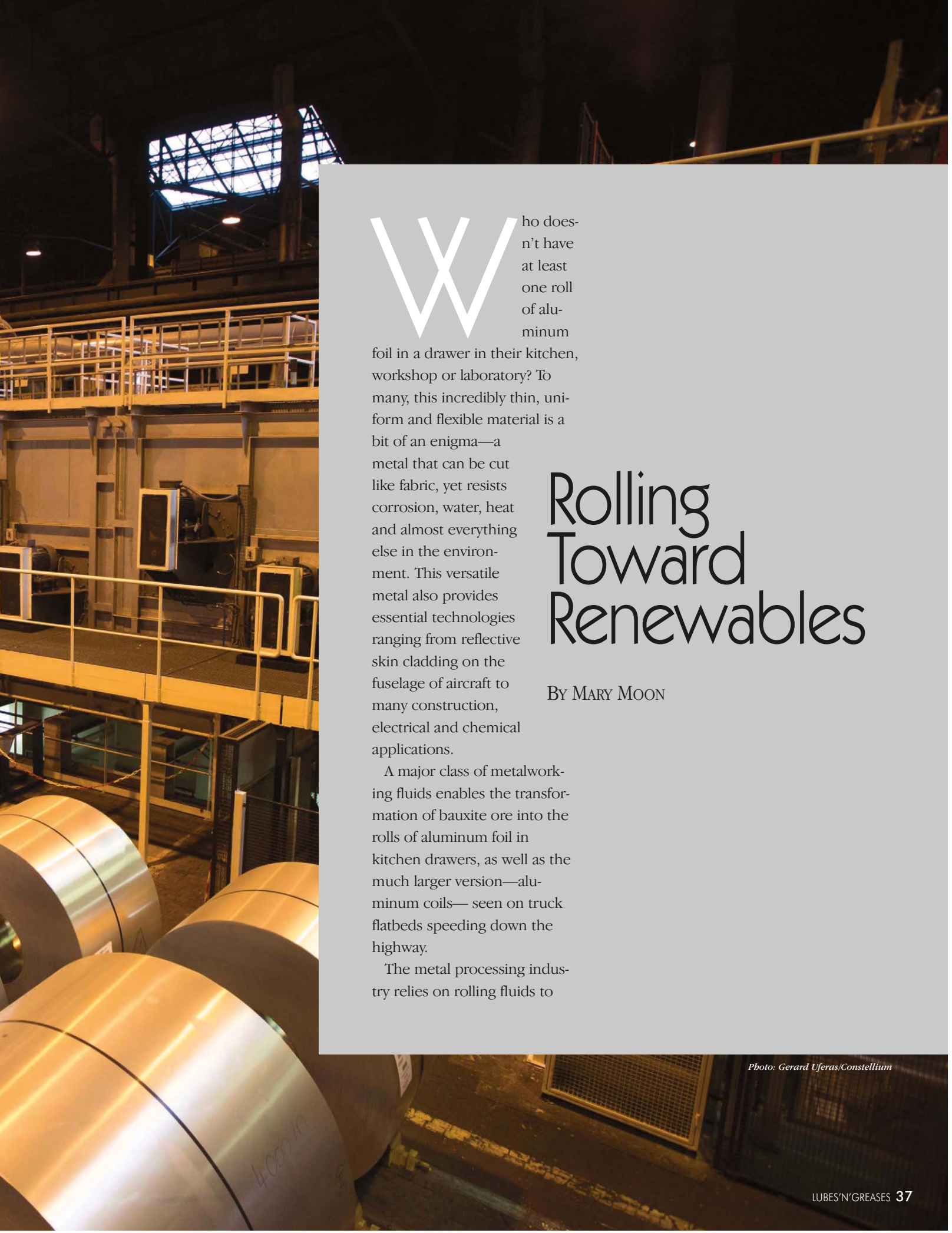


Rolling Toward Renewables

By Mary Moon

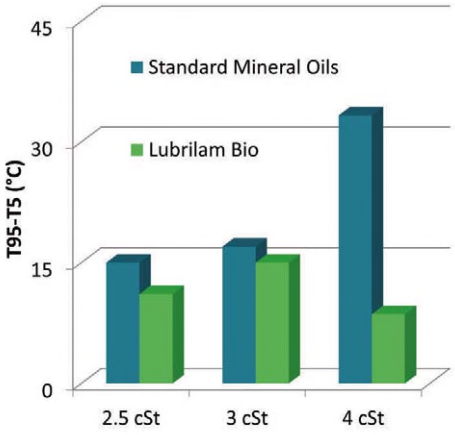
Who doesn't have at least one roll of aluminum foil in a drawer in their kitchen, workshop or laboratory? To many, this incredibly thin, uniform and flexible material is a bit of an enigma—a metal that can be cut like fabric, yet resists corrosion, water, heat and almost everything else in the environment. This versatile metal also provides essential technologies ranging from reflective skin cladding on the fuselage of aircraft to many construction, electrical and chemical applications.

A major class of metalworking fluids enables the transformation of bauxite ore into the rolls of aluminum foil in kitchen drawers, as well as the much larger version—aluminum coils— seen on truck flatbeds speeding down the highway.

The metal processing industry relies on rolling fluids to

Photo: Gerard Uferas/Constellium

Distillation range
ASTM D86



Source for all: Total Fluides

manufacture foils and sheets of aluminum and its alloys. For decades, cold rolling fluids have been formulated from highly refined petroleum base oils (and sometimes water-based emulsions), along with select additives to improve load bearing capacity, reduce friction, improve wetting and provide corrosion and oxidation resistance, among other properties. The current generation of commercial rolling fluids was developed to enhance metal surface quality and mill productivity.

Today, biobased oils from renewable sources offer potential environmental and technical advantages over traditional mineral oils for rolling applications. In the laboratory, manufacturer Total Fluides, part of France's Total, has found that bio-sourced isoparaffins—derived from hydrogenated vegetable oils—show greater thermal conductivity and heat transfer rates than comparable mineral oils, suggesting greater capacity to cool rolls in mills.

Turning Down the Heat

Rolling fluids must perform under challenging conditions of high heat and high pressure.

For aluminum and its many alloys, production begins with a process called annealing, in which ingots are heated above the recrystallization temperature of the metal (around 500 degrees Celsius). During annealing, atoms of alloying elements such as chromium, manganese and magnesium re-distribute themselves in the matrix of aluminum atoms. This removes imperfections in the grain structure, improving the homogeneity of the microstructure. The ingots are then hot rolled, passing between rollers to reduce their thickness. After the metal cools, it is cold milled, or repeatedly rolled to increase its strength and further reduce its gauge.

Rolling fluids are sprayed onto rollers to reduce friction as metal is processed under applied pressure at speeds up to hundreds of meters per minute. These lubricants also help ensure efficient reduction of metal thickness in the minimum number of passes. The fluids are relatively light to enhance the surface finish of the product and facilitate filtration to remove contaminants that can damage metal surfaces.

Alois Joassard, a product manager in the metalworking department at Total, is challenging the status quo of using light mineral oils to formulate cold rolling fluids for aluminum. During the Society of Tribologists and Lubrication Engineers' late spring meeting in Las Vegas, Joassard described new bio-sourced isoparaffins derived from plant sources that show promise for use as base oils in such formulations.

The Nanterre, France-based company has developed three grades of these renewable base stocks, with viscosities of 2.5 centiStokes, 3 cSt and 4 cSt at 40 C. Joassard compared means of producing the isoparaffins, which are branched hydrocarbon molecules, with traditional production of normal paraffins from petroleum, which are linear and unbranched.

In the manufacturing process for standard mineral base oils, conventional refineries treat crude oil to remove sulfur-containing molecules, hydrogenate aromatic molecules and distill separate grades or cuts of normal and isoparaffins with well-defined carbon

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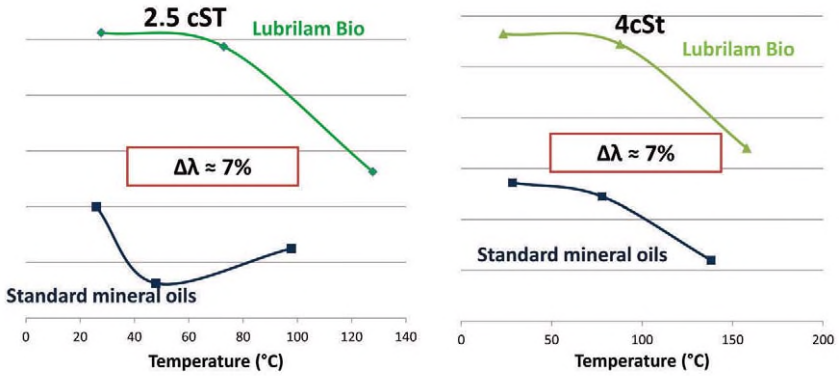
Thermal conductivity [W/(m.K)]
Total Internal Method



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backbone lengths.

In contrast, Total's new manufacturing process transforms renewable feedstock obtained from crude palm oil into highly purified isoparaffins. From there, a patented process called hydro de-aromatization (HDA) under high pressure allows reduction of the total aromatic content to less than 50 ppm and suppresses traces of polyaromatics, Joassard told the STLE audience. Naphthalene content is reduced below 5 ppm.

The selection of hydrogenated vegetable oil feedstock provides a stable repartition of molecules, Joassard explained, giving enhanced stability and performance to the final rolling oils. Narrow-cut distillations are key to controlling evaporation losses and viscosity variations during rolling.

Sheets of Green

Total's biobased rolling oils, marketed as Lubrilam Bio, are made up of more than 95 percent biobased carbon content. The company says its colorless, odorless products meet several European standards, including classification as readily biodegradable under OECD guidelines. The HDA process and narrow cut distillations also allow the fluids to pass the purity requirement of the European Pharmacopoeia standards for use in manufacturing medicines.

To address increasing concerns about the role of palm oil in climate change, Total sought feedstock that is certified in accordance with International Sustainability and Carbon Certification, as well as the Roundtable on Sustainable Palm Oil scheme. Joassard noted this type of feedstock is available on an industrial scale. A life cycle analysis using the ISO 14040 method found that production of the biobased feedstock emitted 400 percent less greenhouse gases than a standard mineral oil product. Production of the oils themselves uses 80 percent less energy.

In contrast with general perception of biobased lubricants, Joassard pointed out that his company's product boasts higher performance than traditional rolling oils. Laboratory tests using the standard ASTM flash point method (ASTM D93) showed the three grades of Lubrilam Bio had flash points significantly higher than standard mineral oils of equivalent viscosity. Joassard explained that it would be possible to

switch from 3 cSt mineral oil to 2.5 cSt Lubrilam Bio oil without increasing risks associated with fire and flammability. Lower viscosity oils are easier to filter and tend to enhance the surface finish of metal, he said.

Likewise, pour points of the biobased oils were substantially lower than their mineral oil-sourced counterparts. Lower pour points are an advantage for storage and end-use applications at lower temperatures.

Distillation range, tested with the ASTM D86 method, refers to the temperature range at which a group of liquids boils at a given pressure. For applications in rolling fluids, base oils with a narrow distillation range are preferred because there is less evaporation during service and less risk of staining metal. Joassard's data showed that distillation ranges for the biobased products were narrower than for standard mineral oils. He explained that this should give the product better viscosity control and stability during rolling.

Joassard later told *Lubes'n'Greases* that he was most surprised by the improved heat transfer capacities of the new oils. Thermal conductivity was measured with an in-house method. For the 2.5 cSt and 4 cSt grades, Lubrilam Bio had 7 percent higher thermal conductivity relative to standard mineral oils. Likewise, specific heats between 0 C and 90 C were 11 percent higher for the biobased oils versus standard mineral oils.

Higher thermal conductivity is an important advantage for rolling fluids because it provides better capacity for cooling the working rolls during milling. Better cooling delays or reduces flattening of rollers as well as heat wrinkles in the rolled metal.

"My work offers new perspectives to aluminum rolling companies," Joassard summarized. "These new oils could improve productivity, but also safety, while being better for the environment, as the CO_2 footprint is strongly decreased compared to mineral oils."

Encouraged by the laboratory study results, Joassard's next challenge is conducting field tests. Once the oils have proved their mettle, he hopes that Lubrilam Bio will further advance productivity in the aluminum rolling industry while helping to meet environmental goals. ▮

Mary Moon, Ph.D., is a physical chemist with hands-on R&D and management experience in the lubricating oil and grease and specialty chemicals industries. She is skilled in industrial applications of tribology, electrochemistry and spectroscopy. She has been an officer and active member of the Philadelphia section of STLE. Contact her at mmmoon@ix.netcom.com or (267) 567-7234.