Renewable resource metalworking fluids are gaining more attention in the marketplace and for good reason. Metalworking fluid producers are looking for more effective technologies to increase productivity and reduce downtime—without increasing costs. Changing regulatory requirements are driving the development of products with reduced environmental impact. At the same time, increasing concerns about workers’ health and safety are putting pressure on the industry to develop better solutions.

Renewable resource products based on vegetable oils offer an effective alternative to traditional petroleum-based products.

Market Drivers

The number one market driver for vegetable-oil technology? It works. Polar vegetable oils are more effective lubricants than non-polar petroleum-based oils. And that can translate into improved part quality and surface finish, optimized tool life and potentially lower total fluid consumption. Because the technology is so effective, fewer chemicals are needed, reducing costs and the amount of fluid introduced into the environment, an important consideration in today’s market, where the push is on to create a more environmentally responsible metalworking fluid.

End users, such as workers’ unions and major manufacturers, perceive that renewable resource products offer an improved health, safety and environmental profile when compared with traditional petroleum options. Governmental preference programs, including tax incentives and preferred procurement programs, provide an additional incentive to move toward vegetable oil-based metalworking fluids.

A final potential market driver moving vegetable oils to the forefront is...
Historically, refined vegetable oils have held substantially higher market price levels than their petroleum base stock counterparts; however, this price spread has narrowed in recent years. For the first time, the economics of switching to vegetable oils are workable.

**Market Challenges**

While it is generally accepted that vegetable oils can outperform petroleum-based products in many areas, usage issues still remain that limit their application. First on the list: formulation challenges. Emulsification is more difficult with vegetable oils, which require a lower hydrophilic-lipophilic balance (HLB), resulting in the need for more and stronger emulsifiers. Natural oils are also more susceptible to hydrolysis, a condition that is accelerated by the alkaline nature of metalworking fluids. And during machining, it is inevitable that metal ions will be introduced to the fluid, which speeds up the process of oxidation. These issues are certainly not insurmountable and can be addressed with the appropriate fluid technologies.

Another challenge to additive suppliers is fluid formulators’ and end users’ high level of comfort with the status quo. The “if it’s not broken, don’t fix it” mentality comes into play here. End users have been working with petroleum-based fluids for quite some time, and they like and understand how these products operate. Add in the fact that, even with rising petroleum prices, these products are still relatively inexpensive, and it becomes clear that end users will need a compelling reason to make a change.

**Not all Vegetable Oils are the Same**

Although there will be variations between Group I, II or III basestocks, for the most part, naphthenic and paraffinic minerals are similar in nature. This is not true when it comes to vegetable oils. Canola oil, rapeseed oil and soybean oil will all behave differently. That’s why an understanding of the oil’s fatty acid composition and its likely impact on product stability and durability is essential.

In particular, the amount and type of unsaturated fatty acids (double bonds per carbon chain) is critical to the oxidative stability of the oil. Fully saturated carbon chains, like those found in petroleum-based oils, are ideal for oxidative stability, but the high degree of saturation can result in less fluidity, especially at lower temperatures. Canola oil, containing primarily monounsaturated fatty acid chains, is the easiest vegetable oil for formulation; rapeseed oil, with its longer carbon chain is slightly more chal-
The Lubrizol Corporation (continued)

Lenging to emulsify, and soybean oil, with high levels of polyunsaturation, is best reserved for applications where expectations for long emulsion service life are low. Another option is the use of synthetic esters in place of the vegetable oils. These esters offer the formulator a more predictable, controlled structure. Oxidation can still be an issue, but emulsification is easier, and properly designed esters are the best option for avoiding polyunsaturation.

Current Vegetable Emulsifier Technologies

There are a number of drawbacks to currently available vegetable emulsifier technologies, starting with high treat rates – often in the 35 to 40 percent range – compared to 15 to 20 percent in a typical mineral oil formulation. As a result, formulations require twice as much of a more expensive product, and using more emulsifier can result in high foaming tendency. In addition, many emulsifier technologies have limited flexibility across different oils.

Attaining the desired pH range (9 to 9.5) is also a problem. Vegetable oils in general are not tolerant of alkalinity. Adding amine can cause them to become hazy and makes stable concentrates with good emulsification properties difficult to achieve. To address the alkalinity challenge, many manufacturers employ a “two-phase” system. One phase contains the oil/emulsifier combination, while another contains water-soluble alkaline builders so that oil and alkalinity can be kept separately. The two phases are both added to a working system, a difficult process that requires careful measurement and monitoring practices. The result is added complexity for the end user, increasing the possibility of operator error.

Introducing Lubrizol® MC944V

Lubrizol MC944V was designed to address many of the issues seen in currently available vegetable oil emulsifier technologies. In particular, this is a “one phase” product offering exceptional emulsification across a range of vegetable oils and esters, with finished products providing natural lubricity. Lubrizol MC944V is effective at low treat rates and capable of building alkalinity and pH levels for improved emulsion durability. It also produces inherently low foaming emulsions.

Testing Confirms Performance

To demonstrate the benefits of Lubrizol MC944V, Lubrizol conducted foam and lubricity performance testing. Formulations for both sets of tests consisted of 20% Lubrizol MC944V in high oleic canola and 18% industry standard package in naphthenic mineral-based oil.

Low Foaming: As fluids are forced into smaller sumps at higher speeds, foaming occurs and fluid can spill out of the sump. Excessive foaming can also have an impact on the lubricity of the formulation. Defoamers are usually recommended with metalworking fluid to combat the negative effects of foam, but they can be filtered out and need to be replenished. Because it is built from a low foaming ester, little or no defoamer is necessary in products formulated with Lubrizol’s MC944V emulsifier.

Lubricity: The lubricity of the vegetable oil formulated with Lubrizol MC944V was measured against the standard mineral-based oils. Microtap tests in aluminum and steel, run on a customized program, demonstrate the clear advantages of vegetable-based metalworking fluids.

Biological Resistance: An industry perception exists that vegetable oil-based emulsion products are inherently more subject to attack by bacteria and fungus than comparable petroleum oil products. In reality, laboratory testing has shown that vegetable emulsion products built from Lubrizol MC944V show a similar degree of attack and degradation from microorganisms as a petroleum-based product, when no biocide is incorporated. When an appropriate biocide is used, the vegetable oil emulsion shows extended protection from microbial growth and fluid degradation.

Addressing the Needs of the Marketplace

Lubrizol MC944V was designed in response to the market demand for renewable resource metalworking fluids. Tests prove that vegetable oil emulsions can be technically and economically viable. Based on a unique combination of emulsifier chemistries, MC944V addresses the specific challenges of the end market, providing exceptional emulsification in a wide range of vegetable oils and esters. ■