Accu-Lube®

NEEDS OF ALUMINUM CUTTING & MACHINING LEAD TO NEW BREED OF HYBRID LUBRICANT

ITW PRO BRANDS

GETTING THE MOST OUT OF YOUR NEW MQL

Often, operational management quickly sees the benefits of MQLs, however, the change is very dramatic and sometimes slow to be understood and accepted by the operators at the machines.

WHY? They are used to seeing GALLONS of liquid deluging the cut, 24/7 - a process they've seen going on non-stop for years, even decades. The mere idea that the same - or more - can be accomplished with just a tiny spritz of specialized fluid takes some getting used to.

WE'VE HEARD IT ALL: "If the operators don't see it spurting out of the nozzle, they think it's not there", and "they were used to thinking more is better". So, given access to the controls, they turn up the volume of the MQL equipment, putting way too much lubricant on the tool (and the part). Ironically, this reduces, and can even eliminate, the benefits that the operation sought to gain.

The solution to this problem is simple: training and education. Explain the differences between the operation of flood coolants and MQLs to operators as part of the equipment training during the switch. Make sure that they understand that, unlike in the past, a tiny amount is all that is necessary, and works better, and if they can see it they are using too much. It is, after all, called "near dry machining" for a reason.

In doing so, you'll want to explain the benefits of the operation - the benefits that apply directly to them through the evolution from flood coolant to MQL: less need for messy system maintenance work, better and healthier working conditions, less de-burring, cleaning and other manual intervention, less need to keep removing blades for sharpening, less dealing with stained metal, less cleaning, and so much more!

IDENTIFYING THE MOST EFFECTIVE LUBRICATION OPTIONS

After extrusion of raw billets; manufacturers, aluminum houses and machine shops have the need to cut and shape freshly extruded rods at many points—from cutting the long bars to specified sizes to performing highly customized fabrication of components for automotive, aerospace, aviation, rail, construction and other industrial and consumer end uses.

Sawing, cutting, drilling and other high-volume, high-speed fabricating operations can be tough on both the tool and the metal—even one with the relative softness of aluminum. Indeed, replacing and resharpening blades is a significant operating expense in aluminum cutting operations of all kinds. Further, the need to reclaim poorly cut pieces with labor-intensive manual interventions, such as setting up deburring stations, also leads to significant labor and material costs—especially as blades begin to lose their efficacy with use.

While some operations continue dry-cutting and accept the relative consequences, most others use one of a number of relatively sophisticated chemical options to help improve the quality of the cut and/or the useful life of the blade, with flood coolants and minimum quantity lubricants (MQLs) being the major categories.

While these engineered chemical solutions often provide cleaner cuts and longer tool efficacy through various mechanisms and extents, operations that must immediately move the cut aluminum into a heat treatment process to impart the required molecular strength to the metal face an additional challenge—the need to manually dry or clean the part, removing any remnant of coolant or lubricant to avoid burning, staining and other detrimental impacts on the aluminum in the oven. Failure to do so can lead to high reject rates with excess waste and scrap, adding to production costs and decreasing desired yield levels.

Many of these operations have long struggled with the fact that the majority of chemical cutting solutions—flood coolants and MQLs alike—were historically formulated for general metal cutting, as opposed to being crafted to the specific needs of aluminum cutting and subsequent heat treating. It has been observed that, for most organizations, cutting operations are a "making do with what's available" balance of performance advantages and disadvantages. Each organization strategically selects the solution offering the acceptable balance of tool wear, cutting quality, chemical cost, heating performance, waste level and other metrics that go into their profitability calculations.

While many operations have made their long term choice from among dry machining, flood coolants and traditional MQLs, installed their necessary infrastructure as needed and made long-term peace with the relative pros and cons, many others have started to investigate newer categories of specialized aluminum-optimized MQLs that address the specific issues they face for both cutting and heat treating. As well-known manufacturers of flood coolants, standard vegetable oil-based MQLs and more sophisticated hybrid-formulated MQLs alike, unique perspectives have been introduced into the potential pros and cons facing aluminum operations when selecting the best lubrication strategy for their needs. This paper will discuss some important facts, insights and considerations based on observations at hundreds of facilities over several decades.

ALUMINUM CUTTING AIDS: THE UNIVERSE OF OPTIONS

As discussed, there are a number of commercially available, chemically engineered lubrication options. However, the default solution still employed by some operations, is using "nothing at all," also referred to as "dry cutting."

Pros and cons? As users will be quick to tell you, a big pro is that "it doesn't cost us anything." However, this simply isn't accurate. Dry cutting a metal as "gummy" as aluminum is especially tough on both the saw blades and the aluminum product itself. The high temperatures generated by the process exacerbate this issue—both blade and metal can overheat quite quickly at the point where they meet, leading to jagged cutting results and excess blade wear and damage, with microtwists, bends and cracks. Advocates of dry cutting might not realize that the need to replace and/or resharpen blades as frequently as once or more per shift, while it might have long ago become their operation's status quo, might not be the status quo for similar operations. In fact, they might have significant room for improvement at a cost savings. Further, the need to deburr and otherwise manually finish a part after a cut might not be a "normal" part of other companies' operations; furthermore; those labor and scrap costs could potentially be reduced or even eliminated altogether.

Evolving towards an engineered solution, the various technologies available provide some combination and some level of lubricating the process, reducing friction and cooling the cut to reduce impact on both the blade and the metal.

As noted, the two main categories of chemical technologies are flood coolants and minimum quantity lubricants (MQLs). The former literally flood the area with an ever-flowing deluge of liquid, while the latter, in stark contrast, are applied with an atomizer-like spritz directly on the cutting edge of the tool at the point of cut. These fluids are sometimes referred to as mist coolants or near dry lubricants (as a nod to being between flood coolant and dry machining). The respective enabling "philosophies" are also quite different, with flood coolants improving the cut primarily through the cooling action of the liquid, along with a small increase in lubricity provide by the chemistry of the product. MQLs, meanwhile, are engineered to provide large increases in lubricity, while reducing the build-up of heat in the first place, rather than cooling the cut after the fact. The two technologies are not interchangeable and require an upfront decision and commitment to one or the other in a particular operating line in that they each require different infrastructure.

The impact that chemicals used in cutting operations during later processes, such as the use of heat treat ovens is a major concern for aluminum operations. This is not be a concern using dry cutting. Parts saturated with flood coolants must be manually cleaned and dried in some way, as must those using many MQLs, since, even at small "atomized" quantities, remaining residues can lead to burn marks on the finished part. The exception, as noted, are newer generation hybrid MQLs.

FLOOD COOLANTS: CHEMISTRY, INFRASTRUCTURE, AND IMPACT

Flood coolants have been the "go-to" technology in this space for many years, a work-horse method that has been shown to get the job done reasonably well in many instances. With its proven efficacy, many organizations stay with it, being comfortable and familiar with the process and seeing no reason to investigate more "modern" technologies as long as nothing dramatic—like an environmental impact, worker injury or cost re-evaluation—occurs.

Indeed, one of the major drawbacks of the flood coolant method is the cost of the initial infrastructure, so once this is done, the cost is "sunk". This infrastructure includes circulating tanks, piping, sump systems, skimmers and scrapers designed to filter and recirculate the flow of liquid and keep it moving at high volumes and speeds. However, ongoing maintenance and handling costs are also an ongoing factor.

Flood coolants, like most chemicals in this category, are highly sophisticated, engineered products. The highly concentrated and usually manufacturer-proprietary formulas often include mineral oils, emulsifiers, corrosion inhibitors and base biocides that are designed to be dissolved in large quantities of water. This methodology—deluging the cut in large quantities of liquid at forced pressures—saturates the area around the cut, surrounding it and cooling it by pulling away the building heat with the mechanisms of the water and the chemicals, while providing a degree of lubricity to the cut. This "deluge" mechanically removes the need for precision—every "nook and cranny" for the most part is steeped. This makes it an effective choice if the tool edge cannot be precisely reached during operation.

In fact, one of the pros/cons of the system is that the same 20-40 gallons of water-based liquid can be continually recirculated for months at a time, potentially saving time and money on chemicals. We say "pros/cons" because this initially cost-effective, long-term use also leads to several perhaps less obvious ongoing impacts and costs. For example, simple microbiology dictates that the flood coolant will become infested with mold, fungus, and bacteria without intervention, so strong biocides and fungicides need to be continually pumped into the system. These biocides add moderate cost, but, perhaps more dramatically, along with other components tend to make the resulting fluid a hazardous waste, with potential health impacts on workers, and the need to handle the fluid appropriately under state, local and federal laws. This means the need for special environmental, health and safety handling and resulting cost at every stage of the life cycle—managing, deploying, storing, shipping and, especially, disposal of the spent fluid as hazardous waste, which usually requires the regular intervention of specialized remediation companies.

Indeed, one such operation had years of circulating flood coolant "splash" out of the system and onto the adjacent concrete floor. Following an EPA related audit, the saturated floor was demolished, handled and disposed of as hazardous waste. In addition, workers exposed to the chemicals in flood coolants, diluted and undiluted, often complain of dermatitis and breathing impacts as chemical components inevitably enter the surrounding air. Worker safety precautions and risk mitigation should be taken. Indeed, the air surrounding many flood coolant operations is known to have a sour chemical smell that can be a constant source of discomfort and a drain on the productivity of workers. In addition, due to its chemistry, flood coolant, even when highly diluted, is quite acidic and caustic, and it can cause wear and damage to many plastics and rubber materials within and adjacent to the process, especially due to the fact that many components sit completely immersed and saturated for long periods of time. Lastly, any metal parts saturated with flood coolant come out of the cutting process dripping wet with a hazardous fluid, and often must be cleaned and dried in some manner before further processing can safely commence—leading to increased time, resources, cost and worker safety issues alike.

TRADITIONAL MQLS: CHEMISTRY, INFRASTRUCTURE, AND IMPACT

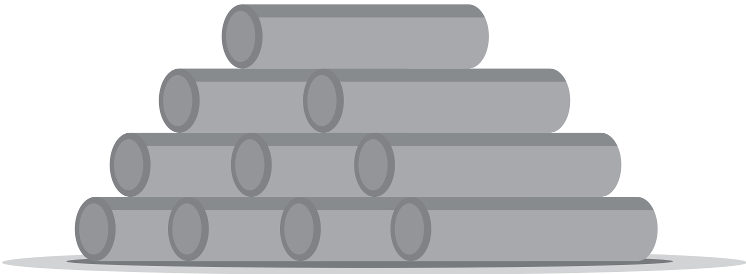
As noted, Minimum Quantity Lubricants came on the scene well after flood coolants were already in regular use. These oils are a completely different concept in both chemistry and methodology.

Perhaps most dramatically, MQLs are designed to be used as is, "straight out of the bottle," at very small quantities—only around 2 ounces of fluid per 8-hour shift. Indeed, this vast difference in mindset becomes a training issue for many operations that choose to evolve from flood coolant to MQL technologies. (See sidebar).

Most traditional MQLs are a proprietary formulation of nearly all natural vegetable-sourced, biodegradable, renewable oils (such as corn, rapeseed/canola, palm kernel and similar esters and long chain fatty acids) usually with the addition of small, but highly impactful blends of high tech additives. The inherent polarity of the oil, sprayed right at the cutting surface, transfers heat away from the point where the blade meets the metal. With this dissipation designed to eliminate detrimental levels of heat build-up before they begin, the temperatures at critical points are kept well below a damaging threshold.

To the natural oil base, manufacturers might add a few different performance-enhancing components. These often include lubrication boosters, such as phosphorus compounds, to increase lubricity and further reduce heat and friction to protect the aluminum and the blade. These components might also be referred to as "boundary lubricants" or "anti-wear" additives. Some are also deemed "extreme pressure compounds" further protecting against heat buildup and friction at the point of contact, such as chlorinated paraffins. Some formulations include anti-corrosion compounds, colorants, or odorants. As with all chemically engineered products, manufacturers must test products carefully to ensure compatibility among selected components of the formulation—and, eventually, against equipment materials to ensure compatibility with specific rubber and plastic so that no damage occurs.

As opposed to flood coolants, these traditional MQLs, being mostly natural biodegradable oils, typically don't need specialized safety or environmental handling. Furthermore,



because the oil is used up in the cutting process and in such small quantities, no hazardous waste remediation is required. They are certainly considered the "green" option in this category—perhaps even as compared to "dry cutting," since the latter method leads to significant metal product waste.

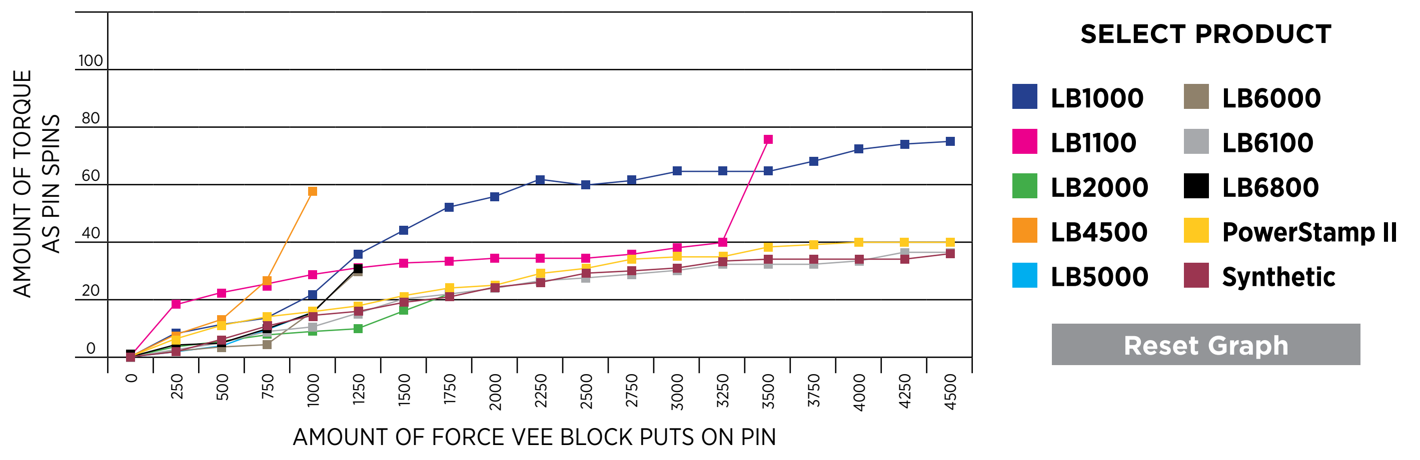
As noted, MQLs work by placing a nearly invisible, small quantity directly on the blade or bit as opposed to heavily saturating everything around it as flood coolants are designed to do. As such, they need to be precisely directed onto the tip of the cutting blade; this precision often necessitates an occasional tweaking of positioning and deployment of the infrastructure.

Speaking of infrastructure, an MQL line necessitates specific equipment, as does a flood coolant line, but there is little, if any, overlap in mechanical components. MQL equipment, in fact, tends to be less complex than flood coolant infrastructure, with an investment well below most organizations' "capex" thresholds—often in the "petty cash" realm. The delivery system is simply an applicator with a reservoir—usually based upon highly accurate and reliable air-driven positive displacement pump technology, which utilizes the natural Venturi-effect to aerosolize the liquid. Some operations use vacuum-driven pumps as well. In either case, there is no complex piping and filtering equipment needed as with a flood coolant system. Sometimes, decision makers opt to place the pump(s) within a steel security box to eliminate purposeful or accidental handling by floor operators and help maintain the exact placement of the MQL spray. Line design is highly flexible and customizable, and many MQL manufacturers offer access to expertise, helping operators create highly efficient lines with specialized nozzles and up to several dozen pumps operating at a time.

These properties have made MQLs an extremely attractive option for new operations, and an attractive long-term option for metal cutting operations evolving from the use of flood coolants. A downside is the one-time hassle of breaking down, draining, and drying out the flood coolant infrastructure, with the central sump, skimmers, pumps, piping and other equipment either being resold on the secondary market or appropriately disposed of. Conversely, ROI for doing so can typically be measured in mere months, not years or decades, as once believed.

The one attribute absent or less effective in most traditional MQLs and flood coolants as it pertains specifically to aluminum is the ability to evaporate off cleanly. This is critical to ensure that residues do not impact subsequent

Pin and Vee Block Results



Graph: Lubricity can be measured using the Pin and Vee Block Test. In this test, the appropriate piece of metal is immersed in a lubricant and two V-shaped blocks apply pressure as the metal is spun against a stainless steel pin. The machine measures the torque at which the pin will break—under dry conditions it will break almost instantly. Highly lubricious materials can allow the pin to survive beyond the optimum measure of the machine – 4,500 pounds of pressure. Lubricants can be compared to each other using these numbers to gain a sense of relative lubricity. ***This graph is interactive, select the products you want to visualize or compare against each other.***

onsite heat treating. This need is not common in cutting other metals, but is inherent in many aluminum operations, where the metal must be heat treated to impart greater strength to the softer metal, as opposed to steel or iron operations. Residues of oil and other chemicals, when subjected to high heats will often burn and leave a scorch mark on the metal or otherwise negatively impact the process. While traditional MQLs have made strides to reducing this issue, mostly through strategic use of specialized additives and different mixtures of natural oils and esters, they can never likely be alleviated entirely when large amounts of natural oils are used, a perhaps unavoidable trade-off. As a result, the status quo for aluminum cutting operations using flood coolants or traditional MQLs is to either set up an intermediate cleaning/drying step, and/or accept some percentage of burned, stained, or otherwise damaged metal pieces.

This final need, unaddressed for many years in other solutions, is being addressed in a new breed of hybrid MQLs.

THE NEW BREED OF ALUMINUM-OPTIMIZED HYBRID MQLS: CHEMISTRY, INFRASTRUCTURE AND IMPACT

In recent years, a number of leading lubricant manufacturers have set their sights on developing a new generation of chemically engineered products that would specifically meet the needs of aluminum fabricators, delivering both high quality cutting and easy heat treatment without concern for metal staining and burning in the high temperature industrial ovens. One such product, Accu-Lube® LB-8500, was specifically formulated and designed with properties to impact these key operational factors. While we obviously cannot attest to other manufacturers' formulations, we assume that the driver was the same in developing their aluminum specific products.

This aluminum-optimized product—and presumably similar efforts in the market—are a hybrid of strategically proportioned vegetable and mineral oil blends in a precise ratio—along with proprietary performance-enhancing additives—designed to deliver an exact mix of desired properties and benefits. The blend allows the product to deliver the outstanding lubricity in "atomized" quantities inherent to traditional MQLs, with the added capability of evaporating nearly completely without intervention. Eliminating in one fell swoop the costly need for cleaning operations as well as the burning and staining of aluminum during the aging step. The blending additionally delivers this added capability at reduced cost as compared to traditional MQLs in most cases.

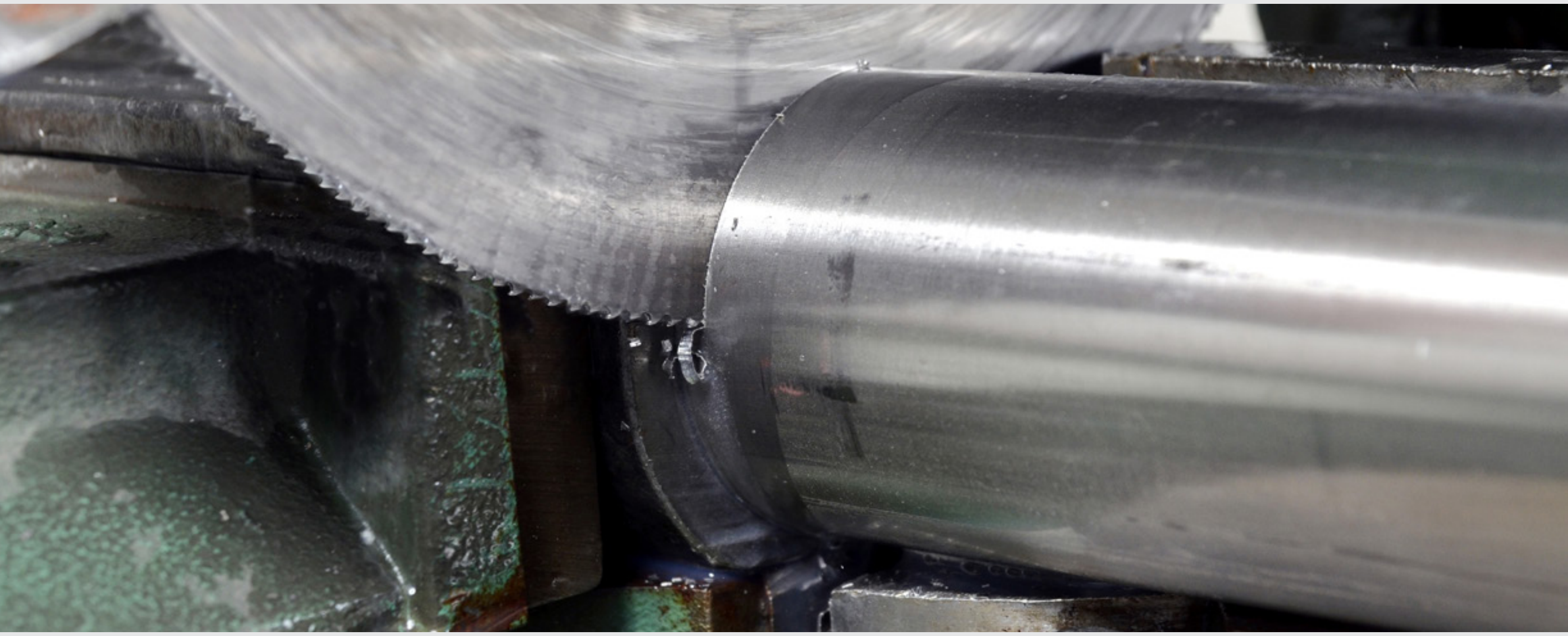
The product is designed to utilize the same infrastructure as traditional MQLs, so it can be readily deployed to gain these additional benefits, although a thorough cleaning of the lines in transition is recommended.

Aluminum cutters are finding this mix of properties a long awaited, complete, comprehensive answer to their operating needs: increasing blade life significantly, improving cut quality, reducing heat damage and waste, and eliminating additional labor steps such as deburring and cleaning—all at an attractive price point.

One potential drawback, like most all products that include mineral oil, VOC content can trigger environmental concerns in some jurisdictions. Such products, for example, cannot be sold in California's South Coast Air Quality Management District (SCAQMD). Arguably, hybrid MQLs are still a "greener" choice as compared to flood coolants, requiring no hazardous waste disposal efforts or specialized HAZMAT gear during storage, use, disposal, or any other point in their life cycle. They cause no known dermatitis or irritation issues. In fact, hybrid MQLs inherently do their job—well—and then, as is the case with LB-8500, are burned up in the cut or otherwise evaporate completely, leaving the aluminum extrusion ready to go directly to the heat treatment process without additional interventions. Further, even as compared to otherwise "greener" traditional MQLs, users have reported the further elimination of respiratory-impacting odors (especially during heat treating), air-borne mists and process smoking when switching from these older products.

ALUMINUM CUTTING AIDS: RELATIVE PERFORMANCE ATTRIBUTES TO CONSIDER

While we have discussed many attributes of this category from the product perspective, let's take a deeper dive into and a different "cut" at the issue, and discuss the category from the perspective of the specific needs of an aluminum cutting and post heat treating operation, and the relative operational benefits possible.



OPTIMIZED BLADE LIFE

A "hidden" cost of production for many aluminum cutting operations is the expense of resharpening and replacing blades. Indeed, most blades can be resharpened several times—often with diminishing returns—until replacement with a new blade is deemed necessary. In either case, the line must be stopped to attend to the blade, which, in many operations, can be a weekly or even more frequent need on each line. While many operations have considered these processes a static and unavoidable "cost of doing business," the advent of hybrid MQLs have shown that this is not necessarily true.

Blade life in this category often comes down to the control of two major factors that constantly put pressure on the efficacy of the cutting tool—temperature, with high temperatures potentially malforming the blade over time, and lubricity, which is the ability to reduce friction, or strain on the blade as it cuts through the material. The study of the interaction among surfaces in regard to lubrication, friction and wear is called tribology.

Nearly all chemical methods of enhancing the cut—flood coolants, standard lubricants and newer hybrid MQLs—do an effective job of reducing temperatures, although, as noted, they do so in very different ways, with flood coolants removing heat through a deluge of liquid and MQLs reducing heat build-up initially at the source of the cut.

Lubricity is a different issue. Flood coolants generally add a relatively small degree of lubricity to the process, while MQLs are designed specifically to enhance lubricity in large measures. However, while most MQLs generally deliver greater lubricity than most flood coolants, the class of products themselves provide a wide range of performance in this regard.

In the lab, lubricity is measured using two ASTM standard tests, the pin and vee test and the tapping torque test. In the first, the appropriate piece of metal is immersed in the target lubricant and two V-shaped blocks apply pressure as the metal is spun against a stainless steel pin, with the lubricant smoothing the way for the interaction between metal and pin. The machine measures the torque at which the pin will break—under dry conditions, for example, it will break almost instantly. Highly lubricious materials could allow the pin to survive beyond the optimum measure of the machine—4,500 pounds of pressure. Lubricants can be compared to each other using these numbers to gain a sense of relative lubricity.

The tapping torque test, often considered more directly relatable to the real world needs of aluminum machining, can use a choice of target metal. The lubricant is applied, and the testing device measures the pressure and torque necessary to tap holes in the metal. Again, relative results can be used for comparative measures of lubricity. Quality manufacturers will often use these measures in benchmarking and positioning the comparative efficacy of their products, and often make them available on technical data sheets and similar literature.

Of vital note, with superior demonstrated lubricity and other properties, the best performing hybrid MQLs have been shown to increase blade life 3x or more over other options in many aluminum cutting operations. This can not only reduce the presumed "fixed" costs of resharpening and replacement, but also potentially increase yields through the reduction of downtime associated with stopping the lines to access blades. Many operations factor these potential benefits into a cost-benefit analysis of current operations in determining the best aluminum cutting strategy for them.

REDUCED BURRING

Another potentially unavoidable cost that has become commonly accepted in many aluminum cutting operations is the percentage of pieces that may be left with burrs—rough, uneven areas — that must be remediated.

Burrs can scratch and damage other "in spec" components in the production process, cause injuries in casual handling, and, as they are moved at high speed, break off to cause "foreign object debris" that can damage rollers and similar parts downstream on the line. These particles can even work their way into and become lodged in the inner mechanisms of machinery, causing significant systemic damage. In other words, burrs are a defect that can go on to multiply defects throughout the operation. Perhaps even more detrimental, all these parts will likely be considered "off spec" and unacceptable by the ultimate customer, causing outside reputational and business damage to the operation.

With so much to lose, the most common practice is for operators to set up quality control examinations to visually catch burrs, flag and separate the parts so designated, and send them off to a separate manual deburring station for grinding, polishing and other interventions.

This process is time and labor consuming and considering the often razor sharpness of aluminum burrs, cuts and other injuries to operators engaged in the process are a constant concern.

Clearly then, the best defense is to not have burrs in the first place.

Burrs are most often caused by imperfections in the saw blade that can occur over time and are a chief indicator of the need for resharpening or replacement. These imperfections can develop and are exacerbated by high temperatures or low lubricity of the cut. Any chemical intervention—flood coolant or MQL—is likely to improve the quality of the cut and reduce the incidence of burring as compared to dry cutting, but it stands to reason that improved lubricity that leads to longer blade life and cleaner cuts will lead to reduced burring as well. This observation has been made in facilities utilizing the newer breed of hybrid MQLs, in parallel with an order of magnitude increase in blade efficacy, as discussed above.

NO METAL STAINING IN THE OVEN—WITHOUT NEED FOR MANUAL DRYING

In many cases, aluminum, after being cut to its desired shape, undergoes a heat-treating process to align the molecules, creating a harder, more robust product. Problem is, having undergone cutting moments before, some amount of cutting fluid—flood coolant or MQL—is likely still on the part, and, when heated, many of these fluids will burn, smoke, or scorch and stain the part. Anyone who has ever left an oiled frying pan on the stove has seen this phenomenon in action. Such damaged parts are not only unsightly, they will resist further production functions such as painting, anodizing, welding, plating, or coating, or even resist proper operation, for example, potentially malfunctioning in sensitive electronics applications. Interventions must be taken to ensure that these parts don't get out to the next stage of production or to the customer, and they usually end up as scrap and waste.

To avoid this situation, many operations set up an intermediate step between cutting and heat treating, with operators manually attending to the part. In many cases, this has become the status quo, and the additional labor is considered an integral part of the operating cost equation.

Innovative MQL manufacturers have been trying to solve this problem on behalf of aluminum manufacturers for several years and had been making great strides with tweaking the properties of traditional MQLs. The standard lab test to prove out efficacy is a pan burn off test in which 0.2 grams of MQL is baked in an aluminum pan at 205°C for one hour. Products that bake off at an impressive 96% or more can use the term "non-staining" on their labels from a marketing perspective. It should be noted, this 4% remaining residue may or may not be acceptable to avoid scrap waste in a particular application, and it may or may not be visible.

However, with the advent of the new breed of hybrid MQLs, this concern—and the overall vexing problem—has finally been alleviated. These MQLs, like LB-8500, after lubricating the cut, evaporate or burn off 100%, they come out of the heat treatment process unblemished, ready for the next step of production.

TOTAL COST

For any business operation, the bottom-line cost of any option is always of paramount concern. There are two pieces of sound advice to any aluminum cutting operation as they crunch the numbers toward establishing the best strategy for them.

First, it is preferable to work on real world numbers for your specific line and location. If possible, set up a test line using a potentially superior option in your specific cutting operation, and generate enough data on all related performance metrics to compare to your status quo. Second, and related, understand that in this category, the cost of the liquid is only one factor in the overall cost of a cutting operation, and perhaps counterintuitively, a relatively minor one at that. Costs related to ongoing infrastructure and maintenance of the cutting liquid can dwarf the cost of the liquid itself in many instances. Further, impacts on productivity—cutting blade resharpening and replacement costs and related downtime, relative reject rates, scrap and waste costs, supplemental manual labor needed for processes such as deburring or drying if any—and more should be factored into the equation during your trial testing. With experience in aluminum operations using flood coolants, traditional MQLs and hybrid MQLs, setting up the right trials with proper metalworking fluid selection and ROI documentation can arm you with actionable information needed to lower operating costs.

To learn more about how ***ITW Pro Brands*** can help you, contact the ***Metalworking Segment Group or our Technical Sales & Support Team*** today.

Visit ***www.itwprobrands.com*** or call ***1-800-443-9536***.

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