➤BY SUSAN WOODS, FEATURES EDITOR

Vegetable oil-based metalworking fluids can provide better performance and environmental results than mineral oil-based fluids.

Going Green

Interest in vegetable oil-based metalworking fluids is growing.

"People are interested in protecting the environment, protecting the health and safety of their employees, and supporting the U.S. economy and making us less dependant on foreign oil," said Gene Tripp, product manager for metalworking fluids at Environmental Lubricants Manufacturing Inc., Plainfield, Iowa.

The application of vegetable oil MWFs may be driven by environmental and safety issues, but the performance results are what keep shops using them. Among them are improved surface finish and longer tool life.

Sources of seeds used for vegetable oils for MWFs include soybean and rapeseed, or canola, among others. As with other MWFs, vegetable oil-based products fall into one of four classes:

- Straight oils, which are not mixed with water and are used more for lubrication than cooling.
- Soluble oils, which are high-oil content products that form an emulsion when mixed with water and are used for cooling and lubrication.
- Semisynthetic fluids, which are low-oil-content fluids that are a combination of the best properties of synthetics and soluble oils.
- Synthetic fluids, which contain no oil and are true solutions of water-soluble materials that cool and lubricate.

"Some people might call products made with vegetable oil-based materials totally synthetic, even though they are emulsions," said Jerry Byers, manager of research and development, Milacron Inc., Cincinnati. "Mostly, we think of synthetics as being completely water-soluble, but you could have an emulsion of water-insoluble synthetic ingredients. Some people refer to certain vegetable oil-derived products made into a very microfine emulsion as a synthetic."

Better Performance

Vegetable oil-based MWFs can be used in the same operations as mineral-based, or petroleum-based, fluids. However, compared to mineral oil, vegetable oil can enhance cutting performance, extend tool life and improve part surface finish. The environmental benefits, though important, are secondary.

"Of the two soybean oils we use, the surface finish is much improved over regular oil and tool chatter is reduced," said Greg Helton, advanced development program machinist at Goodrich Turbine Fuel Technologies, West Des Moines, Iowa.

Lyle Michael, president and owner of Hawkeye Tool & Die Inc., Jesup, Iowa, said his shop had been using a semisynthetic coolant but noticed a change with vegetable oil. "There is a distinct difference in machinability," he said. "It machines parts better and faster and adds tool life."

One reason vegetable oil performs better is its lubricity. Vegetable oil carries a slight polar charge. This charge draws the vegetable oil molecule to a metallic surface and is tenacious enough to resist being easily wiped off. Mineral oil has no charge and, therefore, adheres less tightly to a metal surface.

"A mineral oil is just a straight hydrocarbon," said Byers. "A vegetable oil has some functional groups containing oxygen, which makes it more attractive to the metal surface and it bonds more tightly. Therefore, it makes a better lubricant."

Another reason vegetable oil performs better than mineral oil is that it has a higher flash point, which reduces smoke formation and the risk of fire. According to Helton, the soybean oil his company uses has a flash point of 450° F compared to a flash point of about 235° F for the mineral oil it used previously.

He said: "The smoking is almost nonexistent. The flash point is a couple of hundred degrees higher than any cutting oil we have used in the past. That is one reason you don't have as much smoke. I'm not saying it won't catch on fire, but it hasn't so far."

ELM

A bandsaw cuts tubular steel using SoyEasy-Cool.

A third reason vegetable oil performs better is that it has a high natural viscosity. When the machining temperature increases, the viscosity of vegetable oil drops more slowly than that of mineral oil. Conversely, as the temperature falls, vegetable oil remains more fluid than mineral oil, facilitating quicker drainage from chips and workpieces. The higher viscosity index of vegetable oil ensures that it will provide more stable lubricity across the operating temperature range.

The high viscosity also means that vegetable oil can be used as a lubricant for the guide ways and gears in machine tools. "The viscosity is high enough that it makes a good lube oil, along with it being a cutting oil," said Gary Eliason, president of Waterloo (Iowa) Screw Machine Products Inc.

Helton also mentioned that his company uses soybean oil as a cutting oil and for way lubes.

Limitations

There are some drawbacks to using vegetable oil. It lacks sufficient oxidative stability for many lubrication applications. Low oxidative stability means the oil will oxidize rather quickly during use, becoming thick as it polymerizes to a plastic-like consistency. If the oil is too thick or too thin, cutting tools wear quicker.

"Vegetable oils can become oxidized and change chemically," said Byers. "Their viscosity and lubricating ability can change. There is more of a concern with the vegetable oil reacting with the environment (oxygen and metals) and breaking down than with petroleum oils. Both will oxidize under heat, but vegetable oils are more prone to oxidation."

Another drawback is vegetable oil's lack of hydrolytic stability. Typically, when making an emulsion, oil and water are present. If oxygen and some sort of alkaline component are present, it can cause certain ester linkages within the vegetable oil to break down. These broken-down components act differently than the original vegetable oil. Mineral oil is resistant to hydrolytic reactions.

An ester is a molecule made by condensing fatty acids and alcohols together. Vegetable oils naturally exist as esters, typically called "triglycerides," a condensation of a fatty acid plus glycerine. Under the right conditions, the triglyceride can split and revert back to a fatty acid and glycerine, which will act differently from the original ester. Mineral oils do not contain ester linkages and do not break down, or "hydrolyze."

However, advances in biotechnology have led to the development of genetically enhanced oilseeds that are naturally stable and may eliminate these problems. These stability problems can also be overcome by using additives, such as antioxidants, or by chemically modifying the vegetable oil.

Still another drawback of vegetable oil is that it supports microbial growth more than mineral oil does. "Biodegradability is a good thing when it comes to waste treatment," said Byers, "but it is not a good thing when it happens right there in the machine sump and the fluid turns sour and stinky. Vegetable oil has a tendency to do that more so than pe-

The following companies contributed to this report:

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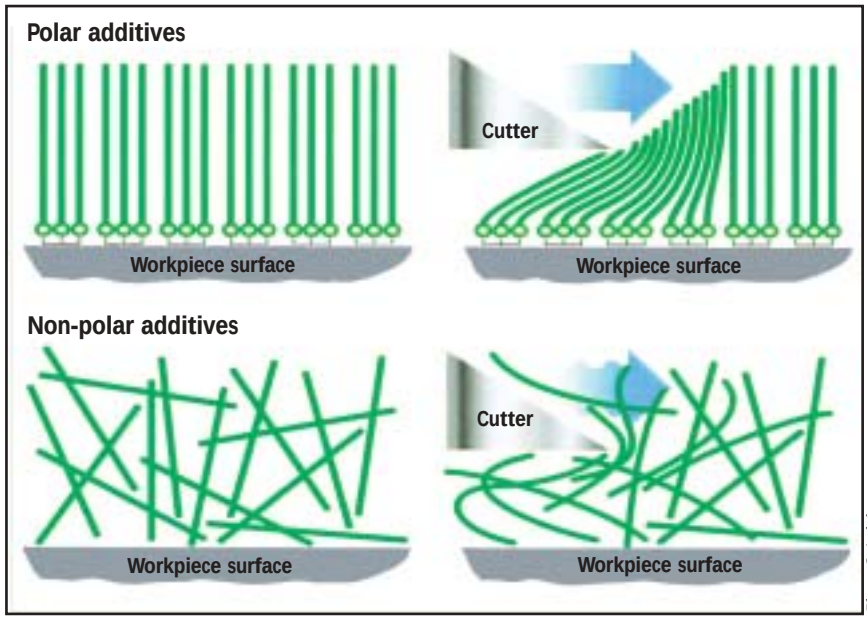
troleum-based products, and may require higher levels of EPA-registered biocides (bactericides and fungicides)—either as part of the formulation or as tank-side additives."

For many, the biggest drawback to using vegetable oil is it costs more than mineral oil. Canola oil, for example, can be more than three times as expensive as petroleum oil. In addition, costly ingredients are required to control oxidation and enhance biological stability, which add to the cost of the finished product.

"If the price were the same, then most everyone would be using it, due to its environmental and safety benefits," said Randy Templin, product manager, Blaser Swisslube Inc., Goshen, N.Y. "Fortunately, there are many operations where the use of vegetable oil-based products is easily justified based on performance."



Blaser Swisslube

Depiction of the natural affinity of polaric oil to a metal surface and the way the molecules line up "like magnets." This structure creates a stronger lubricant film than nonpolar oil.

Cleaning and Disposal

When cleaning vegetable oil, the same filtration systems and waste-treatment processes used for mineral oil will work.

"In most cases, you will not have to modify your operation or equipment to use vegetable oil," said Tripp.

Even though vegetable oil is biodegradable, there are still disposal issues. "You cannot just dump biodegradable industrial fluids down the drain," said Byers. "It would play havoc with the waste-treatment system down the line. Even if the fluid was 100 percent biodegradable, you wouldn't dump it down the sewer because of the dissolved metals, way oils and other contaminants in the used fluid."

Environmental Lubricants Manufacturing has a recycling program. "We're willing to take the product back, filter it and turn it into other usable, biodegradable products," said Tripp. "We can use it in some heavier products like grease, rail grease, truck grease—these are 100 percent lost in the environment. There is no recovery."

While the federal government does not enforce the application of biodegradable MWFs, it has introduced initiatives to promote the use of environmentally friendly products within federal agencies. A federal law passed in 2003 requires any government agency to consider using bio-based fluids, but if doing so would be cost-prohibitive another product can be chosen.

Vegetable oil provides machining performance that is superior to that of mineral oil in most applications. And, as the cost comes down, it will be become more prevalent. One way or another, more manufacturers will be getting their vegetables. △

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A hob cuts a starter ring using SoyEasy-UNICut.