Microfluidizer® Processor Can Dramatically Improve Mineral Recovery U.S. Department of Energy Study Shows

Ralph Lai, a researcher at the U.S. Department of Energy's Federal Energy Technology Center in Pittsburgh, Pennsylvania, is working on a way to dramatically reduce the amount of time and chemicals required to recover high-grade coal, iron oxide, and copper sulfide from mined ore. Preliminary results, using the Microfluidizer processor, show that this chemical requirement may be able to be cut in half.

Often the ore that comes from the ground contains a very small amount of the mineral (less than 1% in the case of copper) for which the ore is mined. To get from this low level up to a concentration that is useful for industry (35% in the case of copper), some mechanical upgrading process needs to be applied. Such processes can be expensive, time consuming, and call for large physical plants – sometimes on the order of several acres. If savings like those suggested by Lai's research can indeed be achieved on a broad scale, it would vastly reduce the cost of processing. If similar savings could be achieved when extracting other minerals, it could affect the price of almost everything made out of metal.

How the Process Works

Since the early 1900s, the principle way to extract minerals from ore has been to essentially "bubble it out" with detergent. The ore is ground up into particles of less than one millimeter diameter and mixed with water, creating a "slurry." Then a surfactant similar to soap or detergent is added to make the surface of the mineral particles hydrophobic (i.e., dislikes water). Air is forced through the slurry, creating bubbles to which the particles attach. This is evident as a froth of coal or (in the case of copper, iron, or other metals) metallic sulfides or silicates. The loaded bubbles would rise to the surface as froth which is then skimmed off by mechanical skimmers. In the case of coal, the material in the froth would taken away, dried, and eventually burned. In the case of copper, iron ore, or other minerals, the material in the froth is concentrated metals sulfides or oxide, leaving the silicate behind in the skim tank (called a flotation cell).

Lai's work was targeted at improving the efficiency with which the surfactant is able to attach to the particles and to create and stabilize millions of small bubbles. "The key to this research was the use of the Microfluidizer processor to create highly dispersed colloidal suspensions which were then added to slurries to enhance recovery efficiency," Lai says. "Among other things that affect the stickiness of the particles to the bubbles is their surface tension and the uniformity of dispersion of the surfactant in the water. What the Microfluidizer processor allows us to do is to create a highly uniform dispersion of the reagents which then can be introduced into the slurry. We create smaller, more uniform bubbles which do a better job of attaching to particles. The combined effect is to enhance the adsorption of reagents at the particle-water interface and reduce air-water interfacial tension. This is like taking the air out of tires to increase traction. The smaller and more flexible you make the bubbles, the more you increase their surface area, and the better job they do of grabbing particles."

Until now, however, this process has not been inexpensive, due to relatively high level of kinetic energy needed to create the required dispersion — similar to mixing oil and water. Another source of expense is the exotic reagents employed to help the particles stick to the air bubbles. What Lai was looking for in the Microfluidizer Processor was essentially a better mixer — one that could mix the reagents and water with a higher degree of dispersion while requiring less energy than with conventional methods. He also wanted a mixer that could create very small bubbles to which the reagent molecules (and the particle dust) could attach.

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A Better Mixer

"The Microfluidizer processor works on an entirely different principle from the conventional methods used in the application," Lai says. "Typically, those are ultrasound or atomizers. Both of which are very impractical, and (as we show) not particular efficient."

In ultrasound, a piece of metal vibrating at an extremely high frequency is placed in the slurry. Since the amount of slurry that comes into contact (or near contact) with the ultrasound is relatively small, the amount of dispersion that occurs at any one time is limited. Furthermore, the mixing effect is not consistent since some of the slurry is closer to the ultrasound source than other parts. Atomizers are also inefficient. The chemicals must be forced through a small opening and then collected before it can be drained into the flotation cell. While the action of being pushed through the opening creates a fine spray of chemicals, it does not do a good enough hob of producing small bubbles.

By contrast, the Microfluidizer Processor employes shear and impact forces to create a large number of micron size reagent globules in suspension in the water. In the Microfluidizer Processor (Lai uses the Model M-110Y), the chemical and water mixture is forced through a reservoir, divided into two streams within very small microchannels which change direction rapidly and then impinge on each other (with very high energy conversion) within a controlled interaction chamber. Not only does the design produce the requisite chemicals in a very uniform dispersion — but the rate at which processing can occur is also very high. That rate is essentially the rate at which chemical and water mixture can be forced through the machine at its operating pressure. Lai uses 13,000 psi and runs his lab model from a pressurized nitrogen canister.

Lai's efforts to date have focused on coal recovery and cleaning. Specifically, he has demonstrated the ability to recover Upper Freeport coal from Indiana County Pennsylvania using dispersion of MIBC (methylisobutyl carbinol) and Dowfroth 250 (polyglycol ether). Results indicate that a half dosage (0.16 lb/ton) of the colloidal MIBC is almost as effective as a full dosage (0.32 lb/ton) of the "regular" MIBC (i.e., prepared using conventional mixing techniques). Results with Dowfroth were similar.

Encouraged by these results, Lai is currently attempting to repeat his success with other minerals. "It should take less than a year to demonstrate the same process advantage with other minerals as we see for coal," Lai says. "It is not everyday you get to cut the time and expense it takes to process mined minerals."

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