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Treat MWFs Right

Water treatment is necessary for water-soluble metalworking fluids.

Milacron

Water can constitute up to 99 percent of a water-soluble metalworking fluid. Untreated water always contains impurities. If these impurities react or combine with an MWF's ingredients, it can change the fluid's performance characteristics.

Accordingly, water treatment often is necessary to obtain the full benefits of a water-soluble MWF.

Water quality varies with the source and the season. It may or may not contain significant amounts of dissolved minerals, dissolved gases, organic matter, microorganisms or a combination of these impurities. In most cases, to estimate the effect of water impurities on an MWF mix, you need to measure the following:

- total hardness;
- pH;
- P and M alkalinity; and
- chloride, sulfate and phosphate contents.

Total Hardness

Total hardness has perhaps the greatest effect on an MWF mix. Hardness comes from dissolved minerals, usually calcium and magnesium ions. It is reported in ppm of calcium carbonate ($CaCO_3$). The ideal hardness of water used for making an MWF mix ranges from 80 ppm to 125 ppm. By comparison, "soft" water has less than 100 ppm $CaCO_3$, while "hard" water exceeds 200 ppm.

When the mix water has a total hardness of less than 75 ppm, the MWF may foam—especially in applications where there is high agitation. Typically, soluble oils and semisynthetics foam more readily in soft water.

Foam causes problems when it overflows the reservoir, the machine and the return trenches. It may also interfere with settling-type separators, because foam suspends swarf and prevents settling, obscures the workpiece and diminishes the fluid's cooling capacity.

After exposing an MWF to chips, dirt and tramp oil for a few days, foam tends to dissipate. If waiting that long is impractical, inspect the system for physical conditions that can contribute to excessive foam: sharp hose turns, high-pressure nozzles and malfunctioning pumps. If these are not the source of the problem, you can decrease foaming by adding foam depressants, chemical water hardeners or antifoam agents to the mix.

Hard water, when combined with a water-soluble MWF, promotes the formation of insoluble soaps. The dissolved minerals in the water combine with anionic emulsifiers in the fluid concentrate to form insoluble compounds that appear as scum in the mix. Such scum can coat the sides of the fluid reservoir, clog pipes and filters, cover the machine with a sticky residue and cause gages to stick.

Soluble oils typically have the least stability in hard water of any water-soluble MWF. Therefore, hard water has a more detrimental effect on them. Separation of the mix is apparent in severe cases and is characterized by an oil layer rising to the top of a fresh mix.

Semisynthetic and synthetic MWFs may not be visibly affected by water hardness. Some are formulated to tolerate hard water. However, dissolved minerals can react with fluid ingredients other than emulsifiers. These reactions with fluid ingredients can negatively affect the fluid's performance.

Dissolved mineral content increases in an MWF with use. This is a result of the "boiler effect" that exists in a fluid reservoir, wherein water evaporates and leaves dissolved minerals behind. Then, makeup water (usually 3 to 10 percent per day) introduces more dissolved minerals. After 30 days, the minerals in the mix can increase three to five times the original amount.

Alkalinity

The pH level indicates whether a substance is acidic, neutral or alkaline. A pH of 7 is neutral, below 7 is acidic and above 7 is alkaline (basic). Water in the U.S. normally varies from 6.4 to 8.9 in pH, depending on its source.

The buffering ability of an MWF is far greater than that of any clean water supply and, therefore, pH adjustments to the water are rarely needed.

Two kinds of alkalinity exist in water: P and M.

P alkalinity is the measure of the carbonate ion (CO_3^{2-}) content and is expressed in ppm of calcium carbonate. This is sometimes referred to as permanent alkalinity, because it is not changed by boiling.

M alkalinity is the combined measure of the carbonate ion content (P alkalinity) and the bicarbonate ion (HCO_3^-) content. This value is also expressed in ppm of calcium carbonate. It is referred to as total alkalinity and temporary alkalinity. This is because its value can be lowered to that of P alkalinity by boiling.

MWFs typically perform best when their pH is between 8.8 and 9.5. They require a certain amount of alkalinity to ensure good cleaning action and to control corrosion and rancidity. If pH and total alkalinity become too high, however, pitting and staining of nonferrous metals may occur. Operators may also experience skin irritation.

Chloride, Sulfate and Phosphate

When chloride ion (Cl^-) content is high—above 50 ppm—in the water mixed with an MWF, it is more difficult for the product to prevent corrosion. Richer concentrations of the MWF mix may counteract the effects of chloride in some instances. In others, excessive chloride ions must be removed from the water by demineralization prior to use.

Sulfate (SO_4^{2-}) ions also affect the ability of an MWF mix to prevent corrosion, though not as much as chloride ions. In addition, they can promote the growth of bacteria and residues. If sulfate ion content exceeds 100 ppm, richer concentrations of the fluid may improve corrosion and rancidity control.

Phosphate ions (PO_4^{3-} and others) contribute to total alkalinity and can stimulate microbial growth, leading to rancidity problems. Phosphate ions in the water should be removed by demineralization to prevent these problems.

Water Treatment

Two processes are commonly used to treat hard water: water softening and demineralization. The chemistry of the water, water-quantity needs, water-quality requirements, and capital and operating costs are all considerations in selecting a suitable treatment method.

With water softening, water passes through zeolite (a softening agent), which exchanges calcium and magnesium ions for nonhardening sodium ions. The total amount of dissolved minerals does not decrease, but sodium ions do not promote the formation of insoluble soaps.

The softening agent does not remove corrosive, aggressive negative ions, such as chlorides. They can build up in the fluid mix, leading to corrosion or salty deposits. Accordingly, the use of "softened" water is not recommended with water-soluble MWFs.

Demineralization is the recommended treatment method. Either deionizers or reverse-osmosis units can be used to remove dissolved minerals. Deionizers remove some, or all, types of dissolved minerals by directing the water through resin beds. Usually, a two-bed deionizer demineralizes water to a sufficient degree. A more expensive mixed-bed deionizer would be needed to obtain pure water.

Reverse-osmosis units remove dissolved minerals by forcing water through a semipermeable membrane under high pressure. Typically, this method removes 90 to 95 percent of the dissolved minerals.

These deionizers cost less than reverse-osmosis units but are more expensive to operate. Deionizers can provide higher-quality water, but the resin beds must be regenerated frequently. If not, water quality deteriorates and the resin beds can promote massive bacteria growth.

A reverse-osmosis unit does not require regeneration. But, depending on the quality of the water fed into the unit, it may require membrane replacement over time.

The use of a pretreatment system, prior to either a deionization or reverse-osmosis process, usually lengthens membrane life.

Either method of demineralization can lead to foaming when initially charging an MWF system. To avoid foam, the initial charge can be made with untreated water, except in cases where dissolved mineral content is excessive, and subsequent makeup could be mixed with the demineralized water. Chips, grinding grit and debris will eventually add impurities to the initial charge, but the amount is insignificant compared to using untreated water for the daily makeup.

The most significant point to remember about water-soluble MWFs is that their performance can be enhanced—or inhibited—by the water used to make them.

About the Author

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