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Editorial

Grinding and Concentration Technology of Critical Metals

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1. Introduction and Scope

The production and supply of raw materials in a global market are not without risks, and both the recent COVID-19 pandemic and the current one (Russia–Ukrania conflict) raised public awareness about the importance of multiple value chains.

Despite the great inertia characterising the mineral raw materials sector, some steps towards the Industry 4.0 paradigm can be envisaged. Significant challenges to the mining sector are the appropriate process design using the best available technologies; the increase in energy efficiency; the responsible use of water and handling of mining wastes; the social acceptance of the activity; and the digitalisation challenge. More than ten years ago, the European Union elaborated a list of critical raw materials (CRMs), taking the economic and strategic importance for the European economy and the supply risk. Although focused mainly on the energy sector, the USA, Canada, and other countries took recently similar steps.

This Special Issue aims to propose strategies that can help face those challenges, especially in increasing energy efficiency in comminution operations.

2. Contributions

In the first contribution of this Special Issue, Ciribeni et al. [1] proposed a simplified procedure for calculating grinding kinetic parameters, providing a spreadsheet to help work index calculation through simulation using the characterisation performed. They then compared the results with actual Bond ball-mill work index results and validate the proposed methodology.

Another contribution regarding grinding kinetics of a Ta ore was the research objective in Nava et al. [2]. Some variations to classical population balance model methodologies and functional operational correlations were found among the feed size; the specific breakage rate; and the Sn, Ta, and Nb contents. This study was completed with additional experimental tests on this same ore by Nava et al. [3], obtaining a more profound comprehension about the relationship among each kinetic parameter and the operational conditions (mill speed and feed grain size), which permitted the definition of the operation conditions to improve grinding efficiency.

A different and very innovative approach to energy efficiency improvement in grinding is proposed in the paper authored by Kolev et al. [4]. The substitution of steel balls by Relo grinding media (RGM) in tumbling mills is the focus of the research study. RGM are claimed by the producer, the Bulgarian company RELO-B, as a better alternative for balls. RGM were tested at laboratory scale under different conditions and compared with balls equivalent in diameter. Although standard Bond tests were not conclusive, results were promising in terms of grinding efficiency, reaching, for the RGM, the same undersize production as balls with lower circulating load values. Further research is needed to clarify the effect on mineral liberation.

In the paper proposed by García et al. [5], a deep study on the Bond ball-mill and Bond rod-mill standard tests is shown with different ores. The most impacting result of this work is the different results when matching work index values and grindability index

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values from the od mill's size range to the ball mill's size range, showing that the parameter which reflects ore grinding properties is the grindability index, which allowed the work index to have additional influences from operational conditions. Furthermore, the authors proposed the Maxson index when referring to the grindability index, based on the historical importance of Walter Maxson and its mentoring role on Fred Bond's initial research stage at Allis Chalmers laboratories.

The sixth paper in this Special Issue, authored by Ciribeni et al. [6], discussed the relationship between the Maxson Index and the kinetic parameter obtained in the grinding kinetics characterisation of several ores following the Cummulative Kinetic Method (CKM). Up to twelve different ores tested under fifteen different conditions proved that these parameters have a strong correlation, which led the authors to propose a rapid methodology of work index determination.

With all the results presented in previous papers, the time to perform a deep revision arrived, and this task was performed in the paper authored by Nikolić et al. [7]. This excellent review paper, which is not exhaustive but very well focused, revised up to twenty-two alternative procedures to work index determination, performing a revealing comparative of the mean square relative error in each case.

A place in this Special Issue was also left to the research work authored by Colorado-Arango et al. [8]. Although the research addressed the grinding of metallurgical coke, the study focused on the influence of the selection among different particle size distribution (PSD) models when predicting grinding products, with importances when performing interpolations to obtain PSD characteristic sizes (d_{80}).

The ninth contribution to this Special Issue, signed by García et al. [9], discusses the variability on the work index when performing the Bond ball-mill standard test due to the lack of definition of several test conditions. An ANOVA test shows the influence of F_{80}, P_{100} and the feed fines percentage (% < P_{100}), highlighting that, with the same ore, the Bond work index values can show significant differences, and its proper interpretation needs additional information further than the sole value result.

Finally, the last contribution to this Special Issue by Llera et al. [10] proposes a kinetic model of the comminution process in a high voltage impulse electrofragmentation device. The authors studied the influence of feed particle size, impulse number, and impulse polarity on the grinding product and the model parameters, evidencing original conclusions that interest this breakthrough comminution technology.

3. Conclusions and Outlook

The papers published in this Special Issue evidenced that increasing energy efficiency is a major challenge that can be faced with a better understanding of traditional approaches, as is the case of Bond's methodology or grinding-kinetics ore characterisation. However, this major challenge must also consider innovative approaches in the state-of-the-art methodologies, as is the case of the RGM use in conventional tumbling mills or focusing on the scaling up of revolutionary technologies, as is the case of electrofragmentation technology in comminution.

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