Washing-machine science helps recover coal from slurry ponds

By Lynn Nystrom, College of Engineering

These Microcel units are used for cleaning freshly mined coal at large mines in Australia.

Appalachia is full of coal impoundments – places where water-soaked ultrafine coal is discarded. A key decision made by mining executives has emptied one such pond near the small town of Carbo in Southwest Virginia, and turned a whopping $50 million profit. The up-front investment, by comparison, was minimal. They paid roughly $1.5 million for the entire project, including a specific type of separation technology that enabled the recovery of the fine coal from the pond.

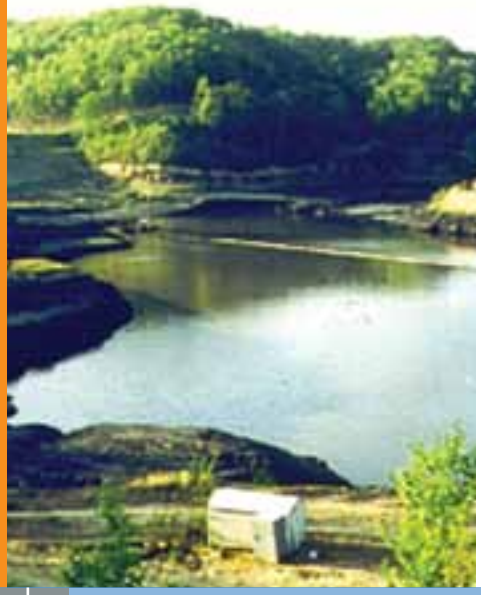
How to separate ultrafine coal particles from clay and water during a cleaning operation is a problem the industry has faced for decades. A recent study conducted by the National Research Council under congressional mandate reports some 70 to 90 million tons of fine coal are being discarded to coal slurry impoundments annually by the U.S. coal industry.

When the coal company that owned the property took the risk and implemented the clean-up project, it also regained the use of the land where the impoundment existed – a piece of real estate now worth several million dollars. And they restored the environment.

Much of the credit for this particular achievement and several others in fine coal recovery and the associated environmental benefits goes to decades of work led by Roe-Hoan Yoon of Virginia Tech, a member of the National Academy of Engineering. Since the 1980s, he and his colleagues have developed four different advanced separation processes for the mining industry: Microcel flotation technology, dewatering aids, a hyperbaric centrifuge, and another novel process for which the patent is pending.

"For the first time in the history of coal mining, the industry can now recover much of the fine coal that has previously gone to waste due to the lack of appropriate separation technologies," Yoon asserts.

The ability to capture and dewater fine coal also means less coal will be placed into slurry ponds. The suite of new advanced technologies is becoming available at a time when the public is becoming more conscious of environmental impacts of the energy industry, particularly in light of the severely damaged Japanese nuclear reactors after the March 2011 tsunami.



A Microcel flotation column collects fine coal on the surface of microbubbles while impurities are rejected from the bottom of the column.

'This was a missing link, and we took this on as a challenge.'
- Roe-Hoan Yoon

Cleaning with bubbles

For Yoon, his life's work started after he learned in a high school chemistry class how detergents remove dirt from clothes. He was hooked on the "why factor." From this teenager's fascination with bubbles came the use of microbubbles to clean coal better. He secured research funding from the U.S. Department of Energy and Virginia's Center for Innovative Technology (CIT) in the 1980s to develop and patent the microbubble flotation process. His research group at Virginia Tech eventually proved the utility of this process at a commercial scale.

"The whole purpose of cleaning coal is to reduce the ash content so that the users, usually utility companies, don't have to deal with it," said Gerald H. Luttrell, the Massey Professor of Mining and Mineral Engineering at Virginia Tech. "The lower-ash and lower-moisture coals also produce less carbon dioxide (CO_2) to clean up. They burn more efficiently and thus require less coal to generate a given amount of electricity."

Yoon's primary collaborators in the 1980s remain his colleagues today. Luttrell was his Ph.D. student. Greg Adel, faculty colleague for almost 30 years, is the mining and minerals engineering department head. They studied the collision between bubbles and particles in water and they sent highly trained graduates out into the professional world as ambassadors of clean coal technologies.

The microbubble flotation technology is being marketed under the trade name Microcel. In 1990, a license agreement was signed with the CIT to commercialize the new technology.

Getting any newly developed technology into the marketplace is always a challenge, but today, Eriez and Metso Minerals, two of the world's leading manufacturers of flotation columns, have licenses to market the Microcel technology to coal and mineral industries. The technology is popular among coal and mineral companies, including BHP Mitsui Coal Pty Ltd., Australia's largest coal producer, and the world's largest supplier to the seaborne coking coal market.

Eriez employs three Virginia Tech graduates who received their Ph.D.s while working on flotation as part of their thesis work. The expertise and scientific background they acquired during their studies at Tech were instrumental in bringing the Microcel technology to the marketplace. Mike Mankosa, a 1983 Ph.D. graduate of the mining engineering program, is now vice president of operations at Eriez, and is a past recipient of the mining and minerals engineering department's Outstanding Alumni Award for his achievements.

Dewatering – the missing link

During the past 15 years or more, Yoon and his colleagues have been developing advanced technologies to aid in the coal dewatering process. "This was a missing link, and we took this on as a challenge," Yoon explains.

As the coal fines are cleaned, whether with the Microcel technology or another method, the clean coal product becomes wet. It is necessary to remove the water before shipping and utilization. One of the advanced dewatering technologies

Decanter Machine Inc. of Johnson City, Tenn., produced the Centribaric system, which dewaters fine coal.

developed at Virginia Tech involves using specialty chemicals that can be added to various vacuum or pressure filters. This process is now licensed to Nalco, a $3.5 billion company, for worldwide distribution. Steve Abbatello, a 1982 graduate of the mining department, is responsible for this activity as the strategic business unit leader of Nalco's Global Mining and Metals Division.

To facilitate the marketing and sales of the specialty chemicals, Nalco opened a laboratory at the Virginia Tech Corporate Research Center and hired two of Yoon's former Ph.D. students. "Industry needs the high-tech trainee to understand the value of the technology and to transfer it properly to the industry," Luttrell says.

Recovering fine coal – a long time coming

Microcel technology also played a role in the next commercial success of the Center for Advanced Separation Technology (CAST), a multi-university consortium directed by Yoon. Recovering coal shards that are talcum-powder fine has been a passion for Yoon for many years. An estimated 2.5 billion tons of fine coal resides in ponds throughout Appalachia – a wasted resource. But he has been bothered even more by the threat to the environment and the quality of life in these beautiful mountains.

For eight years, CAST and the Office of Fossil Energy's National Energy Technology Laboratory collaborated on a project to remove water from fine coal slurries. One of the more recent developments is the hyperbaric centrifugal filtration process, marketed by Decanter Machine Inc. (DMI) of Johnson City, Tenn., under the trade name Centrabaric centrifuge.

"The hyperbaric centrifuge is like the spin cycle on a washing machine, with the addition of compressed air. Combining increased spinning and compressed air has a synergistic effect and cuts the moisture in half compared to conventional technology," says Yoon.

"There has been no technology to economically dewater coal fines below 44 microns," says Yoon. "Now this technology can be used to re-mine the fine coal discarded to impoundments and to help companies minimize waste generation.

"For me, that is a great accomplishment," says Yoon. "People living in coal mining districts will see fewer and smaller slurry ponds. We have done something for the industry and for the public."

The U.S. Department of Energy (DOE) supported this research at Virginia Tech, during the course of which DMI built a prototype unit as part of its cost-sharing commitment to the DOE project. The test results obtained in several different operating plants with this prototype were outstanding, Yoon says.

Encouraged by these results, DMI constructed a full-scale commercial unit and tested it at Jim Walter Resources of Brookwood, Ala., for nearly a year. As a result of the successful long-term test results, the Alabama coal company has installed nine of these units and is now recovering the ultrafine coal that used to be discarded to waste impoundments, and creating additional revenues.

Joel Franklin of Jim Walter Resources presented a paper describing the company's experience with the installation of the hyperbaric centrifuges at the 2011 International Coal Preparation Congress in Lexington, Ky.

"This success story will be an encouragement for other companies to follow suit," says Yoon.

Pinnacle was able to remine and empty its impoundment, thanks to the centrifuge developed by Roe-Hoan Yoon and his research team.