The mysterious world of MWF additives

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When it comes to evaluating additives used in metalworking fluids, chemists and suppliers take a close look at compatibility and performance issues.

In the June TLT we talked about how metalworking fluids promote tool life by removing heat, lubricating the interface between the tool and the workpiece, carrying away chips and preventing in-process corrosion.

Those are the macro issues. Imbedded in these functions are preventing such phenomena as poor surface finish, chemical attacks on the workpiece, workpiece mechanical damage, metallurgical change to the workpiece, thermal damage and electrical changes to the workpiece.

But these are just the operational parts. In addition, metalworking fluids can contribute to a number of negative phenomena, all of which must be minimized. These include mist leading to respiratory problems; dermatitis; fungal and microbial growth, which can lead to employee health and safety issues; plugging filters and other operational problems.

Speaking as a chemist, this is a formidable set of interrelated and interacting problems. How do chemists balance all these different issues? Aside from choosing from a selection of base fluid materials (straight oils, soluble oils, semisynthetic oils and synthetic oils) and concentration, they use a mystifying array of additives.

What do we mean by additives?

Additives are a chemical component or blend used at a specific treat rate to provide one or more functions in the fluid. Ideally, components are multifunctional and generally used at treat rates from < 1% to 35%. They are soluble in mineral oil, water and, in some cases, both.

Of course, there are many types of additives: boundary lubricity additives, extreme-pressure additives, corrosion inhibiters, reserve alkalinity boosters, metal deactivators, emulsifiers, couplers, water conditioners/softeners (chelating agents), antimist additives, antimicrobial pesticides, antifoamers and defoamers, and dyes. That's quite a list!

Thus, it is easy to understand why chemists look for multifunctional additives and why, with so many different chemicals in a formulation, additive compatibility, both with other additives as well as with the base fluid, is of critical importance.

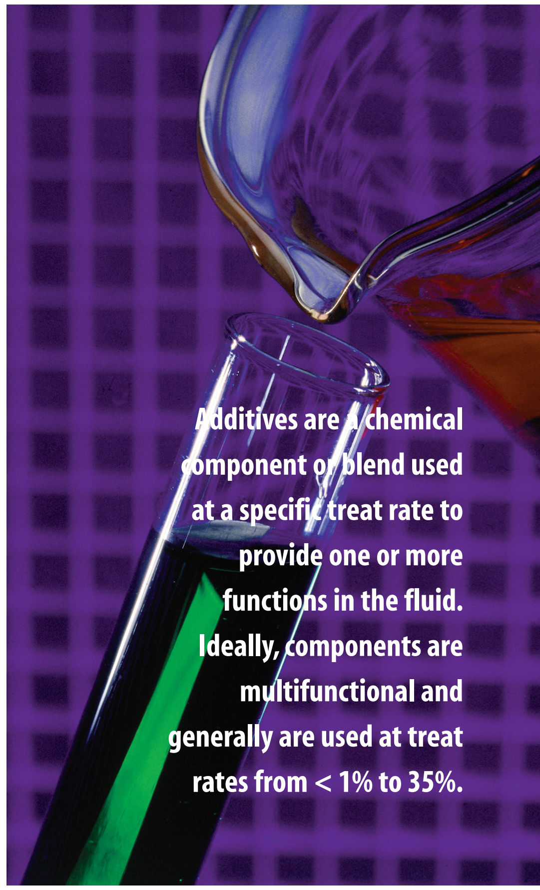
Are you mystified yet? In the future, we will examine biocides and defoamers, but for now let's take a very quick look at the most common of the performance-related additive types.

The world of additives

Boundary lubricity additives enhance the lubricity of the fluid by adsorbing on the surface of the metal to form a film, reducing metal-to-metal contact. These additives typically have a polar group that interfaces with metal and a tail that is compatible with mineral oil or water. Examples are lard oil and canola oil.

Extreme pressure additives are a special type of boundary lubricity additive that actually reacts with the metal surface, instead of adsorbing on the surface, to form a metal salt layer or a physical barrier between the tool and the workpiece under severe metalworking conditions. The layer acts as a barrier to reduce friction, wear and damage. Examples are chlorinated paraffins, sulfurized lard oils, phosphate esters and overbased calcium sulfonates. These additives have different temperatures of activation. Thus, the chemist also chooses the additive according to the application conditions, so that the additive will, in fact, be activated.

Corrosion inhibitors prevent the fluid from corroding the metal workpiece, cutting tool and machine tool. They perform by either forming a protective coating on the metal surface or by neutralizing corrosive contaminants in the fluid. Examples are overbased sulfonates (some of these also can act as extreme-pressure additives), alkanolamides, aminoborates and amino-carboxylates.



Reserve alkalinity additives maintain the fluid's corrosion protection by neutralizing acidic contaminants and by maintaining the pH in a suitable range. These additives also can act as form emulsifiers with other components to stabilize the fluid. Examples are alkanolamines like monoethanolamine, triethanolamine, aminomethylpropanol and 2-(2-aminoethoxy) ethanol.

Metal deactivators prevent the fluid from staining nonferrous alloys (such as copper and brass) and reduce corrosion when dissimilar metals contact each other. They act by forming a protective coating on the metal surface. Examples are mercaptobenzothiazole, tolyltriazole and benzotriazole.

Emulsifiers stabilize oil-soluble additives in water-dilutable metalworking fluids by reducing interfacial tension between incompatible components by forming micelles (a submicroscopic aggregation of molecules, as a droplet in a colloidal system). These droplets then can remain suspended in the fluid. This is what you do when you wash your hands. For example, milk is an emulsion. In metalworking fluids, examples of emulsifiers are sodium petroleum sulfonate and alkanolamine salts of fatty acids.

Couplers assist in stabilizing water-dilutable metalworking fluids in the concentrate to prevent separation of components. Couplers facilitate formation of emulsions for soluble oils. Examples are

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propylene glycol, glycol ethers and nonionic alkoxylates.

Chelating agents (also known as water softeners or conditioners) reduce the destabilizing effect of hard water (calcium and magnesium ions) on metalworking fluid emulsions. Chelating agents bind calcium and magnesium salts to prevent them from reacting with anionic emulsifiers such as fatty acid salts of alkanolamines. An example might be ethylenediaminetetracetic acid.

Antimist additives minimize the amount of lubricant that disperses into the air during machining. They are typically polymers and/or wetting agents. For oil-based systems, ethylene, propylene copolymers and polyisobutenes are used. For water-based systems, polyethylene oxides are typical.

Finally, dyes give the metalworking fluid a specific color type desired by the customer. Their main value is in water-diluted fluids to indicate that product is present, since these can be clear and water-like in appearance. However, dyes often carry negatives as well, as they can stain skin and paint. Some water-soluble dyes are unstable and can change color. And some dyes can pass thru waste treatment systems resulting in pollution downstream.

Clearly, this is quite a list, and the skill of the chemist is needed to keep everything under control. Arbitrary use of additives at the tank side carries substantial risk when not done under the supervision of a chemist familiar with the original formulation. It is important to have a good working relationship with your fluid supplier to know how best to manage the fluids in your valuable machinery.

STLE members who have attained the society's new Certified Metalworking Fluid Specialist certification are aware of these issues and can keep your system in balance and safely working at optimum levels—this is what they do. **<<**

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