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Waterbased Metalworking Fluids: Proper Mixing Practices

Introduction

Waterbased metalworking fluids must be properly mixed and maintained in the proper concentration range to maximize performance. When fluid concentrate and water are mixed to charge the machine's fluid reservoir or central system, the fluid concentration must be tested to insure that the starting concentration is correct. The concentration can be measured with a CIMCOOL Refractometer, CIMCHEK™ test strips or a chemical titration method.

Concentration may be expressed as a percentage or as a ratio of the amount of metalworking fluid concentrate to the total volume of mix.

Example: Adding 4 gallons of concentrate to 96 gallons of water = 4% or a 1:25 mix ratio. Typically metalworking fluids are used in a concentration range of 5% to 10%. Ideally the concentration is tested daily and adjustments made as required. Makeup mix may be required daily to replace losses due to evaporation and carry-off.

A "charge" mix ratio is the concentration used to initially fill an empty sump. The "makeup" mix ratio is the concentration used to replace fluid losses due to evaporation and carry-off, and is typically a lower concentration than the charge ratio.

Types of Waterbased Metalworking Fluids

There are three types of water dilutable (miscible) metalworking fluids. They are soluble oil, semi-synthetic and synthetic fluids.

Soluble oil (or emulsifiable oil) fluid is a combination of oil, emulsifiers and other performance additives that are supplied as a concentrate to the end user. Soluble oil concentrates generally contains 60% to 90%[1] oil. They are diluted with water, typically at a ratio of one part concentrate to 20 parts water or 5%. When mixed with water they have an opaque, milky appearance. They generally are considered as general purpose fluids, since they often have the capability to be used with both ferrous and nonferrous materials in a variety of applications.[2]

Semi-synthetic fluids have much lower oil content than soluble oils. The concentrate typically contains 2% to 30%[1] oil. When mixed with water, characteristically at a ratio of one part concentrate to 20 parts water or 5%, the blend will appear opaque to translucent. These fluids have also been referred to as chemical or preformed chemical emulsions since the concentrate contains water and the emulsion or dispersion of oil occurred during formulation, which contrasts with the soluble oil where the emulsion does not form until diluted for use. These fluids usually have lubricity sufficient for applications in the moderate to heavy-duty range (i.e. centerless & creep feed grinding or turning & drilling). Their wetting and cooling properties are better than soluble oils, which allow for faster speeds and feed rates.[2]

Synthetic fluids contain no mineral oil. Most synthetic fluids have a transparent appearance when mixed with water. There are some synthetic fluids that are categorized as synthetic emulsions, which contain no mineral oil but appear as an opaque, milky emulsion when mixed with water. Synthetic fluids have the capability to work in applications ranging from light (i.e. double disk grinding, surface grinding or milling) to heavy-duty (i.e. creep feed, threading & drilling) while the synthetic emulsions can perform very heavy duty operations. Synthetic fluids generally are low foaming, clean and have good cooling properties allowing for high speeds and feeds, high production rates and good size control.[2]

How To Mix Metalworking Fluids

When mixing CIMCOOL®metalworking fluids, we recommend that a proportioner be used to insure that a stable mix is formed at the correct concentration. CIMCOOL® proportioners are available in three models:

1. Mix Master® Automatic Proportioner - mounts vertically to a fluid reservoir wall to automatically mix fluid concentrate with water to a pre-determined level.
2. Mix Master ®II Proportioner - drum mounted that supplies 3 to 4 gallons per minute of premix fluid for individual machine tanks
3. Mix Station® - provides two dilutions of a single metalworking fluid concentrate for the "charging" and "makeup" of a machine tank.

Mixing manually is an option but is prone to errors. Two common errors that often occur which result in improper mix concentration are:

1) Inaccurate estimate of machine tank volume (gallons) causing the wrong volume of fluid concentrate to be added to the water.
2) Incorrect order of addition - adding water to concentrate may form an inverted emulsion (mix), affecting many metalworking fluid performance properties.

If mixing manually is the only option, it is imperative that the fluid concentrate is added to the water and not the reverse.

When adding *"soluble oil"* concentrate to water, the emulsifiers suspend the oil particles in the water, and will form the stable emulsion desired. If the water is added to the concentrate, the emulsifiers "release" part of the concentrate to "grab" for the water. This forms an "inverted emulsion", causing parts of the fluid such as the lubricant package, biocide package or rust inhibitor package to be lost. Some or all of the chemical packages within the fluid may be affected. The mix stability, concentration, and the dye may also be affected by inverting the emulsion. The concentration of the fluid will be less than required and the dye (if the metalworking fluid is dyed) will be partially lost to the floating layer, leaving the fluid a lighter color than would be expected with a properly mixed fluid.

When mixing fluids, manually, in a premix tank or a machine reservoir first, fill the tank half-full with water. Next add the concentrate directly to the water. Then add the remainder of the water to create agitation and allow the fluid to mix thoroughly. Turning on the machine tool coolant pump and circulating the fluid will help to create a uniformly mixed product. Once the product is uniformly mixed, the concentration should be tested using a refractometer, Cimchek™ test strip or chemical titration method. The fluid sample used to check concentration is typically taken at the machine tool fluid delivery nozzle (alternately a representative fluid sample from the reservoir). It is also important to remember that each product will have it's own refractometer "multiplier" or "factor". The factor will be needed to calculate the metalworking fluid mix concentration when using a refractometer. Refer to the CIMCOOL® Product Information Flyer (PIF) for the refractometer factor. Go to www.CIMCOOL.com or contact CIMCOOL Technical Services (513-458-8199) for this information.

Important Do's & Don'ts of Mixing

DO:

- Use a proportioning device to mix and dispense fluid whenever possible.
- Always add concentrate to water when manually mixing.
- Increase fluid concentration by adding concentrate directly to the reservoir in a place that provides good mixing.
- Mix fluid thoroughly before measuring concentration
- Measure the fluid concentration with a CIMCOOL refractometer, Cimchek™ test strip or chemical titration method.

DO NOT:

- Put concentrate into the tank and add water to it.
- Put concentrate in a five-gallon pail or any pre-mix tank and add water to it.
- Mix an "unknown" concentrate into the fluid reservoir.
- Maintain concentration by "sight" or "feel".
- Use water that is colder than 50 degrees F. (Many emulsions are unstable at low temperatures)
- Pour concentrate in the work area of a machine tool, and then turn on the fluid nozzles to mix the concentrate.

Maintaining Concentration & Fluid Volume

Metalworking fluid is "consumed" each day as a result of evaporation, carry off with parts and chips, reaction with hard water, and splashing. On average, consumption from a machine reservoir, on any given day, may be up to 10% of the volume of the tank.

Example: A 100gallon tank that operates for a full day will be reduced to 90 gallons, "consuming" 10 gallons from evaporation, carry-off and splash off. This represents 10% of the volume of the tank. Daily fluid consumption is dependent on the operation, the metalworking fluid type, number of parts processed and other shop conditions that may vary from facility to facility.

It is important to recognize that metalworking fluids contain ingredients that perform certain functions. These ingredients may be:

- Biocides: to combat bacteria and mold growth which cause rancidity
- Rust Inhibitors: to prevent rust on the machine tool, machined part, and the chips/ swarf in the machine tank
- Lubricants: to improve tool life and finish or increase productivity, and
- Antifoam agents: to keep foam from being a problem.

The product ingredients are "consumed" by doing their job and therefore need to be replenished through daily make-up.

Example: When machining cast iron, there is a large demand on the rust inhibitor in the fluid. The rust inhibitor protects the part, the machine and the chips that accumulate in the reservoir. This may deplete the rust inhibitor faster than the lubricant package since these corrosion inhibitors can be used up in the process of protecting the large cast iron surface areas. This is called "selective depletion". Selective depletion can be counteracted through the process of adding daily makeup to the fluid mix.

The following operations are examples of "selective depletion":

- Cast iron: depletes ferrous corrosion inhibitor quickly
- Aluminum: depletes the lubricant package but typically won't affect the rust inhibitor.

- Dirty/oily reservoir: depletes the biocide
- High pressure/high speed operation: depletes the antifoam ingredients.
- Hard water: depletes emulsifiers that hold the product together.

The proper procedure for replenishing fluid volume and maintaining the correct fluid concentration is to add a fluid premix back to the reservoir daily. This mix is made at a lower dilution than the fluid mix used to initially charge the central system or machine reservoir. Do not add water alone.

General recommendations for "makeup mix" (target 5%) concentration:

Soluble oils: daily makeup should be 3%-4%.

Semi-synthetics: daily make up should be at 2% to 3%.

Synthetics: daily make up should be at 1% to 2%.

Note: The values above are only guidelines and the actual makeup concentration required may vary depending on the operation, part configuration, type of fluid, water quality, environmental conditions, filtration system, etc. Even with proper makeup, as fluid ages, there may be an additive required (such as a biocide) to extend fluid life and maintain performance.

What if the Metalworking Fluid Concentration is Too Rich?

If fluid concentration is higher than the recommended level, the concentration must be leaned out. Problems develop with high (or rich) concentrations just as they do when running a fluid too low (or lean).

Attempting to fix the problem by adding only water is not recommended. Only adding water may result in key ingredients becoming too lean, potentially creating an issue such as corrosion, bacterial growth, poor tool life, broken emulsions, etc. The *best* way to address high fluid concentration is to empty part of the fluid tank into a drum or other holding area, and then replace this volume removed with a leaner premix. This will reduce the concentration but still provide the needed performance properties of the fluid.

Summary

Remember that by maintaining the recommended concentration range for your metalworking fluid you will improve the overall performance of the operation, improve productivity, extend fluid life, reduce disposal costs, and improve overall operator satisfaction. It is important to start by mixing the fluid properly as recommended. Routine concentration checks along with proper makeup are essential to good fluid management.

Consult with your regional CIMCOOL® Technical Service Engineer for specific recommendations, or call CIMCOOL® Technical Service at 1-513-458-8199.

[1] G. Foltz, "Definitions of Metalworking Fluids", pp 2-3, *Waste Minimization and Wastewater Treatment of Metalworking Fluids*, R.M. Dick, ed., Independent Lubrication Manufacturers Association, Alexandria, VA, (1990)

[2] A. Ball, "Fluids For Metal Removal Processes", pp 33.1-33.2, *Manufacturing Engineering Handbook*, Hwaiyu Geng, ed., McGraw-Hill Handbooks, New York, (2004)