

# Procemin·GEOMET 2024

20<sup>th</sup> International Mineral Processing Conference and Geometallurgy

## MAGNETIC MILL LINERS (MML): An Innovative Ball Mill Lining Technology

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# Introduction

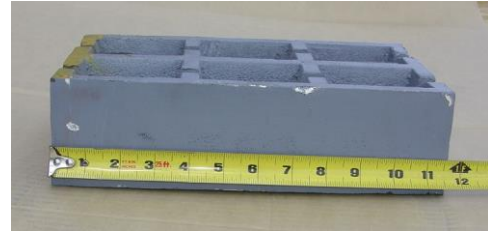
## MAGNETIC MILL LINERS (MML)

- ❑ **Magnetic Mill Liners (MML)** were first invented and patented in China, some **35** years ago, as **Hermes™ Metal Magnetic Mill Linings**.
- ❑ To date, **MML** liners have been installed in more than **600** ball mills, worldwide. The oldest **MML** liners, still in-service, were installed more than **20 (!)** years ago.
- ❑ In spite of their demonstrated performance – *particularly their very extended in-service durability* – **MML** liners have not received full adoption from the hard-rock mineral industry where conventional **Ball Mills** are typically used.

# Magnetic Mill Liners

## MML INSTALLATION

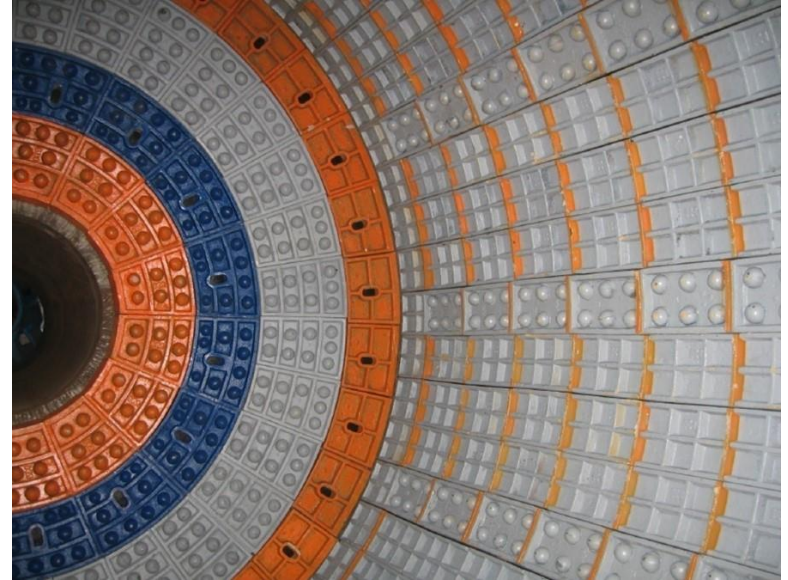
- ❑ **MML** liners consist of permanent magnets embedded in metallic, high chrome **“bricks”** that firmly attach and protect the interior walls of the mill.
- ❑ The heavier of such **“bricks”** weighs less than **20 kgs**.



# Magnetic Mill Liners

## MML INSTALLATION

- ❑ The “*bricks*” may be arranged in rows of high-and-low thickness, in order to create a well-spaced **lifter bars profile**.



# Magnetic Mill Liners

## PROTECTIVE “AUTOGENOUS” LAYER



- ❑ **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”**.

# Magnetic Mill Liners

## PROTECTIVE “AUTOGENOUS” LAYER

- ❑ Such protective , continuously renewable layer may reach **1” to 2”** 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 equally serve the same purpose.



# Industrial Evaluation

## MML TRIALS AT CMP-HUASCO PLANT

- ❑ 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 liners are still operating almost **8 (!) years** later and are expected to last for several more years.
- ❑ Later, in December, 2022, **CMP** installed a second set of **MML** liners, now in **Ball Mill 3**, at the same facility.
- ❑ The comparative performance of both alternative lining systems; i. e., **Steel/Rubber vs. MML**, is discussed next.

# Empirical Database

## MML TRIALS AT CMP-HUASCO PLANT

- ❑ The comparative analysis was based on a set of detailed, **9,001** hourly operating records, for two consecutive periods: **Jun-Dec, 2022** and **Jan-May, 2023**, for both **Mills 1** and **3**, including:
  - Line Capacity, t/h
  - Fresh Feed Fineness, % - 100#
  - Mill Power, kW
  - Mill Head Water Addition, m<sup>3</sup>/h
  - Sump Water Addition, m<sup>3</sup>/h
  - Cyclone Feed Flowrate, m<sup>3</sup>/h
  - Cyclone Feed % Solids
  - Cyclone Overflow % Solids
  - Ground Product Size, % - 325#
- ❑ These data were properly filtered off **“outliers”** by applying the so-called **Data Binning Methodology**.



# Data Filtering

## DATA BINNING METHODOLOGY

- ❑ **Data Binning** is a numerical technique for dealing with data preferentially clustered around similar sets of conditions by placing equal weight on each **“bin”** (narrow range), rather than equal weight on each data point.
- ❑ The equally weighted **“bins”** can more accurately reveal the underlying trends in the data, provided there are sufficient data points per bin across the entire range of interest.
- ❑ A single variable **Data Binning** process was applied, calculating averages of all relevant hourly operating records, for selected ranges of % - **325#**, before and after the installation of **MML** in **Ball Mill 3**.

# Experimental Results

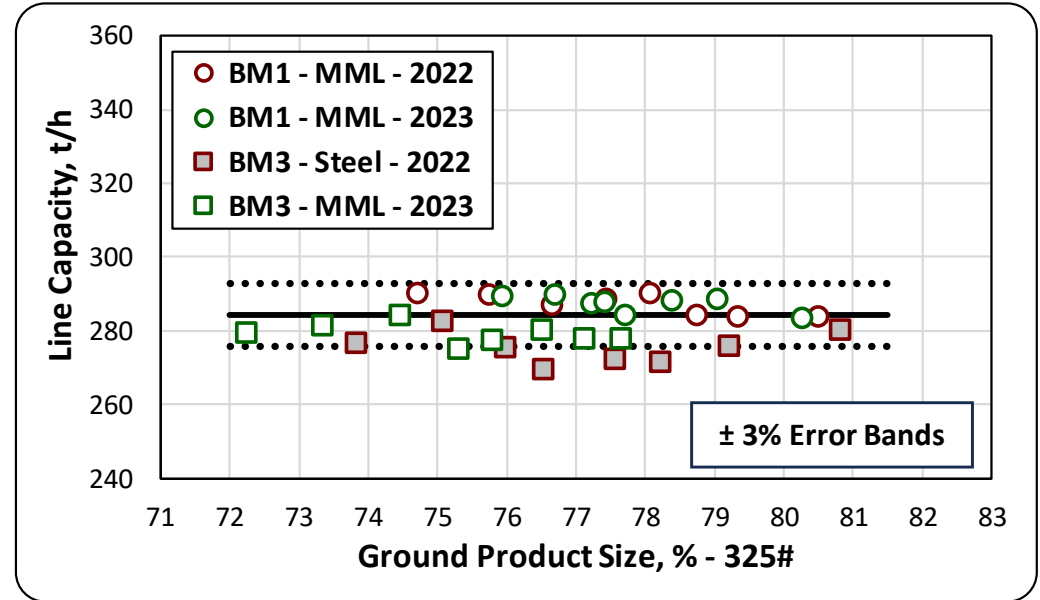
## EVALUATION SCENARIOS

- ❑ Throughout the whole reported period, **MML** liners were installed and running in **Ball Mill 1**.
- ❑ Since **January, 2023**, **MML** liners have also been operating in the parallel **Ball Mill 3** line.
- ❑ **Ball Mill 2** is still equipped with **Steel/Rubber** liners, but its operation has been too discontinuous to be considered as a valid empirical reference for the purposes of the current evaluation.

# Experimental Results

## LINE GRINDING CAPACITY, t/h

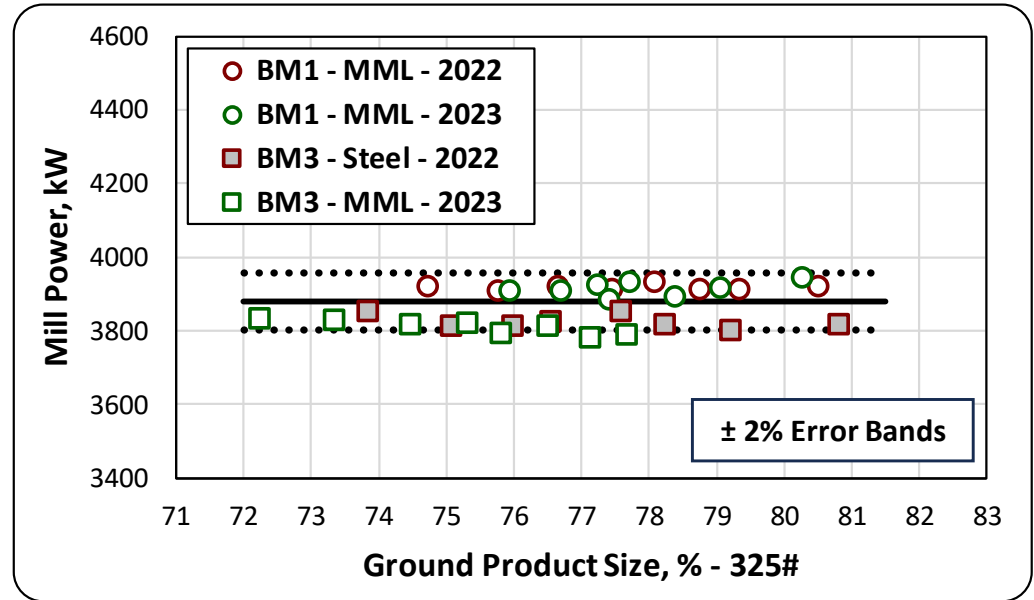
- Within normal process variability ranges, **binned data** indicated that there would be no statistically significant differences in **Line Capacity (t/h)** that could be caused by the **2** alternative mill lining systems under evaluation.
- Notice, however, that **BM3** with **Steel/Rubber** liners developed slightly lower capacities than when **MML** liners were installed.



# Experimental Results

## MILL POWER DRAW, kW

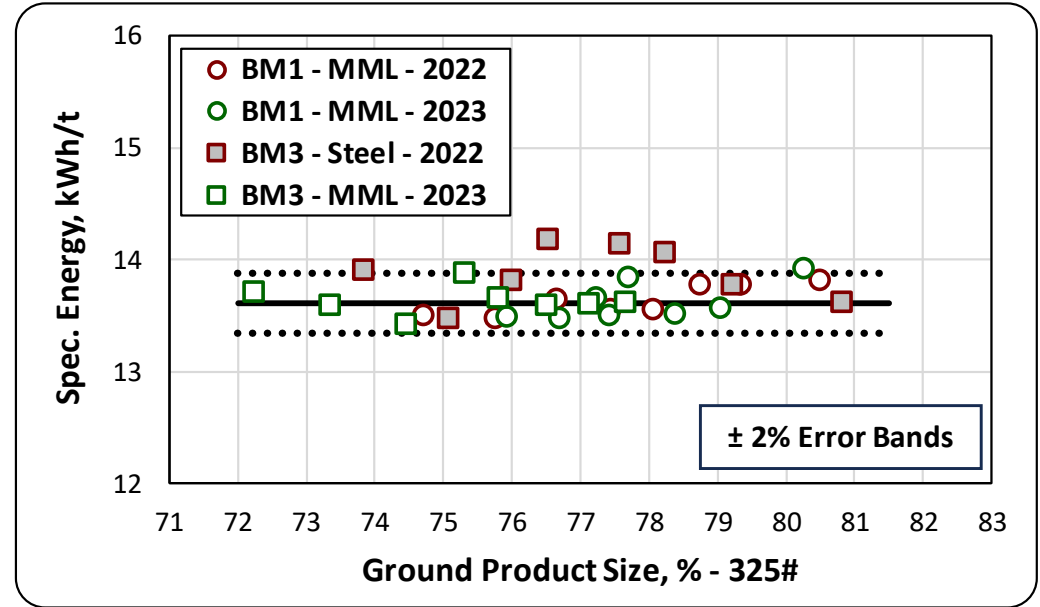
- Same observation applies to the **Mill Power Draw, kW** associated to each lining system.
- These data disqualify the popular belief that **MML** liners draw less power than other types of liners.
- In fact, at least in this case, **Steel/Rubber** liners have drawn slightly lower power than **MML** liners.



# Experimental Results

## SPECIFIC ENERGY, kWh/t

- In terms of **Specific Energy Consumption, kWh/t** – *for comparable grinding tasks* – both lining systems also exhibited similar levels of **Grinding Energy Efficiency**.
- Notice, once again, that **Steel/Rubber** liners would consume more **Specific Energy**, but hardly significantly more.



# FINAL COMMENTS

- ❑ 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 current evaluation* – **MML** liners exhibit other attributes of relevant financial impact, like significant savings in **liner replacement costs** as well as in periodic liner condition inspections (e. g. **liner bolts re-tightening**; simply non-existent in the case of **MML** installations).
- ❑ Both grinding lines will continue to be monitored over longer periods of time for further comparative evaluations.



*¡Thanks for sharing!*