The Most Common Cutting Fluid Problems

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According to the U.S. Census Bureau's 2006 Annual Survey of Manufacturers, there are tens of thousands of machine shops (NAICS 332710) in the United States. Together, they employ more than 262,000 Americans and add nearly $34 billion to the nation's economy.

These shops typically perform a variety of machining operations for different industries using a wide range of materials. As a result, they face diverse operational and metallurgical challenges. Additionally, their customers often demand short production runs and fast turnarounds, and they must be able to customize and deliver high-quality end products.

Job shops also have unique needs when it comes to metalworking fluids and lubricants. But until recently, they were forced to use products and services designed for larger production plants, which often did not address their most common problems.

A unique offer now available from Castrol and its distributor network provides job shops with a solution specifically designed to increase finished-product quality, reduce costs and risks, and provide the fastest, most streamlined operation possible. In addition, it offers the technical support required to optimize productivity and solve problems rapidly.

The most common cutting fluid problems encountered by job shops typically fall into the following five areas: foam, corrosion, residues, odor and dermal irritation.

In this article, we discuss foam and corrosion. We'll cover the remaining cutting-fluid problems in a future installment.

Foam

Foam is created by the entrainment of air within a fluid by either a mechanical or chemical process – or, in rare cases, by both. The first step in solving foam issues is to determine which process is creating the problem.

To determine if the root cause of your foam problem is mechanical or chemical, place an adequate amount of fluid from the machine tool's sump in a covered clear container and shake the sample vigorously for 10 seconds. After shaking, watch how the foam responds. If there is a significant layer of foam that does not dissipate quickly, the issue is chemical. If there is no significant foam layer, or the foam dissipates rapidly, the issue is mechanical.

Mechanically Caused Foam

If the shake test showed the issue is mechanical, the first thing to investigate is whether low fluid levels in the reservoir are causing pump cavitation. A simple inspection of the reservoir while the system is running will determine if low volume is the root cause. Ensure that the pump intake is sufficiently covered with fluid and the reservoir is filled to normal operating level.

The second item to investigate is whether a crack or leak in a pump's housing or intake piping is allowing air entrainment in the fluid. Again, make a thorough inspection of the system and its components. If any cracks or leaks are identified, repair or replace the components as required.

Finally, inspect the system for any areas that generate excessive agitation. These include sharp corners in return flumes, significant pipe-diameter reductions, coolant waterfalls, high fluid velocities and high outlet pressures. Often, simple changes in machine design, such as inserting a metal plate to reduce a waterfall to a consistent return stream,

will eliminate the foam issue. If new processes require or demand high fluid velocities or fluid pressures, it may be necessary to convert to a product that is compatible with those operating parameters.

Chemically Caused Foam

If the shake test showed a significant layer of foam that remained, you should investigate the chemical issues creating the foam.

First, investigate the source of water used to dilute your cutting fluid. A simple water-hardness test will indicate if you need to make adjustments. A hardness level less than 5 grains per gallon is considered soft. With some products, soft water will increase the propensity for foaming, and might require a change in water quality or a different cutting fluid.

If the quality of your make-up water is acceptable, look at the concentration of your cutting fluid. Use a refractometer or titration kit to determine if the concentration is too high. High concentrations (typically > 10%) can increase the potential for foaming. Reduce the concentration by adding water to the system.

Finally, if your make-up water and fluid concentration are acceptable, look for any type of chemical contamination in your fluid system, which can come from the following sources:

- **Incompatible neat oils or water-soluble fluids from prior operations**
- **Machine or process cleaners**
- **Excessive levels of tramp oil (hydraulic oils, way lubes, spindle oils, etc.) from the machine tool itself**
- **Other chemical compounds utilized within the shop**

Besides visually inspecting the fluid or using fluid-handling systems, you can use a pH test – using test strips or an electronic pH probe – to quickly determine if cleaners or high-alkalinity chemicals are contaminating the fluid system. Once the source of contamination is found, make the changes necessary to eliminate or reduce the impact. Often, the contaminating fluid can be managed with tankside defoamers and will dissipate over time; however, if immediate improvement is necessary, a dump and recharge is required.

As a final note regarding foam issues, the use of high-pressure, through-the-tool coolant systems increases the demand on your cutting fluid, making it even more important to select fluids designed to handle this extreme environment.

Eliminating foam issues with your cutting fluids not only provides increased performance for your machine tool and higher throughput, it makes for a much happier operator.

Ferrous Corrosion, or Rust

Corrosion, commonly referred to as rust, is an electrochemical reaction between a substrate – typically a metal surface – and its environment. Rough estimates peg the annual costs of corrosion to U.S. industry at greater than $300 billion. For manufacturers, costs associated with corrosion stem from re-work, scrap, downtime, reduced machine tool and component longevity, lost sales and damaged customer relations.

In general, three elements are required for corrosion to occur: oxygen, water and a metal surface susceptible to corrosion. Since all three elements are required to produce corrosion, eliminating any of the three theoretically eliminates corrosion. All metalworking fluids offer some degree of in-process corrosion protection to the workpiece, the tooling and the machine tool components themselves. The degree of protection, however, can vary widely among different products and product types.

Metalworking fluids generally provide corrosion protection by blocking oxygen or moisture from the metal surface. This is commonly accomplished by utilizing organic, polar molecules to adhere to the metal surface, or by leaving a residual film coating. Most metalworking fluid suppliers use a standard cast-iron chip (CIC) test (typically ASTM D 4627 or variant) to rate corrosion protection of their products. A product providing a CIC result of 3% or less, which means the fluid sample tested does not see corrosion until fluid concentration drops below three, is generally viewed as offering good corrosion protection.

Corrosion appears in a variety of forms, depending on the metallurgy of the substrate and the root cause of corrosion. We will focus most on "red rust" – the corrosion of ferrous metals that occurs subsequent to machining or grinding operations.

Causes of Corrosion

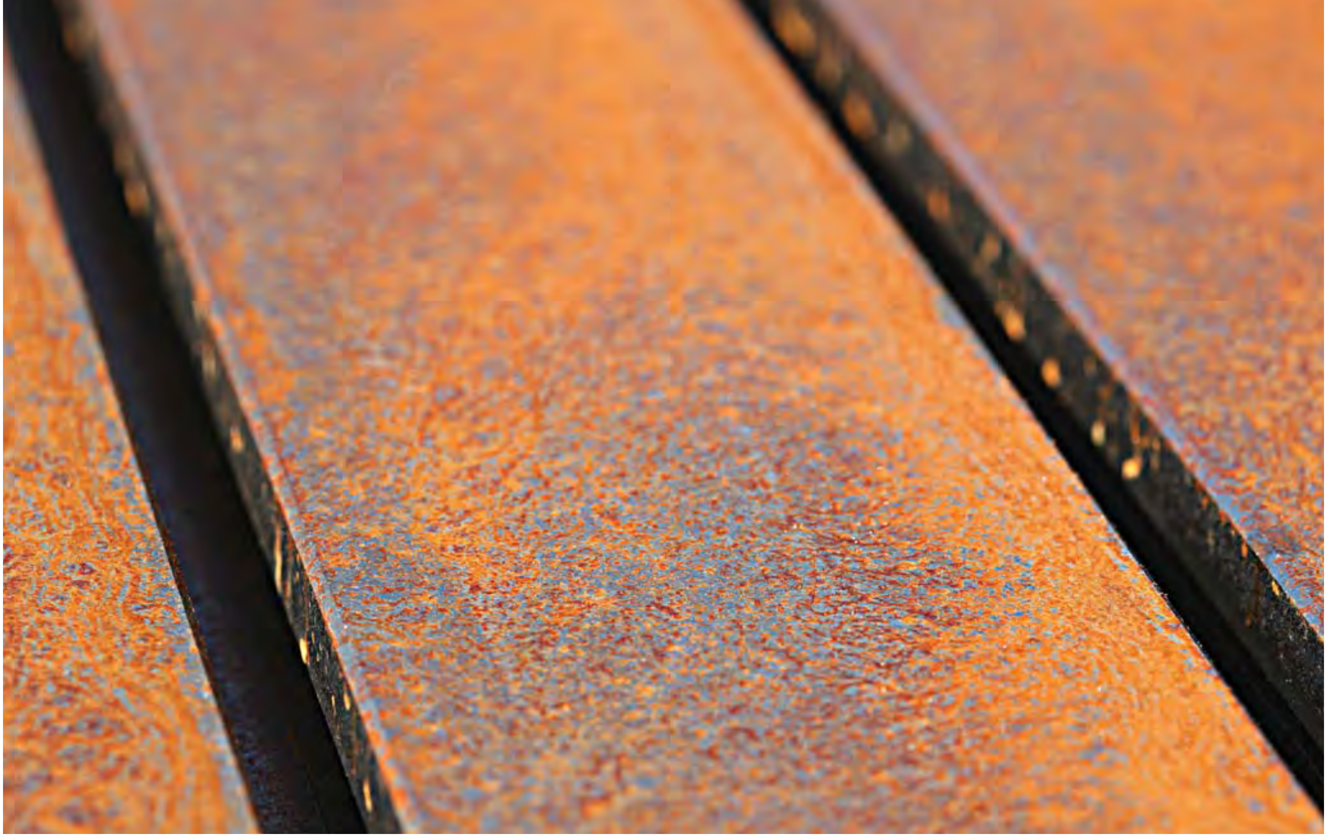
When corrosion occurs in a machine shop, myriad factors must be analyzed to determine the root cause and subsequent corrective action. It is important to investigate all potential causes, as corrosion is commonly caused by several factors.

The concentration of your metalworking fluid is the first item to investigate. Use a refractometer or titration kit to determine if there is sufficient concentrate in your sump.

When concentration levels are low, the components in the fluid that provide corrosion protection are insufficient to protect the metal surfaces. For most metalworking fluids, low concentrations are those generally below 4%. If concentration is lean, simply add sufficient concentrate to bring the system within the recommended range.

If the concentration is acceptable, check for dissolved minerals and ions in the solution. Pitting is the most common type of corrosion when metalworking fluids contain excessive minerals and ions. Simply thought of as dissolved salts in your coolant solution, these minerals and ions usually come from the make-up water used for dilution. The dissolved salts introduced with the initial charge are augmented through additions of make-up water. Because the salts do not evaporate with the water, they remain in the system, resulting in a gradual buildup of water hardness and ions. Depending on your water quality and make-up rates, hardness and ion levels can increase three to four times in a month. Use a hardness test strip to determine if your combined levels of calcium and magnesium are too high. A hardness level greater than 25 grains per gallon significantly increases the potential for corrosion.

In addition to water hardness, other dissolved ions increase the potential for corrosion on machines and parts. One of the most common is chloride. Use a chloride test strip to determine if your chloride level is too high. Laboratory



tests show that corrosion becomes increasingly likely when chlorides are above 300 ppm.

If the concentration and mineral levels are acceptable, check the fluid's pH. Ferrous metals corrode much faster in lower pH environments. Most metalworking fluids are designed to have a pH of 8.0 to 9.5, partially to assist in corrosion protection. Use a pH strip to determine if the fluid's pH is too low. Your metalworking fluid supplier can provide the typical pH for your product. A fluid pH below the recommended range can be caused by several factors, including lean concentration, the presence of bacteria and contamination. Use a bacteria dip-slide to determine if bacteria is present in your fluid. If high levels of bacteria (typically > 105 on the dip-slide) are present, the system should be treated with biocide, or dumped, cleaned and recharged.

If concentration, mineral levels and pH are acceptable, check for high levels of metal particulate in suspension, or a fluid reservoir full of chips and swarf. Re-circulating metal fines in solution, and subsequently depositing these fines on a freshly machined metal surface, typically results in pitting corrosion. These fines increase the amount of metal-to-metal contact, trap moisture on the metal surface and interfere with the metalworking fluid's ability to form a uniform corrosion-protective layer. To check for high levels of particulate in solution, simply fill a clear sample bottle with fluid from the nozzle, allow the sample to sit for several minutes, and observe the bottom of the bottle for settled particulate.

To determine if your reservoir is full of chips, simply use a dip stick to check for chip build-up. Be sure to check various areas of the tank, especially those areas near the fluid return and pump intake. In many cases, if the fluid or reservoir is filled with chips, it is not necessary to dump the metalworking fluid. The fluid can be filtered back to optimum condition. If filtration is unavailable, pump the fluid to clean holding vessels, remove the chips from the reservoir, allow the suspended particulate to settle from the fluid, and pump the "clean" fluid back into the machine.

Finally, if none of the above situations apply, inspect the storage and operating conditions of the facility. Any of the following conditions will increase the likelihood of corrosion:

- **Wet parts in contact with one another**
- **Hot, humid atmospheric conditions**
- **Acidic fumes from other plant operations, such as heat treating or pickling**
- **Improper machine tool grounding**

Corrosion issues are often the most difficult and costly problems to resolve. Many shops dump and replace their metalworking fluids regularly to solve the problem, only to have corrosion re-emerge several months later. Utilizing the approach above can help identify the root cause of corrosion, and eliminate the problem permanently.

In a future article, we will address the remaining three fluid problems: residues, odor and dermal irritation.

For more information regarding Castrol's Job Shop Offer, including product data sheets and case studies demonstrating how others have solved the most common fluid problems, visit www.castroljobshop.com.