Technical Bulletin

Metal Removal Fluids and Corrosion

When dealing with the "corrosion issue" and metalworking fluids, it is very important to differentiate between corrosion, staining, and residue as they often get "lumped" into the same basket on the shop floor. However, they are very different when it comes to fixing the issue.

Corrosion is the wearing away by chemical or electrochemical action of a metal. The most well known form of corrosion is the rust that we see on ferrous (iron containing) material.

Staining is often included with, or as a part of corrosion as it can occur by many of the same processes but does not cause a dimensional change.

Residue is what material is deposited on the surface that changes its appearance or dimension but may be removed.

There are many different ways of classifying types of corrosion. The most basic one divides corrosion into those types of corrosion that are influenced by "other" processes, e.g. erosion or stress corrosion, and those that are not, e.g. pitting corrosion. Alternatively they can be divided into corrosion that is "wet" or "dry". The next level down is to talk about corrosion in terms of location or source:

1. Uniform Corrosion
   a. Aqueous Corrosion
   b. Atmospheric Corrosion
   c. Galvanic Corrosion
   d. Stray-Current Corrosion
   e. Molten Salt Corrosion
   f. Liquid Metal Corrosion
   g. High-Temperature Gaseous Corrosion
2. Localized Corrosion
   a. Pitting Corrosion
   b. Crevice Corrosion
   c. Filiform Corrosion
3. Metallurgically Influenced Corrosion
4. Mechanically Assisted Degradation
   a. Erosion
   b. Fretting Corrosion
   c. Fretting Fatigue
   d. Cavitation Erosion
   e. Water Drop Impingement Corrosion
5. Environmentally Induced Cracking
   a. Stress Corrosion Cracking (SCC)
   b. Hydrogen Damage
   c. Liquid Metal Induced Embrittlement
   d. Solid Metal Induced Embrittlement
6. Microbiologically Influenced Corrosion (MIC)
   a. Biofilm Corrosion
   b. Bacterial Corrosion
   c. FungalCorrosion

Obviously not all these types of corrosion are present or even possible in the typical metalworking environment but it is important to at least be aware of all the types and forms that corrosion can take. In understanding corrosion it is also important to understand that:

- It is unusual for only a single type of corrosion to be present. More often than not, more than one type of corrosion is present in a practical situation.
- While there may be a single thing that can be done to stop or mask the corrosion, often there are multiple contributing causes to the corrosion issue.
- It is nearly impossible to work with any metal and not have some corrosion present. The very act of exposing a freshly cut metallic surface to air will cause it to oxidize (corrode). The issue for industrial manufacturers is to keep it within acceptable levels for the specific situation.
- Nearly all corrosion in an aqueous environment has a galvanic component.

All metal removal fluids are to one degree or another electrolytes (fluids that conduct electricity) and as such tend to facilitate galvanic corrosion.

Metalworking fluids are formulated to reduce the corrosion problems associated with machining metals in a conductive environment. However, there are many things that can be done to improve or maintain the corrosion prevention that was formulated into the fluid by the manufacturer. These things include:

- Control/maintain the concentration of the working solution at the appropriate level. The amount of corrosion inhibitor available in any given fluid is directly related to the concentration of the working solution.
- Properly mix the fluid. Whenever possible, particularly for emulsions, the coolant concentrate should be added to water and then the pre-mix solution added to the working solution in the sump.
- Water can be a major contributor to conductivity (the ease with which a material conducts electricity). Pure water (0 grains of hardness) from whatever source is the best choice. Soft water (water that has been treated with a water softener) can generate very specific corrosion issues because of the addition of chloride ions (Cl-) which can be major contributors to corrosion issues.
- Get the chips out of the system as quickly as possible. The chips represent a very large surface area for their mass and as such use up more corrosion inhibitor than would a similar mass of solid "piece part".
- Maintain and control the pH of the working solution at the proper level for the fluid in use and the material

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being machined.
- Select a fluid with the appropriate levels of corrosion inhibitor for the materials being machined. For example, a fluid optimized to machine cast iron probably has yellow metal corrosion inhibitors in it to protect the brass and copper parts on the machine. It probably does not have enough yellow metal corrosion inhibitor to properly protect the chips and parts on a machine that runs brass full time.
- Insure that the machine tool and all of its components are properly "grounded".

Preventing corrosion or more properly controlling corrosion at an acceptable level involves continual vigilance as it is much easier to prevent it from happening than fix the results and "the Devil is in the details".

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