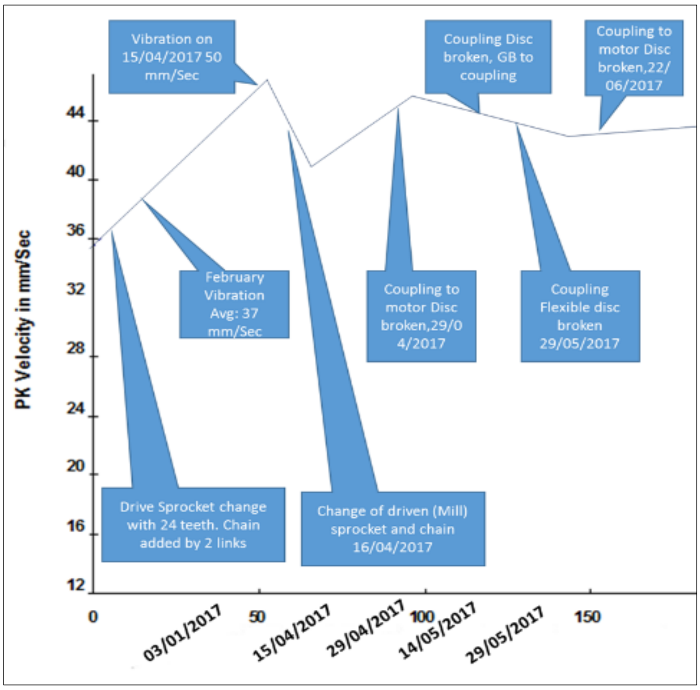

Figure 4. Summary of of AM breakdown history from January-May 2017.

2. Installation of a Crusher during Autogenous Mill Replacement

2.1 Justification

The absence of viable contingency was pointed out as a risk in case of AM failure. A major outage would require a substantial amount of crushed bath bags piling up (up to 30 000 bags after 3 months outage in worst case scenario). Purchasing the bath could cost up to US $ 7.5M. Hiring a mobile crusher was another option, however, its availability was problematic and its mobilization not immediate. The throughput and the critical parts of a rental equipment could not be guaranteed. The rental and operating costs were also significant.

Due to all these considerations, it was decided to purchase a suitable standby crusher (by-pass crusher) that would have the double advantage of supplying enough crushed bath during the change-out of the AM and would serve as a long-term contingency immediately available in the event of an AM failure in the future with minor operating costs.

2.2 Type of Crusher

The bypass crusher had to ensure uninterrupted recycle of cover bath supply to the potline. The cost of replacement and maintenance had to be low.

The presence of aluminum in the bath was also a key issue. In Sohar Aluminum, the best practice consists in daily recycling of the bath from cleaning of ladles and crucibles used in the casthouse, in addition to the pot basement bath, the pot cavity cleaning bath, the spent anodes cover bath and the bath material in lining from postmortem pots. Presence of aluminum is inevitable, even after a stage of visual screening and removal of observed aluminum.

Two types of crushers were considered.

- A cone crusher offered the advantage of larger grain size and a system of hydraulic relief for the uncrushable parts (ex. aluminum pieces). However, the drawback was a reduced throughput and the risk of damage of the cone with hard pieces. Moreover, the hydraulic operation and the feed regulation that necessitated a full crusher chamber and this added complexity to the operation.
- The impact crusher on the other side, while being 30 % cheaper, presented more maintenance friendly aspects and a simple construction requirement. The grain size produced was comparable to the grain size produced by the AM, hence no change but also no advantage.

The choice was set on an impact crusher of 35 t/h nominal capacity to be integrated to the existing structure.

3. Installation and Operation

3.1 Layout

The installation and commissioning of the bypass impact crusher took six months. The pictures in Figure 5 show the installation of the crusher Metso. A vibrating feeder was installed to feed the crusher initially with a screen of 20 mm so that only the bath size greater than 20 mm was crushed.

During a week stored crushed bags were used to supply the potrooms exclusively. During that time, both the autogenous mill and the impact crusher had to be stopped for the final integration and the replacement of the original outlet belt by a vibrating conveyor to supply the crushed product and the fine bath (< 20 mm) to the two storage silos.

The crusher remained a contingency equipment, i.e., kept in case of need. There was no return line implemented to crush a second time the material that would be rejected at the storage silo inlet due to a size greater than 20 mm. Instead, the oversize material was redirected into bins that were manually returned daily to the crusher inlet feed.

Figure 5. Installation of the impact crusher.

3.2 Performance and Findings

Figure 6 and 7, show that the crushed bath particle size did not differ drastically between the autogenous mill and the impact crusher. The statistical analysis shows that the probability of the product is high enough to conclude that nor the mean nor the standard deviation of the crushed bath granulometry are impacted by the impact crusher utilization (after optimizing its supply rate, speed and blow bar gap). The fines fraction of 0 to 0.75 mm remains in average at 12 % all along the 63 days of collection (X-axis). The grains fraction of 3.15 mm to 22 mm stays at an average of 25 %. Too fine bath would create a problem in the pot rooms when covering the anode due to spillage and excessive consumption. Coarser bath exceeding the specification would induce greater heat loss and difficulty to form a crust.

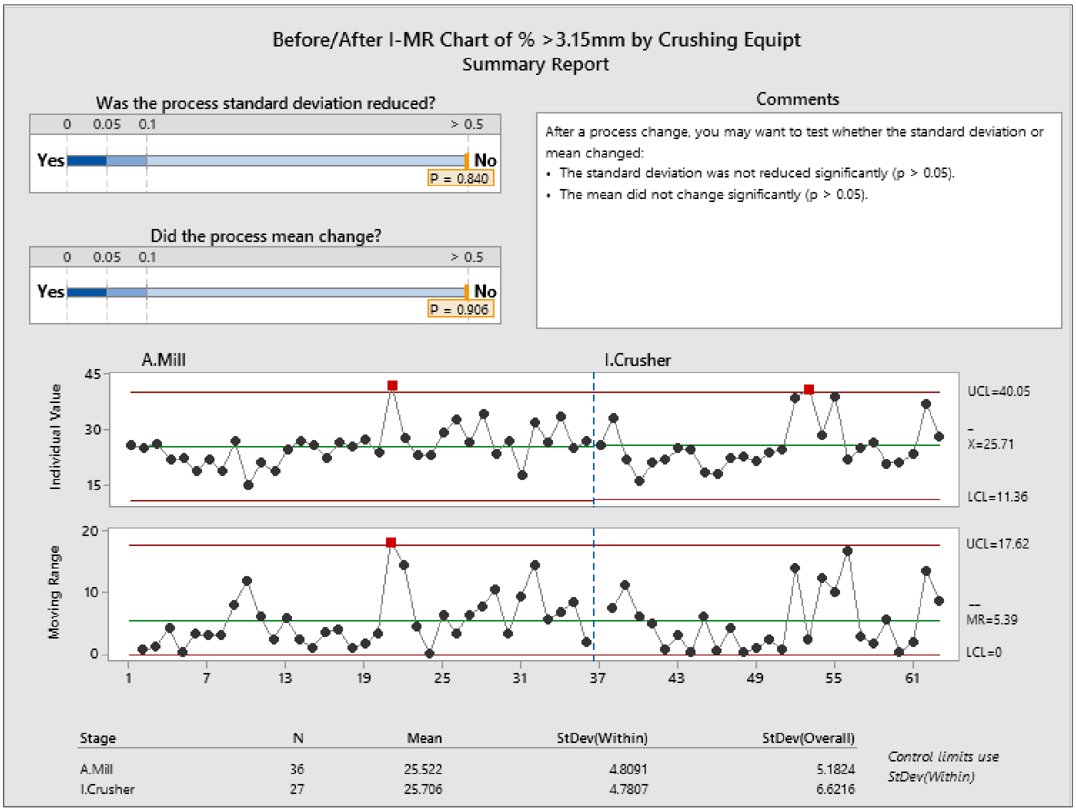

Figure 6. Crushed bath particle size distribution for particles > 3.15 mm. A.Mill = autogeneous mill and I.Crusher = impact crusher.

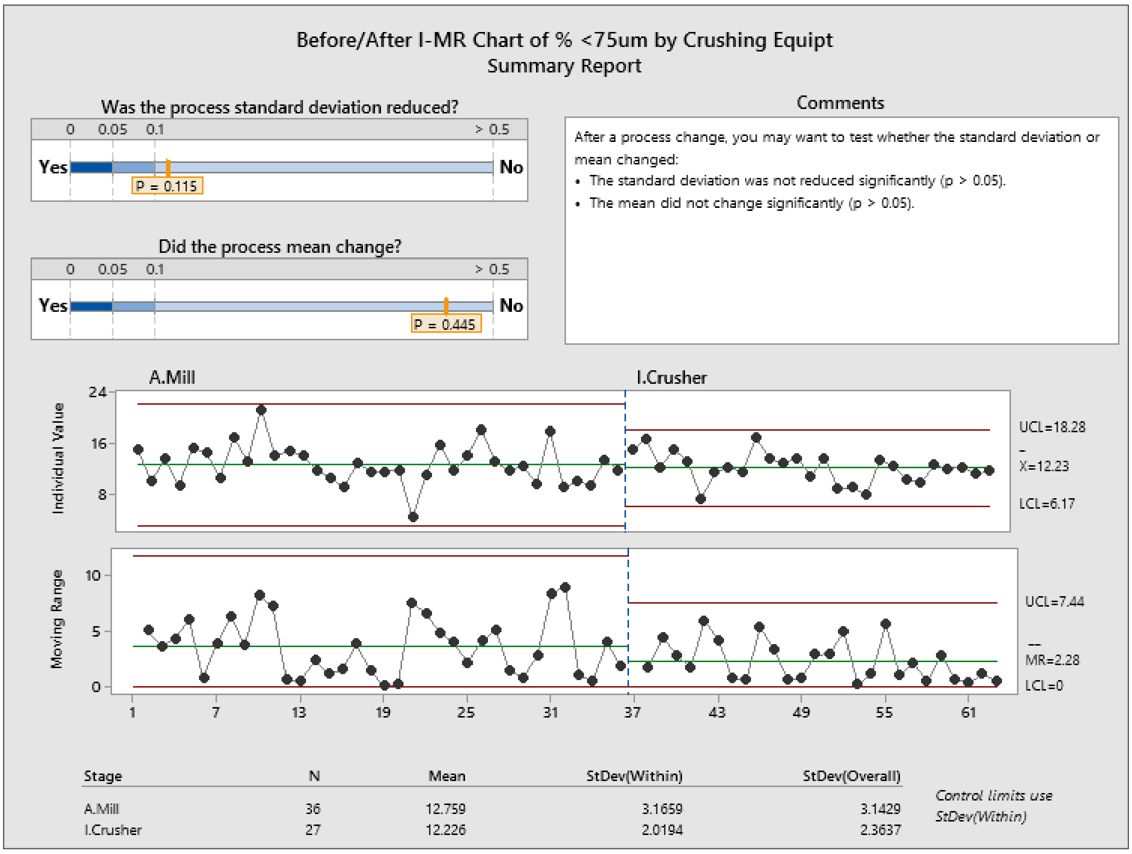

Figure 7. Crushed bath particle size distribution for particles ≤ 0.75 µm. A.Mill = autogeneous mill and I.Crusher = impact crusher.

Within nine months, the autogenous mill foundations were replaced, and a new mill was installed which required a continuous utilization of the bypass crusher for production.

During this period, the impact crusher showed an excellent reliability with no breakdown. The following observations were made:

- The wear of the blow bar was not uniform among the four bars, nor along the length of each bar as shown on Figures 8 and 9. An average tolerance figure had to be considered to decide when and by how much to adjust the gap.
- The blow bars required an adjustment every 5 weeks. Initially at 25 mm based on the OEM recommendation, the gap increased up to 31 mm which resulted in doubling the quantity of oversize bins to recycle.
- It was possible to let the gap grow until 45 mm for the sake of producing a coarser cover bath material but at the expense of more oversize material reprocessing.
- The blow bars had to be changed after six months of operation. They could be reversed once, which made the crusher a very unexpensive equipment to maintain.
- Trials were carried out with the variable impact crusher speed and gap to maximize the outlet crushed bath size. Consistently, the size of the screens (respectively at the crusher inlet and later at the bath storage inlet) was increased along with the crusher gap size.
- Rapidly it was proven that even the bath recycled from the cast house with some residual aluminum pieces could be incorporated into the recipe of feedstock and be crushed without damaging nor jamming the equipment. This finding basically removed all limitation of the operating part.

Figure 8. Blow bar gap and profile after utilization.

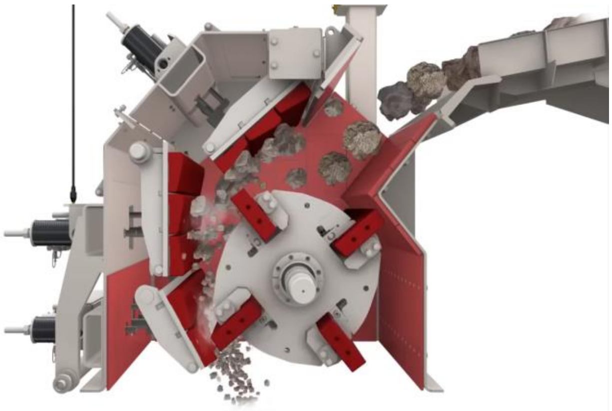

Figure 9. Presence of the four blow bars.

4. Conclusion

The installation commissioning and operation of the impact crusher as an alternative to the autogenous mill were a success. From the point of view of productivity, reliability, cost, outlet product size and type of feeding material, the equipment met all the requirements and the expectations.

It gave enough flexibility to try different setup configuration with the aim of producing coarser material unlike a gravity breaker hole diameter size with a fixed outlet product size maximum.

It successfully permitted the change-out of the AM and provides Sohar Aluminium a permanent, reliable, and resilient contingency to sustain the continuous operation.

5. References

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