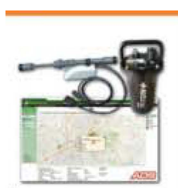
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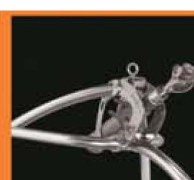
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Embracing the Unconventional

Technologies exist to economically treat any strength of acid mine drainage for industrial reuse.

by Jeff Easton & Jim Woods

Reclamation & reuse of unconventional wastewater sources has increased

Water is required in almost every industrial sector for the processing and manufacturing of products. In 2015, it is estimated that industrial raw water consumption within the U.S. will exceed 2 million mega-liters (500 billion gal) per day. Sources of high-quality raw water for commercial plants are becoming progressively scarce. The availability of water from rivers and lakes is not only diminishing, but what is available is increasingly regulated by federal, state and local mandates. This has made industrial water recycling a high-profile concern.

Use of recycled water by industry has increased substantially due to increases in regulation and the cost of drinking water, and recurring water shortages, which can impact business operations. Cooling water systems, particularly at power plants and oil refineries, are the largest industrial consumers of recycled water due to the high-volume water demand in their cooling towers and boilers. Other industrial applications for recycled water include oil and gas drilling, petroleum refining, chemical plants, metal finishers, textile and carpet dying, paper manufacturing, cement manufacturers, and other cooling and process applications.

Many companies have spotted the risk that growing water constraints could place on their operations, and recognize the need to consider unconventional sources of water. The technology, chemistry and processes exist today to feasibly and economically integrate water reuse from unconventional sources into almost any industrial process application.

Unconventional water sources can originate from wastewater treatment plant sewage effluent, brackish surface and well water, mine pool water and acid mine drainage (AMD), and hydraulic fracturing flowback and produced water.

These water sources may contain varying levels of contaminants, suspended solids, oils and greases, colloidal silica and metals, and dissolved minerals and organics. Because every industrial application requires a different level of finished water quality, understanding the condition of the source water and the finished water quality requirements determines the processes and equipment needed. For most industrial uses of reclaimed water, conventional processes involve secondary treatment, filtration and disinfection steps. Most applications will require multiple processes to achieve the desired finished water quality.

Wastewater treatment plant sewage effluent can be a viable unconventional water source.

Municipal Wastewater Reuse

Recycled municipal wastewater can be used for a broad range of reuse applications, short of direct drinking water and food and beverage manufacturing. Besides traditional uses such as industrial processes and irrigation, some states add recycled water to underground storage basins used as drinking water supplies.

Water recycling is especially important in arid climates. The Sanitation Districts of Los Angeles County operate the largest engineered wastewater recycling program in the world. The sanitation districts' goal is to recycle as much water as possible from their 10 water reclamation plants (WRPs). The WRPs play a major role in meeting Southern California's water needs, providing primary, secondary and tertiary treatment for approximately 510 million gal per day (mgd), 165 mgd of which are available for reuse. The recycled water is used at more than 720 sites for a variety of industrial and commercial purposes. This recycling significantly reduces the Los Angeles Basin's dependence on costly imported water and helps replenish a large percentage of the groundwater used by the region.

An example of using recycled municipal wastewater for power generation is the Fox Energy Center, located in Wrightstown, Wis., a natural gas-fueled electric generating unit that produces electricity for Wisconsin Public Service customers. The power plant features two General Electric combustion turbine generators fueled by natural gas that are cooled by a cooling tower, which uses recycled water from a nearby sewage treatment facility. The plant uses 4,600 gal per minute (gpm) of sewage effluent as makeup water.

Utilizing Mine Pool/AMD Water

Almost 90% of the country's electricity is generated at power plants using steam-based systems, which use water for cooling to condense the steam. Water usage occurs through once-through cooling, or as makeup water in a closed-cycle system, generally involving one or more cooling towers.

New or expanded steam electric power plants frequently need to turn to alternate sources of water for cooling. One alternate water source is groundwater collected in underground pools associated with coal mines, known as mine pool water. When this water flows from the mine to the surface, it is known as AMD, which contains multiple combinations of acidity and metals. These marginal-quality mine pool waters and AMD streams are becoming more attractive for reclamation and reuse. From a cooling perspective, they are desirable because of their relatively consistent and low temperatures year round.

Implementing sustainable and financially viable methods to reuse vast quantities of mine pool/AMD water is an area of growing interest for mining operations. The technologies exist to economically treat any strength of AMD for industrial reuse. Recent technological refinements in treatment processes are making these systems more streamlined and efficient, enabling full-scale mine pool water/AMD reuse projects to control, manage and reuse these contaminated waters.

A coal-fired power plant in West Virginia contracted to access wastewater from a large mine pool water/AMD reservoir at an abandoned coal mine. In addition to other processes, the plant utilized surface aeration to treat the water prior to decanting to the power plant. Consuming 3,000 gpm, the entire reservoir was eventually depleted, at which point the coal mine went back into operation, and now produces coal for the power plant. An advanced surface aeration process was critical in facilitating an economically feasible solution for wastewater treatment.

With this surface aerator technology, new impeller designs increase oxygen transfer efficiency and reduce axial and radial loads, saving significant operational costs, increasing the life of the drive unit and reducing the size of support structures and beams for the surface aerators. Systems like these are making AMD reuse more accessible for mining operations, which require systems to be financially feasible and capable of efficiently handling wastewater streams at remote locations, usually within a confined footprint.

Hydraulic Fracturing Water Sources

The U.S. has vast reserves of oil and natural gas that are commercially reachable as a result of advances in horizontal drilling and hydraulic fracturing technologies. But as the number of hydraulic fracturing wells in operation increases, so does the stress on surface water and groundwater supplies from the withdrawal of large volumes used in the process.

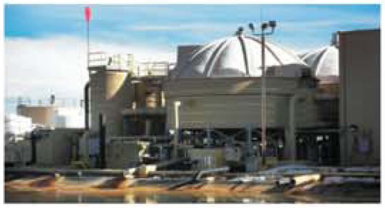
Advanced surface aeration processes applied to AMD

Equally important is the growing volume of wastewater generated from fracturing wells. The fracturing process pushes water down into the rock formation, wedging the rock cracks open. The sand fills in between the cracks. Once the fracturing is done, much of the water comes back up the well as flowback wastewater. Up to 60% of the water injected into a wellhead during the fracturing process will discharge back out of the well shortly thereafter. For the life of the wellhead, it will discharge up to 100,000 gal per day of produced wastewater.

Wastewater associated with shale oil and gas extraction can contain high levels of total dissolved solids (TDS), fracturing fluid additives, total suspended solids, hardness compounds, metals, oil and gas, bacteria and bacteria disinfection agents, and naturally occurring radioactive materials. These contaminants are partially a combination of chemicals and agents inserted deep into the well (9,000 ft and deeper), which modify the water chemistry to increase viscosity, carry more sand and improve conductivity.

Freshwater and wastewater operating procedures are experiencing increasingly stiffer governmental regulations on water availability and disposal limitations. These factors are prompting oil and gas executives to reassess their current water utilization activities regarding fracturing, and adopt a more unified and longer-range perspective on water lifecycle management.

Wellhead recycling. Some drilling operators elect to reuse a portion of the wastewater to replace and/or supplement freshwater in formulating fracturing fluid. Reuse of shale oil and gas wastewater is, in part, dependent on the levels of pollutants in the wastewater and the proximity of other fracturing sites that might reuse the wastewater.



Centralized wastewater treatment for handling flowback and produced wastewater in hydraulic fracturing

Mobile solutions to treat wastewater at the wellhead enable recycling and reuse of flowback without the need to store wastewater in surface ponds on site or truck it for offsite disposal. These solutions, however, do not provide continuous processing to handle produced wastewater. Because produced wastewater represents 95% or more of the wastewater generated during the lifecycle of a well, mobile processing systems do not solve the long-term problems of diminished water sourcing.

Brackish surface and well water. Brackish water refers to water supplies that are more saline than freshwater, but much less salty than seawater. The level of salinity is measured in TDS. In hydraulic fracturing, saline water is introduced into the process by contacting brackish aquifers.

The two most common desalination technologies are membrane and thermal processes. Reverse osmosis (RO) is currently the most common desalination treatment method. In an RO system, the greater the TDS concentration of the water, the higher the pressure needed for the pumps to push water through the membranes, and consequently, the higher the energy costs.

Mine pool water/AMD. In 2013, the Pennsylvania Department of Environmental Protection issued new policies that support using mine pool water/AMD as a source of water for hydraulic fracturing. Hydraulic fracturing uses millions of gallons of water to create microscopic fissures in dense shale formations, allowing the hydrocarbons to flow freely from the formation and into the well bore.

Many current Marcellus Shale oil and gas hydraulic fracturing wells are in close proximity to mine pool water/AMD areas, creating an opportunity to beneficially use these wastewater sites for hydraulic fracturing. According to a 2013 Duke University-led study, much of the naturally occurring radioactivity (radium and barium) in fracturing wastewater might be removed by blending it with wastewater from mine pool water/AMD. Blending can bind some fracturing contaminants into solids that can then be removed before the water is discharged back into waterways.

Centralized handling of flowback and produced wastewater. Centralized treatment of wastewater has emerged as a viable solution for long-term efficiency in managing water sourcing and wastewater treatment in hydraulic fracturing. Centralized treatment facilities handle both the flowback wastewater and produced wastewater from oil and gas wells within a region, at a radius of 40 to 50 miles. Pipeline connects all wellheads directly with the central treatment plant.

Such centralized plants can be integrated with alternative sources of water to supplement freshwater needs for fracking, such as abandoned mines, storm water control basins, municipal treatment plant effluent and power plant cooling water. Centralized water management allows wastewater sourcing to be implemented on an economy of scale that has not before been realized in the shale oil and gas production industry. **wwd**

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