# Technical Resource

## AN INTRODUCTION TO METALWORKING FLUIDS

Metalworking fluids are represented by a wide variety of liquids used in the processes associated with reshaping metal objects into a desired form. They have evolved significantly over time to enhance particular performance characteristics and to alleviate health, safety and environmental concerns.

The use of metalworking fluids can be traced back at least as far as the 16th century, and probably reaches back much further. The use of whale oil or animal fat and water were replaced with products derived from petroleum driven by the requirements associated with the development of the automotive, aerospace and other industries.

The main purposes of these fluids is to ease the manufacturing of metal components by providing lubricity, temperature moderation, corrosion inhibition and metal fines removal. These qualities are of great importance in the metalworking processes classified as cutting, abrading and metal forming.

We may loosely define cutting to include processes that separate metal chips from the work piece. Examples of cutting processes would be milling, drilling, turning, boring, threading, broaching and sawing. Abrading (rubbing the surface to a more refined finish) processes would include lapping, polishing and grinding. Metal forming (changing the shape by pressure) is represented by processes such as stamping, drawing, rolling, forging and extrusion.

In the cutting and abrading processes, lubrication is an extremely desirable trait to have in a metalworking fluid as it prevents galling, tool chatter and seizing in the metal-to-metal contact area between the tool and the work piece.

Temperature moderation, through cooling of the tool-work piece interface, is another leading factor in determining the appropriate fluid for a particular application. The removal of heat stabilizes both the tool's and the work piece's surfaces.

Together, cooling and lubricity provide longer tool life, narrower tolerances and a better surface finish.

Other advantages of the correct metalworking fluid are a cleaner cutting area (with the flushing-out of accumulated metal chips and fines) and the benefit of corrosion mitigation on the machinery and work piece with a rust preventative additive. It should be kept in mind that the rust inhibitors in metalworking fluids are there to help with corrosion inhibition during in-process steps and should not be considered as a long-term protection solution.

No metalworking fluid is applicable to every application, in fact they are specifically formulated for particular applications, processes and metal types. These products are generally defined by the process in which they are used. For instance, a cutting fluid or coolant often functions in both

capacities. The nomenclature depends on the context in which it is used. Fortunately for our purposes, most of these products will fall into one of four classifications.

**1. Straight Metalworking Oils**
Straight metalworking oils are mineral, vegetable or canola oil based fluids that contain no water and may contain various additives which promote better wettability and lubrication (such as EP, extreme pressure additives). They are generally used in low speed applications and with difficult to machine metals such as stainless steel. The advantages of straight oils are very good lubrication, little chance of skin irritation, good corrosion protection and easy maintenance. The disadvantages are poor heat removal, high viscosity, flammability, potentially hazardous mist and they tend to be expensive.

**2. Emulsifiable Oils**
Emulsifiable (also called water soluble) oils are not truly water soluble but are actually an emulsification of the oil in water. This means that the oil is separated into very small droplets and uniformly dispersed throughout the solution. When added to water they will turn milky white. Emulsification is achieved by introducing an emulsifier which reduces the surface tension between the water and the oil, allowing the oil to be dispersed. Like other metalworking fluids, they contain additives to reduce foaming and improve performance characteristics. Advantages of emulsifiable oils include good lubrication, good heat removal (water has excellent cooling capabilities but it also is a corrosion promoter), they have some corrosion protection potential, they are less of a skin irritant than metalworking fluids that contain no oil (oil lessens the chance of the skin drying out, dermatitis), they are not flammable and are relatively inexpensive. Some of the associated disadvantages are that they require more maintenance and anti-bacterial packages (biocides inhibit the growth of bacteria, fungus and mold), they are sensitive to hard water, have an irritating mist and are susceptible to contamination from foreign oils (such as tramp oils which could be lubricants and hydraulic fluids from the metalworking machinery).

**3. Semi-synthetic Metalworking Fluids**
Semi-synthetic metalworking fluids are water-based products that incorporate both oil emulsions and synthetic lubricants. Because they contain both oil and synthetic components, they have some of the advantages and disadvantages associated with emulsifiable oils and synthetic solutions. This means they offer improved cooling capability (compared to straight oils), easier maintenance (than emulsions) and improved corrosion resistance (when compared to a fully synthetic product). Semi-synthetics represent the most widely used category today. Disadvantages are relatively poor stability in hard water, some potential for irritation and they are susceptible to contamination from foreign oils.

**4. Synthetic Metalworking Fluids**
Synthetic metalworking fluids are also water-based products that are composed of synthetic lubricants, various performance-enhancing additives and no oil. They are supplied as a concentrate and mixed with water prior to use. Some advantages are lower shipping cost, very good cooling ability, good lubrication, easy maintenance, good stability in hard water, fair corrosion resistance and may lessen mist concerns. Disadvantages are a higher cost and they may be prone to causing skin irritation.

As water is such a good means of reducing heat, all coolants are added to and/or contain water. This helps differentiate coolants from cutting fluids.

The importance of maintenance cannot be over emphasized.

Regular testing is an integral part of a good maintenance program. Regular testing includes pH, bacteria count, fungus/mold count, concentration, rust test, percentage solids, water hardness and percentage tramp oil. A metalworking fluid manufacturer/supplier should have an experienced Chemist or Tribologist (Tribology is a branch of mechanical engineering that deals with the design, friction, wear and lubrication of interacting surfaces) that will assist in maintaining your systems and your particular applications.