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Case Study
Crusher Performance and Liner Life Improvements
Pebble Crushing Application

1 Introduction

The following document outlines an ongoing development project conducted as a joint effort between Makuri Technology, our foundry partner and a large gold and copper mine operated by a leading multinational mining company. Overall life improvements to date have approached 54% over long-term averages with OEM products, with further gains still to be implemented.

2 Application Overview

Makuri was approached by the site in 2017 to assist with ongoing issues with liner breakage and suboptimal pebble crushing performance. The site had experienced ongoing liner failures with all suppliers and was unable to maintain the target pebble crusher gap setting, which Makuri then reviewed and proposed an ongoing testing programme to implement improvements.

The previous liners used in the crusher were an OEM standard, short-medium design. Long-term life averages with the OEM product was around 1100 hours per set, with numerous failures being reported. The cause of these failures was investigated, and it appears that while many may be related to manufacturing problems, some products simply showed evidence of the machine being overloaded and/or liners coming loose during operation.

2.1 Trial 1: OEM Equivalent set with improved material

The first liner set tested was an OEM equivalent profile, using Makuri's MN2C material – an 18-20% manganese steel grade with a proprietary composition and heat treatment profiles, that regularly outperforms standard materials by around 20-30%.

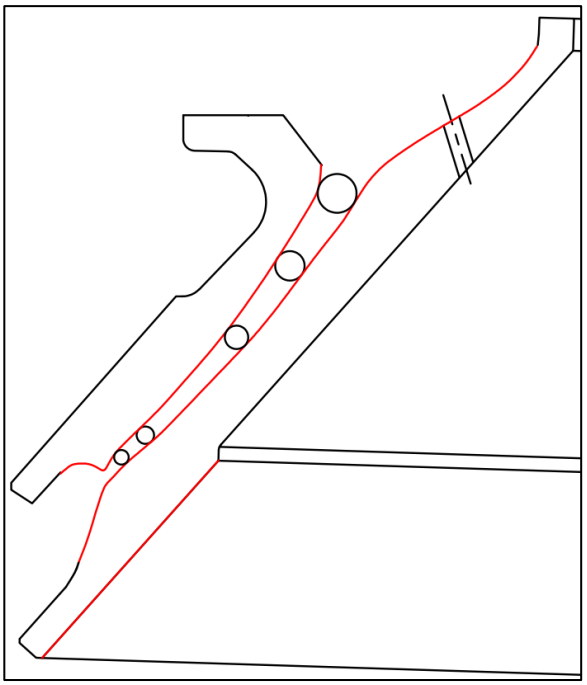
The liner set ran for 1248 operating hours above 200kW, which equates to a 13% improvement over long-term averages. Analysis of the liner set after removal showed that, if run to a conservative target minimum thickness, the liner set could have achieved 1500 hours – an overall improvement of 36%.

Following extensive consultation with the end user and subsequent modelling, a revised design was produced with the aim of maximising the tonnage rate of -10 crushed product. In order to do this, a reduction

in power draw would be required at lower gap settings. A set was then designed and verified using in-house simulation software.

2.2 Trial 2: Makuri Optimised set

The liner set used for this phase was a design modified by Makuri & intended to improve the rate of -10mm material produced, primarily by allowing the crusher to operate at a tighter gap. Unfortunately, unrelated mechanical issues with the crusher prevented this from being fully tested.



At what appears to be a reduced kW target, leading to the CSS being similar to previous sets, the liner set achieved a life of 1410 hours with a projected life of 1700 hours if run to the target minimum thickness. The forecast life figure represents an improvement of 55% over long-term averages.

Wear analysis showed that the liner modification had been successful in maintaining the initial feed opening, producing improved performance over the full liner life by reducing the tendency for power draw to decrease as the liners wear.

2.3 Trial 3: Makuri Optimised set 2

The liner set used in this trial was a second set of the liners used in trial 2, with a target life of 1600 hours set. Unfortunately, the mantle developed cracks at around 1300 hours life due to likely seating issues on a worn head and had to be removed.

Although this trial was not completed, the machine was run at a higher power target than previous. This improved work hardening capability of the liners and confirmed that a target life of 1700-1800 hours is achievable with this set if run at full power.

2.4 Future developments

Based on the previous two trials, it appears that it will be necessary to reduce the active chamber length in order to achieve the target product size. This is expected to reduce tonnage, although it appears the plant has ample capacity to accommodate this. For example, the two SAG mills collectively produce an average of 945 tph of pebbles. Current crushing capacity of the pebble crushers is around 550-600 tph when operated at full power, so the pebble discharge of the SAG mills can be processed by two out of 3 pebble crushers.

Should the end user choose to maintain the current operating parameters and not proceed with further development, a massive life increase has still been achieved, providing a significant potential improvement in Total Cost of Ownership.

3 Other Successes

Makuri has achieved similar improvements in a range of other applications, including pebble crushing improvements at a number of Indonesian gold and copper mines along with massive increases in life of jaw crusher liners and stockpile reclaim chute liners at other sites. These are the subject of additional case studies, and are available on request.

4 Manufacturing Improvements

Makuri's foundry partner utilises quality controls that exceed all ASTM standards and internal OEM procedures, with chemical composition tolerances which are substantially tighter than those followed by any known alternative. In addition to the normal checks, the foundry conducts microstructural checks on every casting – these checks are performed on the surface of the liner, not on cast-on 'coupons' which will often produce misleading results with manganese steel.

The majority of raw materials used by the foundry are sourced from very low phosphorous, high purity 'punch plate' scrap purchased from vehicle and whitegoods manufacturers. This allows the foundry to reduce the upper limit on a range of elements, including phosphorous which has a seriously detrimental effect on manganese steel quality.

Excessive phosphorous in manganese steel produces a phosphoid eutectic phase with secondary carbides at grain boundaries which makes the material extremely brittle and often results in premature failure. While the use of the higher quality raw materials does increase the manufacturing cost, it allows the foundry to maintain a maximum phosphorous level of 0.04% - a significant reduction from ASTM and OEM standards of 0.07%.

In addition, the foundry is currently commissioning a new foundry which:

- Exceeds all international environmental standards
- Implements 3d CNC pattern making facilities for improved accuracy & repeatability
- Automated robotic grinding
- Semi-automated moulding system

These improvements are set to place Makuri Technology and its dedicated foundry partner as the new industry benchmark for manganese steel products in an environment where historical market leaders are cutting costs and redirecting resources towards other priorities.