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# MAGNETIC MILL LINERS: An Innovative Ball Mill Lining Technology

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## ABSTRACT

Magnetic Mill Liners (MML) consist of permanent magnets embedded in metallic "bricks" that firmly attach to the interior walls of the mill. Ball chips and magnetic mineral particles form a thin, continuously renovating layer that provides extended liner wear protection for much longer periods than conventional steel or rubber lining systems.

In December, 2016, Compañía Minera del Pacífico (CMP) installed the first MML liners in Chile in one of the ball mills at the Huasco Pellets Plant, supplied by ERIEZ/Polimin. These liners are still operating today and are expected to last for several more years. In December, 2022, CMP installed a second set of MML liners in another ball mill of similar dimensions, at the same facility.

Comprehensive operating records for both processing lines, from June, 2022 to May, 2023, show no statistically significant differences in the overall performance between the two lines.

## INTRODUCTION

Magnetic Mill Liners (MML) were first invented and patented in China, some 35 years ago. But, in spite of their demonstrated industrial performance, particularly their very extended durability, MML liners have not received full adoption by the hard-rock mineral industry (Fe, Cu, Au, Pb, Zn and others) where conventional ball mills are commonly used.

MML liners consist of permanent magnets embedded in metallic "bricks" that firmly attach and completely cover and protect the interior walls of the mill. MML liners are, in turns, protected by a continuously renewable layer of ball chips and magnetic mineral particles that attach to the exposed surface of the MML "bricks". Such protective layer may reach 1 to 2 inches in thickness. Worth noting that the presence of magnetic mineral particles is not a requirement for the creation of the protective layer; ball chips can also serve that purpose.

In December, 2016, Compañía Minera del Pacífico (CMP) installed the first MML liners in Chile in Ball Mill 1 at their Huasco Pellets Plant. These magnetic liners, originally supplied by ERIEZ/Polimin, are still operating almost 8 (!) years later and are expected to last for several years more. Later, in December, 2022, CMP installed a second set of MML liners in Ball Mill 3, at the same facility.

The purpose of the current publication is to present a summary of the comparative industrial performance of both alternative lining systems: Steel/Rubber vs. MML.

## EMPIRICAL DATABASE

The comparative analysis was based on a set of detailed, relevant, hourly operating records, for the period June, 2022 thru May, 2023, shared by CMP for such specific purpose. These data were properly filtered out of "outliers" before proceeding with the analysis and reaching any conclusions.

Underlying trends in the data were detected using Data Binning Methodology.

## RESULTS AND DISCUSSION

Throughout the whole reported period, MML liners were installed and running in Ball Mill 1. Beginning January, 2023, MML liners have been operating in Ball Mill 3, of the same dimensions as Ball Mill 1, both of them running in similar parallel lines. Ball Mill 2 is still equipped with Steel/Rubber liners, but its operation has been too discontinuous to be included as reference in the current evaluation.

The following table summarizes the comparative results so obtained, for the indicated evaluation periods:

| | Evaluation Period | | | |
|---|---|---|---|---|
| | Jun, 2022 - Dec, 2022 | | Jan, 2023 - Jun, 2023 | |
| **Operating Condition** | **Ball Mill 1** | **Ball Mill 3** | **Ball Mill 1** | **Ball Mill 3** |
| **Liner Type** | **MML** | **Steel/Rubber** | **MML** | **MML** |
| Grinding Capacity, t/h | 287 | 276 | 287 | 280 |
| Mill Power, kW | 3914 | 3816 | 3915 | 3803 |
| Specific Energy, kWh/t | 13.7 | 13.9 | 13.7 | 13.6 |
| Fresh Feed, % -100# | 29.5 | 29.4 | 28.4 | 28.0 |
| Fresh Feed F80, microns (*) | 3414 | 3418 | 3585 | 3666 |
| Final Product, % -325# | 77.9 | 77.4 | 78.1 | 75.3 |
| Product P80, microns (*) | 49.1 | 50.4 | 48.5 | 55.9 |
| Op. Work Index, kWh/t | 10.9 | 11.2 | 10.8 | 11.6 |

(*) Empirical correlations obtained from previous, detailed circuit surveys.

When protected with MML liners, both mills developed slightly higher, average grinding capacities than when steel/rubber liners were installed. Similar observation applies to mill power draw under comparative conditions. In terms of grinding energy efficiency, MML liners achieved somewhat lower specific energy consumption levels and demonstrated similar operational work indices (improved energy efficiency). Finally, product size was also maintained at comparable levels.

Overall – within normal process variability ranges – there would be no significant statistical differences in operational performance that could be associated to the two mill lining systems under evaluation.

Besides the actual grinding performance – the primary purpose of the reported evaluation – MML liners exhibit other attributes of relevant financial impact. The life of MML liners is proving to be 3+ times longer than steel/rubber liners. Considering that a full liner change-out in this specific application takes roughly 5 days of lost production, there are significant savings in total liner replacement cost. Further, there is no need for periodic operational shut downs to check on the current condition of the liner bolts, which are simply inexistent in the case of MML liners.

Both grinding lines will continue to be monitored over longer periods for further evaluations.