IN THE SPOTLIGHT

A S.H.O.T. at saving energy

The global mining industry has relied on comminution, an energy-demanding crushing and grinding process, to supply the valuable minerals that we depend on daily. To process these minerals to produce metals, including copper, zinc, gold, and others, mining companies commonly grind down the ore to very small particle sizes (often as small as the diameter of a human hair) to facilitate separation of the valuable mineral grains from the host rock and enable concentration. Froth flotation is one key concentration technique, which uses a combination of chemicals to render the mineral grains hydrophobic in a liquid suspension. Air bubbles are introduced into the suspension to attract the hydrophobic particles and float them to the surface while the remaining hydrophilic materials remain in suspension.

Current processing methods create significant environmental impacts; comminution accounts for up to 4 percent of global electrical energy demand and about 50 percent of mine-site energy consumption.[1] Notably, in current grinding processes, only about 1 percent of the energy is used to create new surface while the rest is lost as noise and heat. In an effort to encourage a clean technology solution to the mining industry's high energy consumption, the Crush It! Challenge was created. The challenge seeks to identify and accelerate development in a breakthrough mining technology or process innovation that can cut industry-standard comminution energy consumption by 20 percent or more. The Canadian government, the Centre for Excellence in Mining Innovation (CEMI), Goldcorp, and Natural Resources Canada (NRCan) are cooperating with Impact Canada to present the challenge. Now in its third round, the challenge has narrowed the field from 65 competitors to six semifinalists, including the S.H.O.T. (or selective heat ore treatment) team lead by Tracy Holmes at Jenike & Johanson Ltd. (J&J).

The S.H.O.T. team consists of J&J, Toronto, ON; the University of Nottingham, Nottingham, UK; SGS Canada, Lakefield, ON; and Teledyne Dalsa Inc., Waterloo, ON. The team's microwave technology selectively heats valuable minerals embedded in the host rock using short intense bursts of microwave energy. These bursts establish a sharp, thermal gradient across the mineral-rock interfaces to induce microfractures around the mineral grains, which significantly improve the efficiency of the comminution process. To learn more about the technology and challenge, *Powder and Bulk Engineering* (*PBE*) interviewed Tracy Holmes, president at J&J, and Chris Dodds, associate professor at the University of Nottingham.

PBE: When did work begin on the challenge?

Holmes: J&J's involvement in the project started in 2011, but the University of Nottingham really started the project maybe 25 years ago. It wasn't always called the "Crush It! Challenge," but for this competition, we're taking a piece of an application that had existed and presenting it to the Canadian government in this new context.

PBE: What was the existing application?

Holmes: Initially, the project was funded by the Engineering and Physical Sciences Research Council in the UK and then was supported by industry with companies from all over the world. In 2010, Rio Tinto worked closely with the University of Nottingham to accelerate the project. This led to the creation of the world's largest-ever industrial microwave processing plant. As part of this work, a key scale up barrier was the interaction of microwave energy and material handling. This started the collaboration between the university and J&J in 2011 and, in turn, led to the development of the aforementioned plant, which successfully delivered its objectives around 2015. Since then, the university has been looking to move the work from pilot plant to an operating site and that is the ultimate aim of the Crush it! Challenge.

PBE: How does the S.H.O.T. process work?

Holmes: Imagine that you have a rock with a low percentage of valuable mineral grains inside and you microwave the rock. Ideally, the host rock is transparent to the microwaves while the valuable mineral grains heat rapidly due to a higher electrical conductivity. That exposure heats up the mineral grains and creates thermal expansion at the grain boundary which creates hoop stress around the grain, leading to fractures around the grain margin. If you subsequently put that rock into a traditional crushing system, the rock will require much less energy to crush and the mineral grains are much more easily liberated (and at closer to their native size) because the rock tends to crack from the points of weakness — the pre-formed fractures at the mineral margins.

Liberating the grains at, or near to, their natural size enables separation at a more coarse grind size than the current convention allows. This technology can also reduce subsequent handling issues with tailings, or residue (often a slurry), left over from the flotation process. Tailings are often placed in ponds or dams for storage after processing. Having more coarse particles in the tailings can facilitate the dam building and improve its structure and, thereby, minimize the environmental liability for mining companies.

PBE: Can you share what are the most challenging aspects of the project?

Holmes: An open innovation challenge hinges on finding a mining client with an existing plant that's willing to try something new. That's the biggest risk of this whole project actually. We've shown that the technology works, but that isn't enough. You have to show the technology's value and impact on a company's bottom line because implementating new technology requires capital investment. Therefore, proving the technology to a level of comfort at a scale commensurate with the mining industry and the way it operates is important.

Dodds: Good question. Possibly, needing that really close interaction with end users on specific sites as the way to maximize the value is the most challenging part. This will be different for each site, so to gain the maximum benefits you need to really understand the challenges on the proposed mine sites and flowsheets.

PBE: Can you explain more about why the Canadian mining market is suitable for scaling up this S.H.O.T. technology?

Holmes: We have a technology that's well into being proven for copper ore with current systems able to process on the order of 200 metric t/h. There's an attractiveness to the Canadian mining market, because the market here is primarily higher-value minerals like gold, and those tend to be processed at lower rates, for example 500 metric t/h or maybe 300 metric t/h. These lower rates are much closer to our current throughputs, which can serve to mitigate some of the risk for potential clients and reduce some of the engineering challenges associated with much higher throughputs.

PBE: What are the potential benefits to solving this challenge?

Holmes: The Crush It! Challenge definitively is to build a prototype that will save 20 percent of the comminution energy required for processing minerals. The work that we've done so far has shown in one case a 24 percent reduction in the energy required for comminution and a 30 percent throughput increase. That means we achieved a 130 percent output for 76 percent energy. This isn't the result for every ore, but it is a step-change improvement in efficiency and is good for the environment. For a mining company, the overall cost for the flowsheet and overall financial costs should drop significantly.

PBE: How does your S.H.O.T. technique differ from those you're competing with?

Dodds: This technique enhances the breakage mechanism making it significantly more efficient. It, therefore, has the potential to be the first truly step-change innovation in comminution since the introduction of semi-autogenous grinding (SAG) mills or high-pressure grinding rolls. In regard to the microwave technology used, the University of Nottingham owns the fundamental patents on Microwave Sorting and Microwave Fracture for ores.

PBE: Is there another important aspect to the challenge that we haven't touched on?

Holmes: By 2025, it's estimated that the world will face an 8 percent copper shortage required to meet consumption. We have to find ways of processing ore bodies that are currently economically out of reach, those that are too low grade or too hard, for example. The future of our world and our way of living is somewhat in jeopardy. All of the really easy-to-process high-grade ores have been or are being consumed. It's going to get more difficult to find ores to viably process using the current methods. So not only do we want to save money and be good to the environment, but we're heading into territory where we need new technology to satisfy demand and allow us to process lower grades of ore efficiently just to be able to stay the way we are.

PBE: Why is bulk material handling important for this project?

Holmes: Generally, a lot of the processing in mining is in the area of physical size reduction. Success is very dependent upon bulk material handling: feeding the ore into the various process stages and collecting, transporting, and storing it between them. Applying microwave energy at a very early stage is really going to change the rock. And then we're going to feed the treated rock back into exactly the same system, which may give rise to problems in regard to bulk material handling.

Also, in the microwave application process, you've got to collect the material and divert it from the process it would normally be going through and into the microwave process. The microwave energy needs to be applied in a very consistent, reliable way so the ore feed to the microwave applicator needs to be very precisely controlled. It's critical that the rock moves through at a specific rate; otherwise the treatment can waste energy. **PBE**

References

1. Jack Jeswiet, Alex Szekeres, "Energy Consumption in Mining Comminution," Procedia CIRP, Vol. 48, 2016, pages 140-145.

The Crush It! Challenge six semifinalists were announced in early May at the Canadian Institute of Mining, Metallurgy, and Petroleum convention. Each team will have until November 2020 to produce a functional prototype or model and demonstrate and validate the new clean technology or process solution. More information on the challenge and its impact, along with more information on all the competing teams, is available at https://impact.canada.ca/en/challenges/crush-it.