The Benefits of Bio-Based Lubricants

By Bob Frazier and Dwight Smith

Bio-based cutting oils improve tool performance, reduce environmental impact, and are safe and convenient for use in a wide variety of manufacturing applications.
If your company is interested in increasing factory throughput, reducing tool costs, and improving product quality in a safer environment, you may want to consider switching to bio-based metalworking fluids. They have excellent lubricity and superior viscosity vs. temperature characteristics. The use of vegetable, or bio-based, oils can contribute to the goals of energy independence and a cleaner environment.

In the past, the problems of oxidative stability and poor cold flow performance limited the use of these products. Targeted research has successfully addressed these problems. Bio-based metal cutting oils and coolants are being used effectively by many companies for gear cutting, grinding, and general machining. Aside from the environmental advantages, which we will discuss here, bio-based metalworking fluids have many advantages over petroleum-based products:

- Naturally better lubrication;
- Superior viscosity/pressure performance;
- Better thin film strength;
- Lower volatility;
- Higher flash point, less smoke and risk of fire.

**RESEARCH TIMELINE**

This breakthrough technology has been in development for many years. In 1991, a research project at University of Northern Iowa utilized genetic engineering to increase oxidative stability of oil made from seed crops. This was expanded in 1995 into the Ag-Based Industrial Lubricants (ABIL) Research Program. ELM (Environmental Lubricants Manufacturing) was incorporated in 2000 to bring these technical advances to market as commercial products. Performance Biolubes was formed in 2008 to market bio-based lubricants to the metalworking industry.

**THE SCIENCE**

Petroleum-based lubricants get most of their lubricity from additives, such as chlorine and sulfur. Bio-based lubricants have superior lubricity without the need for these chemical additives. This added lubricity reduces friction. With less friction created, cutting forces are reduced and less heat is produced in the metal cutting process, allowing tools to be fed faster. Less friction also reduces wear on cutting tools and grinding wheels, usually extending tool life.

Bio-based oils have a much higher flash point than petroleum. Flash points go down as viscosity of oils is reduced. Comparing oils at a viscosity of 40 cSt, bio-based oil has a flash point of 310 degrees C (590 degrees F) and petroleum has a flash point of about 148 degrees C (300 degrees F). This increased flash point reduces smoke while cutting metal, allowing higher feed rates and providing a less smoky working environment. Complimentary bio-based way oils and hydraulic oils can be introduced to help maintain a pure bio-based system with the highest possible flash point to reduce smoke.

Another characteristic of bio-based lubricants is their polar attraction to metal (see fig. 1). Petroleum-based fluids have no polarity and therefore no affinity to metal. Therefore, they tend to run off of tools and workpieces, leaving surfaces without protective lubrication. The polarity of bio-based lubricants provides metal affinity and more effective thin film protection at the cutting tool/workpiece interface.

**GEARING APPLICATIONS**

The processes of hobbing, shaping, shaving, grinding, and broaching can all benefit from the characteristics found in bio-based cutting oil. The typical performance improvement is increased tool life when petroleum-based cutting oil is replaced by properly formulated bio-based oil. When cutting tools are run at normal feeds and speeds, tool life increases by up to 100 percent. Since cutting forces and heat from friction are reduced, feeds and speeds can usually be increased. Fewer tool changes and faster machining processes can lead to productivity increases of 20 percent or more. Part qual-
ity will improve due to better tool condition and improved surface finishes.

Bio-based oils provide significant improvements for gear grinding. Reductions in friction and the heat produced allows for faster grinding with less chance of burning the part. Surface finish is improved, and grinding wheels retain their size and form longer to improve quality and extend wheel life. Reduced friction improves dressing efficiency and improves dresser life. When gear cutting tools are reground using bio-based oils, the surface finish on the cutting edges is improved to prevent premature cratering that causes reductions in tool life.

**WaTeR soluble coolanTs**

When machining with water miscible coolants, the latest bio-based products offer features that can lead to cost savings, quality improvements, and increased productivity. They provide improved lubricity for better tool life and surface finish. Increased feeds are often possible, as these coolants reduce friction and heat. Excellent sump stability and reduced toxicity make bio-based coolants easy to maintain. Operators are very unlikely to experience dermatitis or any sensitivity to these coolants.

There are bio-based coolants for use on all metals, including the most sensitive aluminum, yellow metals, stainless steels, aerospace alloys, and the usual range of carbon, alloy, and tool steels. The added lubricity is especially helpful when machining difficult stainless steels. Heat is reduced, extending tool life and allowing higher feeds and speeds. Aluminum machining is dramatically improved because bio-based coolants provide improved finishes, reduced tool wear, and reduced built-up edge—the most common reason for tool failure.

In the past, bio-based coolants were not effective in machining cast iron. Cast iron fines were retained in the coolant, causing the creation of a gray paste that coated machine surfaces, creating serious maintenance issues. This problem has been solved with the latest highly refined bio-based coolants made from special bio-esters. These newly formulated coolants are clean running, providing improved tool life, long sump life, and low maintenance.

Grinding operations can benefit greatly from the new bio-based coolants. When grinding these coolants reduce friction, causing abrasive grains to stay sharp longer, allowing much longer time between wheel dresses. This is especially important when form grinding. Wheel life and accuracy is improved. If heat checking is a problem, bio-based coolants reduce the heat generated in most grinding operations. This allows feed rates to be increased without introduction of excessive heat into the part. Since the increased lubricity also provides better surface finish, feed rates can be increased without sacrificing fin-
ish. Some users take full advantage of bio-based coolants and adjust wheel specifications to compliment the new coolants. They change to a coarser abrasive and a more-open wheel structure. These changes let the wheels grind faster and cooler while maintaining surface finish and accuracy due to the extreme lubricity of the bio-based coolant. Overall, grinding productivity and part quality can be dramatically improved with bio-based coolant technology.

EASY CLEANUP
Bio-based oils and coolants are easily cleaned from parts and machines with soap and water. Mineral spirits and other petroleum-based degreasers are not effective. When bio-based residue is left on steel parts it acts as an effective in-process rust preventative. These products are non-staining on most metals, including brass and most aluminum alloys.

Bio-based lubricants are non-hazmat (not ecologically hazardous) prior to being used. Mist from these products forms large droplets that tend to fall close to the source. OSHA limits for bio-based vapors are much higher than for petroleum-based vapors. Dermatitis is not a problem with bio-based fluids, as the operator’s skin doesn’t dry out and crack after contact with these fluids.

REAL-WORLD EXPERIENCE
Case studies reveal very real improvements in tool life, surface finish, and productivity from the use of bio-based cutting oil and water soluble coolants. A Detroit gear manufacturer was running production two shifts per day. Tool costs were reducing profitability on this part. They changed from petroleum-based cutting oil to Performance Biolubes NuCut Plus cutting oil, and tool life was increased by 300 percent. Another company was using a shaper and achieving 11 parts per tool sharpening. After converting to NuCut Plus tools lasted twice as long, and they were able to increase feed rates by 10 percent to further increase throughput.

Bio-based lubricants are attracted to metal

Petroleum Oil is non-polar, no attraction

Fig. 1: Bio-based lubricants possess a polar attraction to metal, while petroleum-based fluids have no polarity and therefore no affinity to metal.

High Performance “Green” Lubricants
formulated to achieve maximum productivity at the lowest cost.

Performance Biolube’s vegetable based fluids have greater lubricity than petroleum oils resulting in faster cutting speeds, greater feed rates and higher part quality. The oils’ natural polarity causes them to be attracted to metal, resulting in improved surface finishes.

- Excellent lubricity to reduce friction
- High Flashpoint — (590° F)
- Safer Smoke
- Free workplace
- High viscosity index for wide temperature range
- Exceptional oxidative stability
- Eliminate or reduce smoke and improve tool life in:
  - Hobbing
  - Shaping
  - Shaving
  - Grinding
  - Broaching splines, keyways and internal gears

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A supplier of aerospace components uses CBN plated form wheels to grind hardened carbon steel parts for proprietary power transmission products. The problem was heat buildup in the part, which could cause part failure and potential loss of life. Expensive quality control processes were in place to reduce risk. Wheel life was approximately 2,500 parts before wheels had to be stripped and re-plated. These CBN wheels were recognized as the highest cost perishable tool in the plant. Some of the grinders were using water-soluble coolant and some were using neat oil. Neither product worked well on this difficult application. After testing, the company converted all grinders to NuCut Plus bio-based cutting oil. The heat checking (grinding burn) was eliminated, allowing increases in production rates and reduction of QC efforts. The grinding wheel life increased to over 10,000 parts per wheel, dramatically reducing tool costs.

This Tier Two supplier to a large bearing manufacturer had a contract to cutoff 85,000 pieces per week from a carbon steel tube. The operation was running 24 hours per day, seven days a week. They selected a Modern cutoff machine and tooled it with blade style indexable carbide cutoff tools. Tool life was approximately 700 parts per tool. To improve the profitability of the job the manufacturer wanted to further improve tool life and reduce cycle time. They replaced the petroleum-based coolant with XXL Plus bio-based coolant from Performance Biolubes. It was determined that tool life doubled and feed rates were increased by about 10 percent. Annual cost savings were approximately $39,000 per year.

CONCLUSION

Environmental and health concerns are important to most shop owners and corporate managers. Performance Biolubes’ metal cutting fluids are truly “green” products, made from North American renewable seed crops. There are no known cases of dermatitis from this product, and most users say that they have eliminated dry skin and cracking that occurred when working with petroleum-based coolants. The vapors from NuCut Plus are not hazardous. Petroleum-based oils get lubricity from additives such as chlorine and sulfur. Bio-based products don’t need these additives due to the much higher natural lubricity.

When both the performance and sustainability of bio-based metal cutting fluids are considered, a compelling case can be made for their use. Savvy shop owners and managers will use these products to cut cost, improve profits, and reduce the shop’s carbon footprint. In addition, health benefits will accrue, resulting in a cleaner, healthier, and more-productive workplace.

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