Does Specific Gravity of Media Have Much Effect on Process Efficiency?

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It has been hypothesised that increasing the specific gravity of the grinding media within a stirred mill will result in subsequent increased efficiencies within the milling process. This is a valid assumption when considering the maximum available stress energy imparted by the grinding media, where Stress Energy $\propto d^3 \cdot v^2 \cdot SG$ where d = Media Diameter, v = Media Velocity and SG = Media Density.

This paper aims to challenge that hypothesis by conducting IsaMill™ signature plot testwork. It showcases how ceramic media's specific gravity, from 2.8 up to 5, influences milling efficiencies. Using a copper and magnetite sample as a benchmark, it aims to develop an economic model to use as a guideline for evaluating ceramic media selection in a stirred horizontal mill.

1. Introduction

When utilizing stirred milling, the main cost drivers are energy, grinding media, and mill wear parts. Therefore, it stands to reason that reducing one of these cost drivers without correspondingly increasing the other cost drivers, will improve overall process efficiency.

It is therefore a reasonable assumption that by increasing the ceramic grinding media’s specific gravity, it will increase the maximum available stress energy from the media to the particles and reduce the specific grinding energy (SGE) required to achieve the desired P_{80}. As the cost of ceramic grinding media increases with an increase in specific gravity, the reduction in SGE should be of such significance as to offset the increased cost of the ceramic media.

This paper investigates the relationship between the increase in the ceramic media's specific gravity and its effect on SGE and the media wear, therefore the overall cost of the ceramic media. Due to the relatively short time for laboratory-scale tests compared to actual operation, the wear life of the mill internals could not be included. The paper will also aim to develop an economic model to use as a guideline for evaluating ceramic media selection in a stirred horizontal mill.

2. Method

To evaluate the difference in SGE when using ceramic media of different specific gravity, signature plots were generated using a M4 IsaMill™ and the Standard Work Procedure for signature plots from Glencore Technology. The signature plots were generated on both a magnetite and copper (chalcopyrite) concentrate feed to the IsaMill™. A graded charge with the same particle size distribution and a top size of 4.5 mm was used for all the signature plots while the specific gravity of the ceramic media was varied from 2.8 to 5.0. The ceramic media used was as follows:

King's MineMate CM-280	2.8 g/cm^3
King's MineMate CM-340	3.4 g/cm^3
King's MineMate TA-380	3.8 g/cm^3
King's MineMate TA-400	4.1 g/cm^3
King's MineMate TA-450	4.5 g/cm^3
King's MineMate TZ-500	5.0 g/cm^3

The target P_{80} set point for the signature plots over all the specific gravities was kept constant for both mineral samples.

To determine the wear of the different ceramic media, wear calculations were done on the media loss during the signature plots. Due to the small losses in mass as well as the relatively short time to conduct a signature plot test, the wear rate was also verified by doing a 6-hour extended continuous wear rate test on the M4 using the magnetite sample. A similar 6-hour wear rate test could not be done on the copper concentrate due to limitations in sample size. To compensate a 6-hour wear test was conducted on the ceramic media using the copper sample in a 5L pin mill. The results were then extrapolated to the M4 wear tests.

Results for both SGE and media wear were then compared to determine the process efficiency gain and cost saving, if any, using ceramic media of different specific gravity.

3. Findings

When comparing SGE from the signature plots, it can be seen from the results in Table 1, that for magnetite, there is a slight reduction in SGE when using a ceramic media of 2.8 g/cm^3 compared to the higher specific gravity media. The SGE increases slightly (<10%) for the very high specific gravity ceramic media (4.5 g/cm^3 and above) which is against expectation.

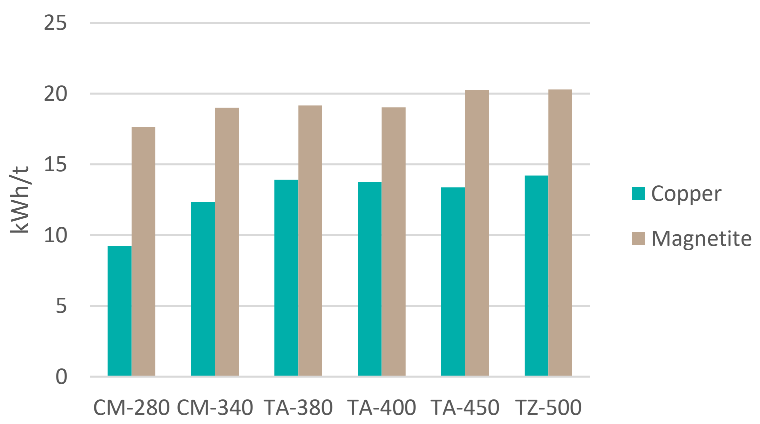

Table 1
Comparative SGE

For the copper sample the SGE increases gradually from the 2.8 g/cm^3 media to the 3.8 g/cm^3 but then stays relatively constant as the specific gravity of the media increases.

Comparing the wear rate of the different specific gravity ceramic media it can be seen from the results in Table 2 that the wear rate of the 2.8 g/cm^3 ceramic media when grinding copper is the highest and then reduces as the specific gravity of the media increases with the lowest wear rate at the 3.8 g/cm^3 and then increasing again as the specific gravity of the media increases.

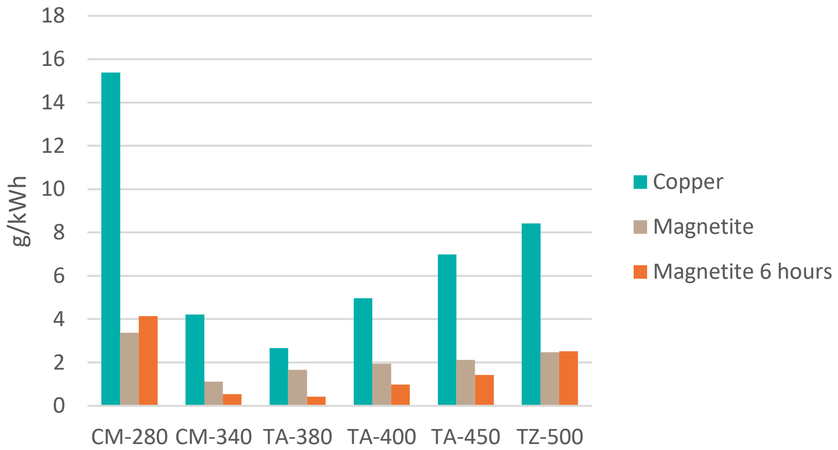

Table 2
Comparative Wear Rate

When grinding magnetite, the 3.4 g/cm^3 ceramic media have the lowest wear rate while the 2.8 g/cm^3 ceramic media again have the highest wear rate. The wear rate of the ceramic media increases when grinding magnetite as the specific gravity of the ceramic media increases above 3.4 g/cm^3. As the wear rate test time increases a similar trend for wear rate with magnetite can be seen as for copper.

4. Conclusion

No significant reduction in SGE was observed when increasing the specific gravity of the ceramic media above 3.8 g/cm^3 while a pronounced increase in media wear was observed. As the cost of the ceramic media increases significantly with increasing specific gravity, there is therefore no process efficiency gains to be achieved by using ceramic media of higher specific gravity than 3.8 g/cm^3 in a horizontal stirred mill. By reducing the specific gravity of the media to 3.4 g/cm^3 a cost saving can possibly be achieved both in SGE and media cost due to the lower cost of 3.4 g/cm^3 ceramic media over 3.8 g/cm^3 ceramic media. This does not seem to be true for grinding copper. It seems that the choice of using a 3.4 g/cm^3 over a 3.8 g/cm^3 to improve process efficiency is ore dependent and needs to be further explored, preferably on a full-scale operation. Using a 2.8 g/cm^3 is not economical due to the high media consumption outweighing the reduction in media cost.

The economic model and ore dependency of the results is explored in the full paper.