A Bright Future for Ozone in the Mining Industry

Jim Lauria, Mazzei Injector Company

Our society is literally built on a foundation of mined minerals and metals. Every American consumes an average of 24 tons of minerals and metals per year. That figure is likely to increase. The cell phone in your pocket contains as many as 60 different minerals, according to Tony O'Neill of Anglo American PLC. In the 1980s, it took just 11 minerals to manufacture a cell phone.

Let's dig deeper into our metaphor. If we are standing on a growing foundation of mined materials, that foundation is floating on a sea of water, which is integral to every aspect of mining from dust suppression and water management at the mine to wet beneficiation (washing ores and minerals), processing, purification and reclamation.

In fact, water is becoming even more important in mining. Companies are turning to deeper or lower-grade sources—or even tailings—for new feedstocks. They are learning how to process ores more thoroughly for the sake of efficiency and to meet ever-increasing demand for ultra-pure products, and they are finding new ways to comply with environmental regulations that govern extraction as well as process water and produced water.

Meanwhile, the Carbon Disclosure Project notes that 25% of mining production will be exposed to significant water stress such as drought and shortages by 2030. Not only is water in ever-increasing demand in mining, but every drop must also be used and treated thoroughly as water becomes more scarce.

As mining companies face increasing pressure to increase both the efficiency of their water use and the quality of their discharge, water treatment systems are becoming ever more critical.

Ozone Interest Grows

Because metals and many minerals are highly reactive, oxidation is an integral process in treating water throughout the mining and processing cycle. Whether reacting out iron in acid mine drainage, converting toxic cyanide into more benign cyanate in tailwater, or oxidizing organics and polymers during the beneficiation process, oxygen is water's key partner. Of course, oxygen is ubiquitous in the environment, and can be introduced to water through measures ranging from simply stirring a slurry to aggressively injecting highly reactive hydrogen peroxide (H_2O_2) or ozone (O_3).

The best solution depends on a wide range of variables, starting with the basic chemistry of understanding the reactions most likely to impact the targeted material, the physical footprint of the treatment system, how much time is available for the reaction, and how much oxygen is needed to accomplish the goal.

Ozone is gaining recognition as a valuable tool for oxidation reactions in many mining applications. Ozone can function as molecular ozone in direct reactions, or form hydroxyl radicals that fuel powerful, indirect radical chain reactions that rapidly oxidize a wide range of compounds.

"An ozone molecule is kind of like a sniper bullet," says Tony Sacco, managing director of Spartan Environmental Technologies in Beachwood, Ohio. "A hydroxyl radical is more like a shotgun. It will kill everything."

"You usually end up with a two-fer or three-fer with ozone," he adds. "And ozone tends to be a faster-reacting agent than peroxide. Faster is cheaper in that world."

Diverse Uses

Spartan Environmental Technologies has been involved in providing advanced oxidation process (AOP) that pairs ozone with peroxide to remove selenium from coal mine tailings. The company is also working with a mining client to harness the power of ozone to convert cyanide to cyanate in a large-scale gold mining application. Both systems dramatically improve the cost-efficiency and footprint of environmental compliance and could also significantly increase the opportunity to recycle process water.

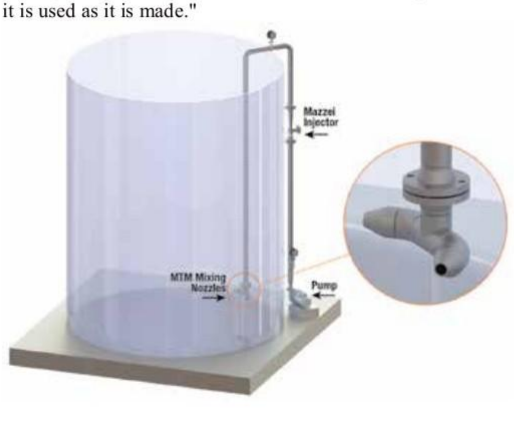
Ozone is familiar to many mining engineers, as it is already widely used in bleaching applications. Ozone attacks chromophores, which are the part of a molecule that gives a compound its color, which makes it an effective and efficient bleaching agent."

Many minerals must undergo thorough processes for use in ultrapure applications like the manufacture of electronics or pharmaceuticals, or the filtration of blood fractionation products. Cleaning silica, diatomaceous earth, or kaolin—a versatile clay molecule used in everything from dishware to glossy paper—starts with a wet beneficiation process, in which the mineral is mixed in water and organic contaminants are floated out. Polymers from the environment or the process itself can get stuck to the minerals. Ozone, with its strong affinity for organic materials, quickly and effectively destroys those contaminants and purifies the minerals.

No Hauling

In addition to its efficacy, ozone offers several other efficiencies that can further improve the environmental footprint of mining operations.

"You can generate ozone from air, so as long as you have electricity, you don't have to haul large volumes of chemicals like peroxide," notes Sacco. "Peroxide is at least half water—depending on the formulation, as much as 70%. Transporting all this water long distances may not be a good option. And if you store large quantities of hydrogen peroxide on-site, you can raise permitting issues. Just holding chemicals creates a liability. Because it is made on site there is no storage of ozone, it is used as it is made."



Effective injection and thorough mixing are vital to ensuring the effectiveness of ozonation or AOP. Pumping ozone through bubble diffusers or other bulk transfer mechanisms can be effective, but energy intensive. Spartan and others in a wide range of ozone applications have found that water treatment systems that run a portion of their volume through venturi injectors, whose shape creates a vacuum in the flowing liquid that draws in ozone without requiring additional pumping,

Oxidant	Electrochemical potential, volts (@ 25° C)
Fluorine	3.03
Hydroxyl radical	2.80
Atomic oxygen	2.42
Ozone	2.07
Hydrogen peroxide	1.78
Perhydroxyl radical	1.70
Permanganate	1.68
Chlorine dioxide	1.57
Hypochlorous acid	1.49
Chlorine	1.36
Bromine	1.09
Iodine	0.54

Ozone and its hydroxyl radicals are among the most powerful oxidants.

In short, ozone is the high-powered oxidizing option in many situations. An ozone molecule has a redox potential of 2.07, while a hydroxyl radical's redox potential is 2.87, second only to flourine, whose redox potential is just 0.01 unit higher. By contrast, the redox potential of hydrogen peroxide is 1.78 and chlorine's is 1.36.

demand almost no maintenance. The ozonated side stream is then mixed with the main flow in a Pipeline Flash Reactor (PFR), which uses specially engineered nozzles to achieve thorough mixing in a matter of a few feet of pipe rather than a large tank or reactor.

Ozone has already proven its value and efficiency in a wide range of municipal and industrial applications around the world. It appears that mining is turning up the next set of golden opportunities for ozone—and, in turn, helping improve the environmental footprint of one of the world's most essential industries.

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