ALCOA, INC. (D469-1)

In aluminum rolling mill operations like this one, Alcoa, Inc., tested ARS's new biobased metalworking fluid and preferred it to the petroleum-based lubricants.

Biodegradable Lube for Metal-working Operations

PEGGY GREB (K9006-1)

A new metalworking fluid derived from soybean oil rather than petroleum is proving a smashing success in trial runs by Alcoa, Inc., a global supplier of primary and fabricated aluminum products.

The Pittsburgh, Pennsylvania-based company is conducting the tests under a cooperative research and development agreement with ARS's National Center for Agricultural Utilization Research, in Peoria, Illinois.

The partnership began in 2001 when, citing supply and other considerations, Alcoa technical consultant Ronald A. Reich informed ARS chemist Girma G. Biresaw of the company's interest in switching from petroleum-based metalworking fluids to biobased ones. Alcoa uses the lubricants for its hot and cold flat-rolling operations, which produce aluminum sheets for everything from beer cans to aircraft-wing panels.

"We originally thought it would be several years before we could make these biobased fluids cost-effective," says Reich. "Turns out, the cost will either be even or about half as much as what we're now paying."

Biresaw, a former Alcoa scientist now with the ARS center's Cereal Products and Food Science Research Unit, suggested contacting ARS supervisory chemist Sevim Erhan. Her research specialty is turning edible vegetable oils into new, valued-added industrial products, such as biodegradable printing inks, lubricants, greases, and specialty additives.

Erhan recalls Reich's specifications for the ideal aluminum-rolling fluid: "It had to readily break down in the environment; it had to come from a renewable resource; the process for making the biofluid had to be economical and be nonpolluting; and it had to meet all industry standards for safety and performance."

The first step for Erhan's team, comprising Biresaw and post-doctorate scientists Atanu Adhvaryu and Brajendra K. Sharma, was to examine the chemical structures that give synthetic metalworking fluids their functional properties. From this, they created two soy-based formulations, using either a chemical or heat treatment to impart the desired properties, such as viscosity and pour point.

"Vegetable oils as lubricants are not new, but they oxidize too easily," says Erhan, who leads the center's Food and Industrial Oils Research Unit. "The biobased oils we provided to Alcoa were processed to resist oxidation. We did this by reducing double bonds in the structure along with adding suitable antioxidants for stability."

Why soy, though?

Second only to corn as America's most widely grown crop, soy is the nation's leading source of food-grade oil. It is a plentiful and renewable alternative to petroleum, a fossil fuel from which mineral oil is derived for use in many current metalworking fluids.

Using data furnished by Erhan's team as well as its own evaluations, Alcoa formulated different soy-based lubricants and chose the most promising. Alcoa then contracted out for a 150-gallon sample to be made for testing, starting in October 2004, at its aluminum-casting plant in Reno, Nevada. The tests included environmental sampling by two other collaborators, director Thomas L. Theis and graduate student Shelie Miller, both in the Institute for Environmental Science and Policy, University of Illinois-Chicago.

"At the Reno site," says Reich, "the test sample performed better than our best technology. In fact, the operators immediately threw out their existing lubricants and replaced them with the biobased one."

In aluminum-rolling mills, the fluid's chief function is to keep the metal—and the heavy steel rolls used to flatten it—from welding together. The fluids further ensure product quality by dispersing heat and filtering out surface debris.

In a single day, Reich estimates, an Alcoa mill may replace 500 gallons of petroleum-based fluid—most of which escapes into the air as fumes containing volatile organic compounds (VOCs). Cutting down on VOC emissions is a driving force behind the company's decision to use biobased products. "We are also under pressure from corporate headquarters and environmental groups to lower our VOCs by 50 percent by 2012," Reich says.

Air monitoring at the Reno plant indicates this may be possible using soybased fluids, he reports. Another benefit is less worker exposure to synthetic fluids and chemical additives they may contain, such as biocides and corrosion inhibitors.

Respiratory conditions, like chronic bronchitis, and skin irritations, such as rashes, are among potential health problems cited by the National Institute for Occupational Safety and Health. According to its website, "Some 1.2 million workers in machine finishing, machine tooling, and other metalworking and metal-forming operations are potentially exposed."

"When you talk about metalworking, you're talking about everything from drilling holes and grinding, to forging and stamping—a multitude of processes with different temperatures, speeds, forces, and lubrication requirements," notes Biresaw. His current research focus is to use predictive modeling to guide development of biobased lubricants that will work best for specific metalworking applications and alloys.

By one estimate, U.S. consumption of industrial lubricants—which includes metalworking fluids—will reach 7.5 billion gallons by 2008. Petroleum's increasing cost and diminishing supply could force the metalworking industry to seek renewable alternatives, especially in the form of home-grown crops like soybean.

Reich hopes success stories like the one in Reno will create a ripple effect among Alcoa's global rolling community. Indeed, also successful was a large-scale trial of the soy-based fluid this past December using a reversing-mill process at Alcoa's Lancaster, Pennsylvania, plant. A third trial is planned for a mill in Melbourne, Australia.—By **Jan Suszkiw,** ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS National Program (#306) described on the World Wide Web at www.nps.ars.usda.gov.

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