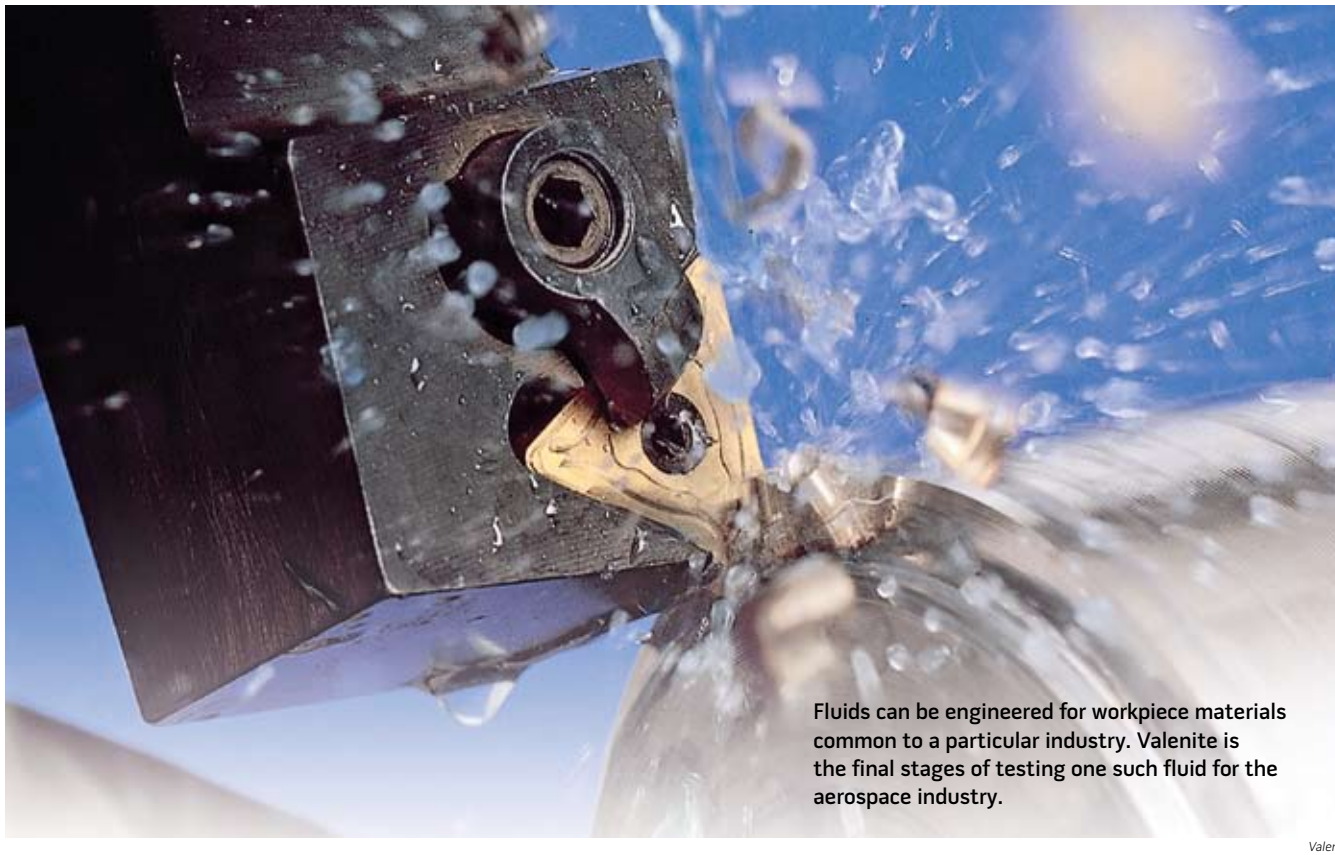


Fluids can be engineered for workpiece materials common to a particular industry. Valenite is the final stages of testing one such fluid for the aerospace industry.

Valenite

Cutting Down on Cutting Fluids?

By Joseph L. Hazelton, Contributing Editor

While using a single cutting fluid to machine and grind all workpiece materials may not be economically feasible, many machine shops can reduce their number of metalworking fluids.

Machine shops in all industries dream of using a single cutting fluid that's effective for machining all types of workpiece materials, in all types of metalworking. Eliminating the need to continually swap out fluids from job to job would undoubtedly be a welcome timesaver.

While it may be possible to develop such a universal metalworking fluid, its cost—to ensure that it had the requisite properties for such wide applications—would surely be prohibitive.

Yet it is possible for shops to reduce their number of needed fluids, depending on their mix of workpiece materials and metalworking processes.

A Fluid for All Grades

Certainly, when it comes to machining a specific material it is possible to devise a metalworking fluid that can be applied to every grade. For instance, ITW ROCOL North America, Glenview, Ill., offers such a fluid for aluminum, Rustlick Ultracut AL.

"Aluminum, with all of its alloys [ranging from gummy to hard] presents many different types of challenges," said Lee Hitchcock, ITW ROCOL's R&D chemist. Overcoming those challenges has been especially important in recent years, as more automotive and airplane manufacturers convert to lightweight aluminum to improve their products' fuel efficiency.

Prime among the features of the Rustlick fluid is that it doesn't stain aluminum, which is especially important for parts used in the aerospace and nuclear industries. Staining is a form of corrosion that can occur when a fluid's pH level is too high for the aluminum alloy being

Cutting Down on Cutting Fluids *(continued)*

machined. (The pH scale ranges from 0 to 14, with 7 as the neutral point. A fluid has a high pH level when it reaches 10, according to Hitchcock.)

Staining can be avoided, Hitchcock said, by lowering the fluid's pH via removal of its high-pH amines or by adding corrosion inhibitors. The ITW fluid for aluminum includes nonstaining amines and corrosion inhibitors.

A Fluid for an Industry

It's also possible to make a metalworking fluid that can be universally applied to the workpiece materials common to a particular industry. Tool and fluid maker Valenite LLC, Madison Heights, Mich., is in the final stages of field-testing a new semisynthetic cutting fluid for the aerospace industry, Aerotech VP, which it expects to market this fall.

Valenite

Creating a more universal metalworking fluid requires additional ingredients, such as additives, to cover the lubrication, cooling, anticorrosion and other properties needed by a wider range of workpiece materials.

To cover the various aluminum grades, ITW ROCOL incorporated into a water-soluble fluid an ester-type lubricant that it knew had considerable lubricity because the company had used it in its stamping and minimum-quantity lubrication (MQL) processes.

The impetus for Valenite's efforts stems from the aerospace industry's growing demand for titanium and, in turn, for a fluid to effectively machine titanium alloys such as Ti6A14V and Ti-5553.

According to Mark Goedtel, Valenite's product manager-ValCool fluids, while the majority of parts machined at aerospace shops are aluminum, use of titanium is growing. For instance, he continued, in the Boeing 777, titanium parts constitute 7 percent to 10 percent of the airplane's weight, more than any of Boeing's previous commercial planes. The new Boeing 787 will be about 14 percent titanium by weight.

To meet the industry's varying fluid needs, Valenite devised a fluid suitable for machining titanium and then engineered the semisynthetic for aluminum and high-temperature alloys.

Goedtel, however, described titanium as the most difficult to machine of the aerospace materials. Among the material's challenges are that it's gummy and a poor heat conductor. Titanium also has a narrow window of speeds and feeds for its machining, around 75 to 100 sfm and 0.006 to 0.008 ipr, respectively.

Moreover, add certain alloying elements and machining titanium becomes even more difficult to machine. Such is the case with Ti-5553. "It contains an additional 3 percent chromium, which adds some abrasiveness to what's typically a springy, gummy kind of material to machine," Goedtel said.

Much of the heat generated at the tool/titanium interface is absorbed by the tool's cutting edge. But water's presence in a metalworking fluid solves that problem, ensuring that the fluid absorbs and removes heat from the interface. "Water's got a higher specific heat," Goedtel said, "so it can absorb and release heat more quickly than oil can."

Consequently, many parts manufacturers may opt for synthetic metalworking fluids when machining titanium. Valenite, however, decided to include a

high percentage of oil, 60 percent to 70 percent, in its new Aerotech VP semisynthetic fluid.

Valenite's strategy is simple: Create a fluid with sufficient lubricity to reduce friction (thus, heat), yet one that also contains water to quickly remove what heat is generated. "Our goal is to prevent [overheating] from occurring and to dissipate it as quickly as we can," Goedtel said. The oil's greater control of heat has the accompanying effect of extending tool life.

"Heat will cause chipping and cracking," Goedtel added. Such damage shortens tool life, but it also can lead to catastrophic tool failure and scrap.

Valenite's in-house tests indicated the fluid's potential for lengthening tool life. The Aerotech VP semisynthetic was applied to machining of Ti6Al4V and Ti-5553. Valenite saw life for indexable-insert mills and drills increase by as much as 300 percent. Valenite also applied the fluid to the machining of 4140 steel, and tool life increased by as much as 50 percent.

Of course, longer tool life means fewer tool changes and therefore less downtime, which boosts productivity.

Also, depending on its workpiece materials, an aerospace shop may be able to use the Valenite fluid in all of its cutting machines—including milling, drilling, turning and grinding. While the Aerotech VP fluid performs well in these applications, some shops may want to use a full synthetic for grinding operations, according to Goedtel.

He added that the new, versatile fluid contains more than a dozen different additives, a high number when compared with the four or five additives in one of Valenite's standard semisynthetics.

Reverse Trend?

While some in the industry have seen a trend toward the use of fewer individual metalworking fluids, Milacron Marketing Co., Cincinnati, marketer of Cimcool fluids, has a different take. "To be honest, I would almost say it's the exact opposite," said Kevin Tucker, product and marketing manager for metalworking fluids. "Many machine shops and large parts manufacturers are looking for customized fluids that can help impart the best-quality finish on a part for a specific work material or cutting operation. Yes, there are shops that want to use one fluid across the entire operation, but for most manufacturers the cost of producing a part can be directly affected by the type of lubricant they use, and they are willing to use different fluids to improve quality on specific parts."

According to Tucker, using a multimetal, multioperation fluid can produce a part cost or quality trade-off for parts that don't exactly match the fluid. "There is no fluid in existence today that is the absolute best for every type of metal and every type of operation. There is always a little performance trade-off depending on the variation in metals used," he said. As an example, he cited machining carbide or magnesium, which require specialized fluids that may not be the best fluids for use with other metals.

Fluid choice, in part, depends on the size of the shop, according to Greg Foltz, Milacron's technical director for metalworking fluids. "A smaller operation with 10 to 30 machine tools may

want to standardize on one fluid," he said. "If you're running aluminum one day and steel the next, you probably want something you can use across the board." However, a much larger plant with multiple, segregated operations machining many different types of materials and workpieces typically uses custom metalworking fluids specific to each type of job. "If you're grinding bearing steel all day, you will likely use a fluid designed just for that operation."

For shops that are looking to reduce the number of metalworking fluids they use, Milacron recommends selecting a fluid based on the shop's most prevalent operation or the operation that presents the highest degree of difficulty, while cautioning that the shop may need to accept poorer results on other applications.

Despite the trend toward more customized products, Milacron still sees demand for broad-based, general-machining fluids, such as its Cimperial 1070 product. It also offers high-tech synthetics and vegetable oil-based products for multifunctional applications. "For example, a synthetic product, Cimtech 310, was designed for aerospace aluminum, but has wide applicability in cast iron and steel as well," said Tucker.

Other metalworking fluids are more narrowly targeted, yet still multifunctional. For example, Milacron's Cimtech 610 is for difficult-to-machine metals such as stainless steel, titanium and beryllium-copper. One version is for metalcutting and one is for grinding.

"It may not be applicable for general purpose machining, but Cimtech 610 is appropriate for manufacturing a family of products such as medical appliances and medical parts," many of which are made from titanium and stainless steel, said Tucker. "It can be used to replace chlorinated products that a shop may not want to deal with. It contains no extreme-pressure additives and still performs as well as or better than products that have EP additives." Cimtech 610 does not contain chlorine, sulfur or mineral oils, so the fluid provides small shops

Valenite

The trade-off between less oil and more water in a metalworking fluid is losing some of oil's lubricity in order to reduce fluid cost.

an advantage in reducing oily mists, a cleaner shop environment and improved part finish and operating performance, according to Milacron.

The Shift to Carbide

One of the ongoing trends in

Options for controlling fluid costs

MACHINE SHOPS CONCERNED with metalworking fluids' increasing prices can look into a few options to reduce expenses. Water-soluble coolants, which represent 65 percent of the U.S. metalworking fluid market, are 50 to 80 percent oil based, and the cost of oil has more than doubled in the last 12 months.

Shops may be able to shift from applying flood coolant to minimum-quantity lubrication. The move can greatly reduce fluid consumption. Instead of using hundreds of gallons of coolant per hour, machine shops may be able to cut that to 2 oz. to 3 oz. per 8-hour shift, said Lee Hitchcock, R&D chemist for fluid maker ITW ROCOL North America.

The shops would have to buy MQL equipment, though, and have it installed on their machines. Also, machinists would need to be trained to use the equipment. "But usually, the return on investment can be done within a few months," said Catherine Fuhr, ITW ROCOL's business unit manager.

If MQL isn't an option, a shop may be able to constrain its fluid expenses by using semisynthetic or synthetic fluids, which contain lower levels of or no oil, respectively, and therefore are not directly affected by increased oil prices. "We are seeing a lot of conversion toward semisynthetics," Fuhr said. ITW ROCOL had a 10 percent increase in demand for semisynthetic fluids in 2007. Hitchcock added that many ITW ROCOL customers use synthetic fluids when grinding.

However, he also said oil provides corrosion protection. The risk of corrosion isn't acceptable to various industries, such as aerospace and nuclear power. Less oil decreases a fluid's lubricity. "You're definitely going to decrease lubricity, which will make your tool work harder," Hitchcock said.

—J.L. Hazelton

ITW Rocol

Machine shops may be able to save money on their metalworking fluids by switching from flood coolant to minimum-quantity lubrication.

Cutting Down on Cutting Fluids *(continued)*

machining is the shift from HSS to carbide cutting tools. That can allow a shift in metalworking fluids from straight oils to water-soluble fluids, said Peter Kotvis, research director for fluid maker Benz Oil, Milwaukee. The fluid shift can also be good economic news for toolmakers.

"The cost of metalworking fluids for machining tool steel is generally higher than for carbides," Kotvis said. Compared to carbides, he explained, steels require grinding fluids with higher viscosities and more chemical reactivity. (A fluid and a workpiece material react chemically to create the film needed for effective machining. During grinding, that film needs to be about 1- or 2-nanometers thick to control friction but leave enough space between the grinding wheel's grits and the workpiece to allow ground particles to escape, according to research published in *Tribology International* 40, 2007.)

A fluid for grinding HSS, therefore, needs more EP additives than one for carbide to have the required activity to create the needed film. Buying the extra additives and placing them in a fluid for HSS applications increases the price.

A toolmaker, however, may well make both HSS and carbide tools. What fluid can the toolmaker select that would allow it to machine both types of workpiece materials without swapping fluids?

Choose a fluid for carbide and the toolmaker will need to compensate for the fluid's lack of reactivity to HSS by

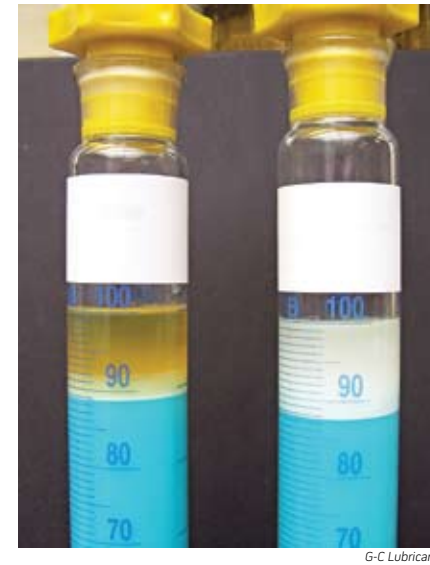
Economizing through better fluid recycling

BRUCE FORNESI, WORLDWIDE metalworking and lubricant product manager for fluid maker G-C Lubricants Co., San Carlos, Calif., has noticed a trend toward metalworking fluids that would permit unlimited recycling and compatibility with companion products. He cited way lubricants that separate quickly from metalworking fluids.

Machine tools often leak way lubricant into the fluid sump. The lubricant floats to the top in a tank of used metalworking fluid, but it also emulsifies with the fluid directly beneath it, so the liquid at the boundary between them becomes a mixture of half-lubricant and half-coolant.

"It's not oil, and it's not water," Fornesi said, adding that the mixture "normally does not stick well to skimmers." Consequently, a machine shop must skim more deeply into the sump or the fluid-recycling tank, taking an amount of still useful metalworking fluid to ensure removal of the way lubricant and the mixture at the boundary.

However, after testing more than 25 additive combinations, G-C Lubricants added three metal wetting and lubrication ingredients to its way lubricant and two to its coolant to make them separate better. "Our way lubricant is designed to demulsify or separate very quickly so that it does not get entrained in the water-based fluid, for instance, and muck it up,"



G-C Lubricants

G-C Lubricants modified a way lubricant and a coolant so the lubricant would separate from the coolant (the left cylinder) instead of becoming emulsified in the coolant as a white foamy liquid.

Fornesi said. As for the coolant, he added, "We found ingredients that don't want to emulsify with the way lube. We found ingredients that want to kick the way lube out without affecting anything else."

The separation allows shops to more easily and efficiently recycle their metalworking fluids. "There's less waste of good coolant being sucked up unintentionally by the skimmers," Fornesi said.

—J.L. Hazelton

adding or increasing additives such as chlorinated and/or sulfurized hydrocarbons and esters. Kotvis said the additive concentrations may be increased by 50 percent to 100 percent, depending on the workpiece material.

Consequently, a machine shop would be paying for additives it may only sometimes need. There may be a point at which those inactive additives are too costly. Each shop would have to review its mix of workpiece materials to learn at what point a more universal fluid becomes a burden rather than a blessing.

A Fluid for Many Purposes

Manufacturers, however, may be able to find a metalworking fluid that can serve several purposes besides cooling and lubricating the tool/workpiece interface. Finding such a fluid depends on the manufacturer's workpiece materials and metalworking operations. Tawas Tools Co. Inc., East Tawas, Mich., was able to replace six fluids and lubricants with two in its toolmaking operations when it switched in spring 2007 to Benz Oil as its fluid supplier.

The more universal fluid is Benz Grind HP-22, which Tawas Tools uses in its 13 form grinders and six tool sharpeners. Before its switch, the toolmaker used four fluids in its form grinders: a spindle oil, a jackshaft spindle lubricant, a hydraulic oil for the grinders themselves, and the primary fluid for grinding the workpiece materials. Jack Thornton, process technician for Tawas Tools, disliked the amount of fluid maintenance, which he described as huge. "I wanted to go to just one product," he said.

Consequently, Tawas Tools ran tests with three metalworking fluids from three different companies. The test was the form grinding of PM-45 tool steel, hardened to 66 HRC, with a cutting speed of 8.3 sfm and the grinding wheel running at 10,000 sfm. The wheel took two passes, each with a 0.006" DOC, to grind the tool's form.

Thornton designed the test to cause grinding burn. Of the three test oils, he said, "Benz Grind HP-22 was the only one that did not generate enough heat to cause burn." He added that HP-22 was able to prevent burn even though it was less viscous than the other two test oils. The tests didn't run at 100° F, but

Cutting Down on Cutting Fluids *(continued)*

HP-22's viscosity at that temperature is 105 saybolt universal seconds (SUS). "The thinner it is, the better it is," Thornton said of metalworking fluids. "It'll actually move the heat out quicker."

In this type of grinding machine, the cutting oil is also used as the way oil for the rails, he said. A lower viscosity oil would cause the saddle of the grinding machine to vibrate as it moves along the rails. "However, we will be testing a lower viscosity oil, Benz Grind HP-15, in one of our PTG sharpening machines," he said. "HP-15 has a viscosity of 70 SUS at 100° F, which will dissipate heat quicker."

Benz Oil

Fluids used for grinding are typically different than those used for cutting, but some fluids can be used for both applications.

There were other benefits, too. The HP-22's lower viscosity resulted in Tawas Tools' vitrified CBN wheels grinding cooler, with no burning and a 4 percent reduction in grinding wheel load. "The thinner that oil is, the more you can saturate that wheel," Thornton said. "You can actually see the oil penetrating the entire wheel, which produces cooler grinding and less heat."

Moreover, Tawas Tools' chillers don't have to work as hard as previously to bring recirculated fluid down to 72° F before returning it to the grinders. "They can pull the heat out of that thin oil so much faster," Thornton said.

Tawas Tools uses HP-22 for the grinding and way oil; Benz Petraspeed 5 (66 SUS at 100° F) for the spindle oil; Benz Petraspeed 22 (106 SUS at 100° F) for the jackshaft oil; and Benz HP-2105 (1,745 SUS at 100° F) as a viscosity additive.

The HP-22 fluid requires less maintenance than the one it replaced. "The previous oils required that we swap out 5 to 10 gallons per machine per month with a heavier oil to boost the viscosity," said Thornton. "The Benz products are much more stable and have drastically reduced the amount of waste oil generated." Tawas Tool has projected annual savings of $7,600 due to the changeover to Benz products.

HP-22 also permits freer grinding than the previous fluids. Tawas Tools became aware of the difference during trials of its three test fluids. "We noticed that our grinding loads were lower," Thornton said. "The wheel was removing the stock easier."

The toolmaker took advantage of this performance by increasing the DOC by 25 percent. "We have not yet capitalized on the full potential of the Benz oil," said Thornton. "Testing in the near future will determine optimum cutting rates, but an operator has already commented that we have reduced grind cycle time by 20 to 25 percent compared with using the previous oils."

In fact, shortened cycle times, improved productivity—and a healthier bottom line—are frequent outcomes when companies set their sights on ways to reduce their number of metalworking fluids. CTE

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