minerals

Editorial

Editorial for Special Issue "Comminution and Comminution Circuits Optimisation"

Ngonidzashe Chimwani

Department of Mining Engineering, University of South Africa (UNISA), Florida Campus, Private Bag X6, Johannesburg 1710, South Africa; ngodzazw@gmail.com

Comminution is the size reduction of rock particles from blasting during the mining stage to crushing and milling during the mineral processing stage. It is known to be the largest consumer of energy across the globe. The blasting stage, among the comminution processes, consumes an insignificant percentage of the input energy to the comminution process, thus crushing and grinding are given more research attention. In that view, a Special Issue was created that covers the optimisation of some crushers and mills as well as some mathematical modelling of some of the comminution equipment to achieve circuit optimisation.

It is important to mention that all the efforts put in by different researchers to optimise comminution equipment are meant to improve operational efficiency and thus reduce operational cost in the form of energy expenditure reduction. In that direction, most papers published in this Special Issue focused on the optimisation of different crushers [1–3], whilst one paper seeks to optimise the operation of the tower mill using a kinetic model [4]. Other papers focused on the pre-treatment methods such as ore blending on the milling and downstream performance such as floatation through the lenses of mineralogy [5] and heat treatment of ores and its effect on the Bond Work Index of the ore [6]. One last paper published in the Special Issue comprehensively reviewed the attainable region technique's milestones in optimizing ball mills' operation at laboratory and industrial scales [7].

The Special Issue attracted authors across all divides, i.e., USA, Brazil, South Africa, Chile, Zimbabwe, Poland, and China, with some boasting of a wide experience in mineral processing and others being founders of comminution theories that form the base on which several research works have been built upon over the years. This thus led to the publication of high-quality journals which address problems encountered in mineral processing, particularly comminution. In some papers, models were built from experimental data [1], pilot plant [4], and real plant data [2], which in turn were validated and used to optimise the operation of comminution equipment whilst other papers focused on purely experimental studies [4–6]. Only one paper reviewed the progress of one of the techniques used to optimise ball mills with an endeavour to promote its adoption by the conservative industry [7].

Having understood the role played by the AR and its importance in the optimisation of ball mills at the laboratory and industrial mills, Chimwani [7] reviewed the development of AR and its footprint in the mineral processing industry. The work demonstrated the technique's prowess to optimise the production of a desired particle size distribution for downstream processes by either minimizing the energy expenditure or maximising the production of a given size class as objective functions. This has managed to unpack the operations of a ball mill, often termed a black box, owing to its concealing nature by studying the behaviour of each parameter that influences the operations of a ball mill. The AR achieved the desired purpose by unveiling all possible outcomes derived from a combination of operational parameters that are bound by trajectories showing the limitations of a system. The objective of the review was two-fold; to promote the adoption of the optimisation technique by the conservative industry and to clarify the source of

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discrepancies between some of the AR recommendations and what is conventionally known concerning the optimal operating conditions of certain parameters.

Taking advantage of the ability of the DEM to provide important information needed to design the equipment and analyse its operations, Bwalya and Chimwani [1] used the technique to assess the operation of an impact crusher. The authors validated the simulations using the energy spectra and threshold energy levels calculated from previously measured drop weight data. The comparison of the single and double impeller crushers done using DEM simulations showed that preference should be given to the double rather than the single impeller crusher. This is because of better energy intensification, and more operational flexibility provided by the easier adjustment of the spacing between the impellers of the double impeller crusher. Thus, making it easier to be tailored to handle the input feed size range.

Still, on impact crushers, Gawenda and Saramak [2] proposed empirical models that describe an impact crusher operation, independent of the technological circuit of aggregate production and the crushing device. The models were each specific to a particular feed material, which consist of dolomite, limestone, gravel, sandstone, and diabase. The models enabled the authors to assess the influence of the crusher rotor velocity and the outlet gap width of the crushing machine on the production of fine particles and size reduction ratio. The assessment showed the gap to be inversely related to the size reduction ratio and the yield of the finest particle size fraction, both in general models and in the models built separately for each type of feed material.

In their quest to improve the capacity of cone crushers, Zhang et al. [3] theoretically investigated the velocity distribution of particles at choke-level in the crushing chamber and developed a cone crusher capacity model. The model developed successfully assessed the structural and operating parameters influencing the capacity of cone crushers, such as the rotational speed of the main shaft, the size of the closed side setting, the eccentric angle of the main shaft, and the base angle of the mantle. In addition to finding the optimal rotating speed of the main shaft, the work shows that the cone crusher capacity is directly proportional to the size of the closed-side setting crusher and the base angle of the mantle whilst it is inversely proportional to the eccentric angle of the main shaft.

Realising that a complete set of data was generated from the pilot-scale tower mill experiments, Austin and Schneider [4] fitted the data with a simple first-order size reduction kinetic model with only two parameters. This served to provide an oversimplified model that quickly assesses breakage in tower mills only from the feed and product size distributions. The model has the potential to be scaled-up to full-scale mills, extended to the steady-state continuous operation, and assess parameters such as residence time distribution given the availability of suitable data.

To unlock the potential of optimising comminution and separation processes as an integral process whilst addressing the variability of heterogenous sulphide ores at a given mine, Dzvinamurungu et al. [5] assessed the influence of blended ore sizes on the floatation performance of pentlandite. The work was purely experimental, comprising sequential grinding and bench-top floatation tests coupled with the quantitative mineralogical investigation of the floatation feed and the associated products. The important contribution of this work to the body of knowledge is the use of a system approach, that is to optimise milling and floatation as an integral unit, which is sparse in the literature. The work also reveals ore blending prior to milling as having the potential to reduce milling time by controlling the amount of orthopyroxene and sulphides in the feed. Though not much has been published about this method as far as ball mill optimisation is concerned, its potential to reduce the energy consumption of comminution circuits cannot be overemphasised.

Ore pre-treatment methods have also played a significant role in the reduction of energy consumed in comminution circuits. This is supported by the work of Cisternas et al. [6], who heated copper ores prior to grinding and measured the response using the Bond Work Index. Heating the ores before grinding is believed to make microfracture develop within the particle and render it weak. This work shows that even moderate temperatures cause a significant reduction in energy consumption during the grinding process. A proper cost and benefit analysis is needed though for this pre-treatment method to assess if the energy consumed during the heating process does not exceed the extra energy needed to break the unroasted ore to a similar degree as the roasted ore.

In conclusion, the Special Issue presents themes ranging from ore pre-treatment of ores to crushing and eventually milling. Although the papers cover a small percentage of the entire research field, they significantly contribute to the body of knowledge.

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