Metalworking Fluids and Water Quality

Using the best quality raw materials possible to make your product is always a wise choice. With water representing more than 90% of a metalworking fluid (MWF) working solution, water quality is critical to ensuring the best possible working solution.

First, let's look at how good water is from a metalworking fluid point of view. It is water that:

- Has low levels of bacterial contamination. Tap water from a municipal treatment plant will typically have between 10^2 and 10^4 bacteria. Industrial well or ground water (from the fire fighting pond out front) can have a far greater concentration of bacteria.
- Is free of suspended particles. It is not unusual for suspended materials to be in water sources. We frequently find sand and other contaminants in well water, and "rust flakes" in city water after they have flushed the fire hydrants.
- Has few, if any, dissolved minerals or other chemicals in the fluid. The dissolved minerals (cations) can generate all types of problems chemically; but we also find high levels of nitrogen from fertilizer run-off, etc. These types of chemicals can create many different problems.

Now the first two just make good sense on an intuitive level but the third requires some explanation. This explanation will require that we look both to the nature of metalworking fluid formulation and at the electrochemistry of corrosion.

Much of the "performance critical chemistry" in metalworking fluid concentrates is anionic (having a negative charge or valence) in nature. When these chemicals come in contact with cationic ions (having a positive charge or valence), they react. When the cations are multivalent (having more than one positive or negative charge), the resulting compounds are often not water soluble. When we are working with aqueous (water based) chemistry, like the typical water dilutable MWF, this renders these compounds less effective or sometimes totally ineffective. These water insoluble compounds are often the basis of some of the nastier residues found in the machine environment.

Typical examples of the types of anionic chemicals found in MWFs include:

- Surfactants
- Emulsifiers
- Corrosion inhibitors
- Antioxidants
- EP additives

While there are many sources of cations in the machine shop, the single largest source is typically the water that is used to mix the metalworking fluids themselves. Typical "city" water contains some amount of dissolved calcium (Ca^{++}) and magnesium (Mg^{++}) from contact with these minerals in the soil as it makes its way through and across the earth. It is not uncommon to find a variety of other metals, such as iron (Fe^{+++}), zinc (Zn^{++}), and copper (Cu^{++}) from plumbing and other sources.

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This reaction phenomenon is most easily observed in soluble oils. Once the cations react with the anionic emulsifiers, the emulsion becomes unstable and will tend to split. This causes very high concentrate usage and poor product performance.

In effect you are using the MWF chemistry to "soften" the water and there are better and substantially less expensive ways of doing that. The picture before offers a classic demonstration of this "splitting" phenomenon. The graduated cylinder on the right is a 10% soluble oil emulsion in 0 grain water and the cylinder on the left is the same product mixed in 30 grain water. Which would you rather use for machining?

Nearly all corrosion that occurs in the metalworking environment is galvanic in nature. The minerals in water increase the ability of the fluid to conduct an electrical current (increase the conductivity of the water or fluid). This increase in conductivity places a bigger load on the corrosion prevention chemistry built into the fluid, increasing the probability it will fail. In this same vein, halide ions, particularly chlorine, are known to contribute to corrosion problems on many of the white and yellow metals. This chlorine should not be confused with the chlorine that would be added as a part of the EP system.

It is important to understand that a machine coolant sump acts like a "still" or a "tea kettle"; the more the fluid is circulated, the more water evaporates. As this occurs, the concentration of minerals in the water phase increases since they do not evaporate. It would not be unusual for the mineral content of the MWF in an individual sump to increase by a factor of four in one month; and in the case of a heated parts washer, this can happen in less than a week. This is often the source of "white water spots" seen after washing. It doesn’t take long for water that "isn’t too bad" to begin generating real problems.

The better the quality of water you use for makeup, the better the final product will be. As a practical matter, any time the water is harder than 5 to 7 grains, better quality water begins to make very good financial sense in terms of concentrate purchase savings. Depending on what the critical parameters of the fluid are, it is not unusual to save between 0.5% and 1% of the MWF concentrate for each grain of hardness removed. The more critical the operation and the more important the fluid performance, the more benefit you will get from 0 hardness water. "Poor quality" water or the lack of "good quality" water is one of the major MWF failure mechanisms.

Good quality water has many other uses in the industrial environment, including:

- Mixing washing compounds and water-based rust preventatives
- Mixing paint and coating chemicals
- As circulation water for induction heat elements
- Boiler water
- Make-up water for industrial batteries e.g., fork truck batteries
- Water for the wire EDM machines

There are many sources of good quality industrial water including:

- Getting lucky and obtaining it from the city tap
- Reverse osmosis units
- Distillation
- Deionization
- Exchange tank units
- Owning your own plant

NOTES:

1. The "hardness" of water is calculated on the basis of 17.1 parts per million (ppm) of calcium carbonate per U.S. gallon as being one "grain."
2. Hardness in "city water" is caused almost entirely by calcium and magnesium ions. One grain of US water hardness equals 17.1 ppm.
3. One degree of hardness on the DIN scale is equal to 17.9 ppm.

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