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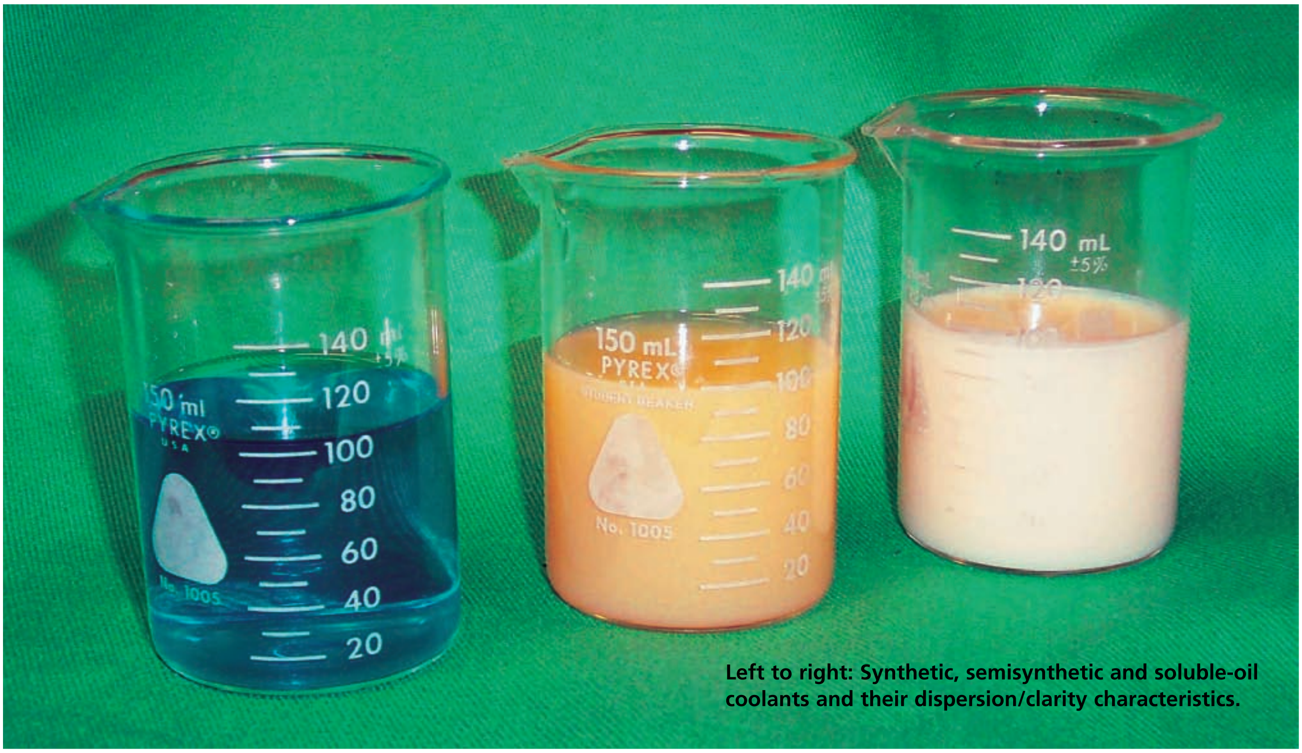
Left to right: Synthetic, semisynthetic and soluble-oil coolants and their dispersion/clarity characteristics.

Pico Chemical

Cool Savings

Replacing soluble-oil coolants with synthetics can save money.

The goal of every facility that uses coolant is to find a product that lasts indefinitely. The economic and operational benefits of this would dramatically impact a company's bottom line.

Even small shops experience serious production losses when they are forced to shut down a machining center for lengthy cleaning of degraded or rancid coolant.

In many facilities, soluble-oil coolants prove costly to use because of waste-treatment and disposal costs. Efforts to reduce these costs by lengthening the coolant's life are ongoing and, in fact, intensifying, because of rising prices and stricter environmental regulations.

Some plants routinely treat their used soluble-oil coolants with chemicals that split the emulsions. Then they send out the waste oil to be "rejuvenated," after which it is returned to the plant for reuse. The fluid and chemical-treatment costs these plants incur are staggering.

Other plants employ evaporators to remove water and reduce the coolant to a disposable sludge. Although this method reduces the volume of fluid for disposal, it generates high energy costs and increases coolant consumption.

The solution to coolant management begins with education, provided by competent coolant suppliers and supported by recycling-equipment manufacturers.

Coolant manufacturers must face today's cost-reduction challenges by producing long-life, high-performance coolants and accepting the trend of users' reducing their coolant consumption. Coolant manufacturers must also be able to supply a single product, or the minimum number of compatible products, for the assorted machining operations performed at many metalworking facilities.

Recycling-equipment manufacturers need to cooperate with coolant suppliers to achieve the most efficient and cost-effective contamination-removal system possible for their customers.

Fluid Types

The three basic types of coolants are:

- soluble oils, which consist of oil, emulsifiers and other extreme-pressure additives that enhance lubricity, corrosion protection, biological control, wetting and defoaming;
- semisynthetics, which are soluble oil and synthetic hybrids typically containing less than 30 percent mineral oil; and
- synthetics, which have no oil and consist of chemical lubricity agents or other additives for corrosion protection, biological control, wetting and defoaming.

Oil-containing coolants are prone to destabilization because of oil's emulsification properties and droplet distribution. Emulsified oil droplets vary in size. The large ones tend to be less stable than the smaller ones. As the soluble oil destabilizes, because of contamination, the larger droplets tend to get even larger and eventually split from the solution. The smaller ones also increase in size. The more oil in the product, the more difficult it becomes for the formulation to remain stable over time.

Efforts to reduce costs by lengthening coolant life are ongoing and, in fact, intensifying, because of rising prices and stricter environmental regulations.

Oil and its emulsification properties have been the traditional "Achilles' heel" of coolant formulations. Oil has remained popular because of its historically low price and effective lubricating quality. But new lubrication technology, rising oil prices and stricter environmental regulations governing oil disposal are driving an attitude change in the marketplace.

Oil-containing coolants are often difficult to mix and emulsify in water, especially if the water is hard. Some soluble oils require special mixing equipment to achieve a decent oil

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Destabilized soluble oil.

"bloom," or dispersion. Using proportioners for mixing is a sound practice to control uniform concentration additions and is encouraged, but semisynthetics and synthetics are much easier to solubilize and disperse in water than soluble oils.

Tramp Oil

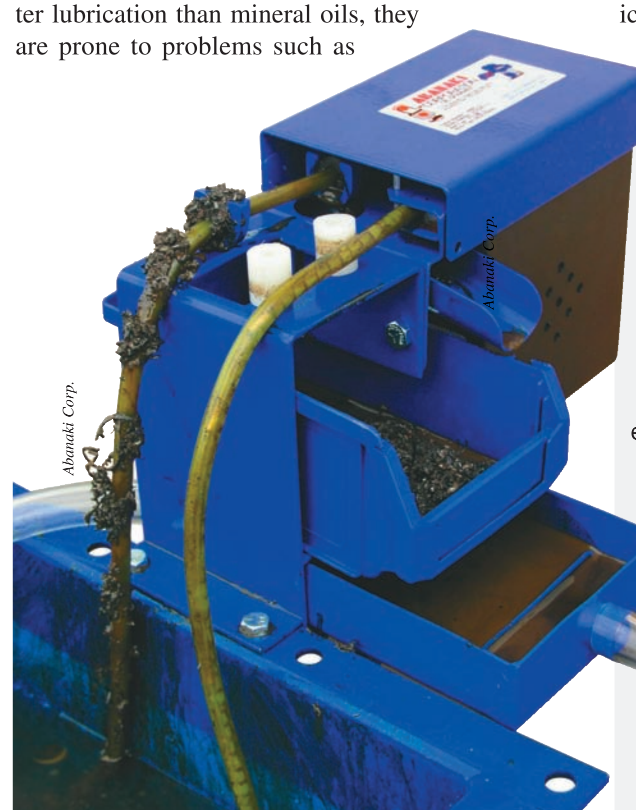
Oil-containing coolants tend to absorb some tramp oil because of the excess emulsifiers built into these products. And, some metal ions can have a negative effect on the emulsifiers and the bond they form with oil. Weak emulsification systems often can entrain metal particles in the coolant, leading to shorter tool life and poorer surface finishes.

Coolant users who have switched from soluble oils to synthetics sometimes are surprised at the increase in tool life and finer part finishes they experience. The reasons for this improvement are new synthetic formulations and more efficient, quicker methods for removing the solids and tramp oil that lead to nonuniform lubrication.

Oil-containing coolants often cannot be treated by microfiltration methods, because the filter will take out the necessary oil along with other entrained ingredients. Because oil-containing coolants often have a wide distribution of oil-droplet-particle sizes and a disparity in electrochemical forces within the fluid, they are subject to the depletion of selected ingredients.

Recently, there has been a movement in the coolant industry to promote micro-emulsion solubles and semisynthetics without petroleum sulfonates. Claims are made that these products are biostable and do not foster foul-smelling, hydrogen-sulfide-gas odors resulting from sulfonate degradation caused by bacterial growth. While these claims are valid in some cases, after prolonged use, the micro-emulsion solutions can foster significant bacterial activity that destabilizes the emulsion and reduces corrosion protection. They also can lead to operational problems such as smoke, oil misting, metal particles being suspended in the solution, oily surfaces, inaccurate refractometer readings and depletion of selected additives.

Another innovation in coolant chemistry is to substitute vegetable oils for mineral oils in soluble-oil formulations. While vegetable oils break down more rapidly when they enter a waste-treatment system, this property promotes bacterial growth in sumps. And although these solubles offer better lubrication than mineral oils, they are prone to problems such as separation and tramp-oil absorption.



Abanaki Corp.

This Chip Grabber removes chips and tramp oil from the coolant.

Vegetable oils are also harder to emulsify and their emulsions tend to exhibit poor stability. As with mineral oils, they can also destabilize due to heat-caused oxidation. This results in oily residues on parts and causes mist to form in the atmosphere.

Synthetic is Better

Compared to other coolant types, synthetics facilitate the removal of tramp oil and solid contamination. They also are more resistant to the negative effects of hard water. Synthetic coolants should be formulated such that hydraulic, gear, spindle and way lubricants readily split from the fluid and, thus, can be easily removed by skimming the top of reservoirs or using gravity separation enhancements.

Synthetics offer another distinct advantage. They can be filtered down to 10µm without losing any constituents. And in critical applications—those requiring ultrafine filtration to prevent the creation of unacceptable surface asperities during machining—synthetics can be filtered down to 1µm.

Properly formulated synthetics have fewer sources for bacteria to thrive on and rarely produce objectionable odors—even after long-term recycling or extended downtimes.

To achieve the ultimate goal of a zero waste stream, or at least significantly reduce all disposable fluid volume, the application of a synthetic needs to be coordinated with the use of all other water-based cleaners and corrosion preventives in a facility. The selection of a coolant should take into account what is coming in from the previous process and where the coolant is going in the next process. Because fluids are carried over from one process to another, even water-based fluids should be recycled.

Earlier-generation synthetics exhibited performance drawbacks, such as limited lubrication capability and the tendency to remove paint, leave sticky residues on surfaces and harm workers' skin. Many of these problems have been overcome. For example, most machine builders now use more chemically resistant paints, such as epoxies. And modern synthetics are able to provide adequate lubrication to allow

Bazell Technologies Corp.

The Microseparator CF85SD is a centrifuge for separating out fines and other solids from coolant, oil or water without the use of a consumable filter media.

the cutting of aluminum and even hard stainless grades.

Although slightly more water tends to evaporate from synthetics, this is not a serious drawback.

A coolant's chemistry, especially its stability under the ever-changing conditions and ingress of contamination, is one of the key elements in developing a sound recycling program. The equipment chosen is critically important to ensure efficient contamination removal without selectively removing any cool-

Recycling considerations

Regardless of the type of coolant being used, cleansing and recycling should be investigated and implemented after coolant cost and other cost considerations, such as downtime and waste disposal, are analyzed.

Setting up a recycling system should be done after in-depth consultation with operational/maintenance management, the fluid supplier and the equipment supplier. The key points to keep in mind as plant personnel plan and execute a recycling program are:

- Keep it as simple as possible; do not overburden shop personnel.
- Make sure everyone understands the objectives and how the program is going to be implemented and function. Although returning the coolant to its original condition is not practical, "refreshing" it is.
- Spell out the responsibilities and duties of each party and make them part of the quality program.
- Make sure communications among plant, chemical and equipment personnel are clear.
- Do a thorough survey of the coolant systems and their locations, the products used and the space considerations so that the coolant can be moved by mobile transport or a pumping and piping system, if necessary.
- Analyze makeup and addition methods to assure that convenience and safety issues are covered.
- Use survey data supplied by manufacturers to determine the optimal coolant for all machining systems.
- Review documentation of coolant practices, experiences and control results, especially any biological activity.
- Have the coolant supplier analyze the process water.
- Make sure the recycling equipment has low maintenance requirements and is compatible with all coolants, if there is more than one.
- Make sure any electrical components are well protected from the coolant's water and the associated vapors. Some separators circumvent liquid-related problems because they run off the compressed air available in many shops.

Lastly, management must commit enough funds for capital investments and manpower to effectively carry out the program.

—J. Manfreda and D. Elenteny

Contamination issues

Any type of coolant could last indefinitely if not for the changes continually occurring while the coolant is in use. These changes include contamination ingress, microbiological activity, water evaporation and nonuniform depletion of coolant constituents. Often the first components to be depleted are those that impart corrosion protection and lubricity.

Sources of contamination are:

- hydrocarbon-based lubricants and process oils (tramp oil);
- metal fines and chips;
- dissolved water constituents;
- biological agents;
- fluids carried in by metal surfaces from previous processing;
- dissolved gases from the air that become entrained; and
- other foreign matter mistakenly introduced into the coolant.

Some contaminants that have an impact on the coolant's life and its continuing effectiveness can be controlled or modified with additives and separation equipment. Others cannot.

Tramp oil may appear in coolants as free floating, mechanically dispersed or emulsified. Primary sources of tramp oil are lubricating oils, grease or oil residues on parts coming into the machining operation. Excessive oil can contribute to misting, residue buildup, odors, grinding burn, nonuniform lubricating action and bacterial growth.

Solid particles, such as metal chips and fines, cast iron dust, rust (iron oxides), plastics, loose fungus, coagulated or clumped grease or sludge, and foreign material, should routinely be removed by filtering, centrifuge, settling, coalescers, dredging, vacuum/pressure, magnetic systems or other mechanical means. These materials can selectively pull out loose, emulsified particles.

Bacterial or fungal growth can be reduced with biocides, fungicides, ozone generators, aeration, ultraviolet light, chemically treated beads and pasteurization. Fungus can create special mechanical problems because of its biomass. Fungus often competes for the same food sources as bacteria. Usually, a coolant is not plagued by both bacteria and fungus at the same time.

Fungus becomes evident when it grows on the walls of sumps near the fluid's surface or in coolant feed lines, and sometimes produces a "sweaty sock" odor. A biomass can turn an oil layer into a mucus-like substance, which can prevent oil from being picked up by a mechanical skimmer. Both mechanical and chemical cleaning is normally required to rid a system of fungal growth.

Extraordinary cleaning agents and methods often need to be employed to effectively and totally remove fungus. Fungus often goes dormant when it encounters harsh cleaners. When conditions become more favorable, fungus re-emerges and recontaminates the coolant. —*J. Manfreda and D. Elenteny*

Contamination effects on coolants

Contaminants	Synthetic	Semisynthetic	Soluble oil	Comments
Water: hardness ions (chlorides and sulfates)	Minimal to no effect on solution, but can help create tacky residues and increase rust potential	Moderate influence on the emulsion and creation of tacky residues and rust potential	Strong negative influence on destabilizing emulsion and increasing rust potential	Water evaporation increases problem; using deionized or distilled water may be necessary
Lubrication oils (tramp oil)	Should readily split from solution	Some splitting and some absorption into coolant promotes bacterial activity	Little splitting and heavy absorption into coolant can replace coolant's oil, strongly destabilize emulsions and promote bacterial activity	Prevent oil from entering coolant and remove by skimming, coalescing, centrifuging as necessary
Chips, fines, abrasives (swarf)	Can be readily separated by filtering, settling, magnets, centrifuges, etc.	Can be separated by filtering, settling, magnets, centrifuges, etc.; very fine swarf can attach to oil particles	Can be separated by filtering, settling, magnets centrifuges, etc.; small particles can attach to oil particles	The finer the particles and the looser the emulsion, the more likely that metal removal becomes more difficult
Organic matter, biological agents from various sources	Usually most components are not attractive food sources and higher alkalinity tends to decrease bio-agents' capacity to thrive	Oil, emulsifiers, fatty substances can be good food sources; alkalinity tends to discourage growth of bio-agents	Oil, emulsifiers, fatty substances can be excellent food sources; bacteria lowers pH and tends to destabilize emulsion and promote rust	Biocides, fungicides and alkalinity boosters may have to be added into the coolant, raising costs and dermatitis potential
Fluids from previous operations	Water-dilutable products mix, oil products tend to split	Water-dilutable products mix, oil products tend to split, but some may emulsify	Water-dilutable products mix, oil products tend to emulsify with some splitting	Fluid entering coolants should be analyzed and coordinated to minimize negative results

ant components.

Some recycling systems are built to minimize oil pull-out from weak emulsion systems by using a "gentle" approach. However, as the emulsion further weakens, oil eventually will stick to parts and equipment with these types of systems.

Newer soluble oils and semisynthetics can be recycled successfully. However, synthetics offer users the best opportunity to develop a successful long-term recycling program and realize indefinite sump life, along with enjoying the benefits of lower consumption costs, cleaner parts and machinery, and reduced biological activity. △

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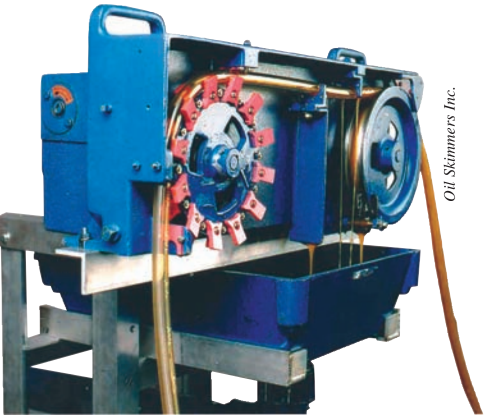

Oil Skimmers Inc.

The Model 6V oil skimmer incorporates a floating tube that removes tramp oil.

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