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Extending the Life of Coolants

Disposal of waste metal working fluids can contribute to water pollution and to solid, and sometimes hazardous, waste streams.

Pollution prevention for metal working fluids or coolants should be practiced whenever possible to reduce the amount of coolants that are disposed prematurely.

Historically, companies have tended to dispose of their coolants or metal working fluids as soon as they showed signs of fouling or decreased efficiency. Much of the time such disposal is not necessary. A thorough management program can indefinitely extend the life of metal working fluids and is profitable for the firm. Firms that practice pollution prevention save on the costs of new materials and on the cost of disposal for used coolant. Considerations for choosing a quality coolant and maximizing the life of coolants are the subjects of this fact sheet.

Why Are Coolants Necessary?

The metal working process creates much heat and friction. If the heat and friction are not reduced, the tools used in the process are quickly damaged and/or destroyed. Also, the quality of the products made is diminished because of inefficient tools and damage to the product while it is being manufactured. Coolants reduce friction at the tool/substrate interface and transfer heat away from the tools and the material being processed, reducing the time to process the metal, increasing the quality of the workmanship, and increasing tool life. The ability to transfer the heat away from the metal working process is why metal working fluids are often called coolants.

Why Do Coolants Work?

Oils are natural lubricants and provide this quality to coolants that are petroleum-based. Other coolants' ability to reduce friction comes from lubricating additives. During the metal working process, heat diffuses into the coolant. The "heated" coolant flows off the work area into a collection container or sump, where it cools off and then enters the cycle again. Water has excellent cooling characteristics and many coolants contain water or are primarily water to cool the machining process. Soluble oils and semi-synthetic oils have both water and oil components. Coolants containing both oil and water require surfactants to form and maintain emulsions, a mixture of the oil and water, so that both properties can work together.

Considerations for Choosing a Coolant

Different metal working processes have varying cooling and lubrication needs. Coolants have many properties that increase their efficiency, extend their life, and minimize the potential to damage tools and products. Therefore, when choosing a coolant, many factors need to be considered. These considerations include:

- Tramp oil rejection
- Ability to settle out solids
- Bacterial resistance
- Corrosion and rust resistance
- Emulsification capability
- Foaming nature and resistance
- Optimal coolant life
- Longevity of coolant as measured against current industrial standards
- Cost of coolant
- Chemical restrictions and reactivity of coolant
- Lubricating quality
- Biodegradability
- Recyclability of coolant
- Capacity of recycled coolant to prevent galvanic attack
- Water compatibility and requirements: pH, deionized water requirements, mineral content and hardness
- History of dermatitis

Coolant Effectiveness

The effectiveness of a coolant for heat transfer and as a lubricant decreases for a number of reasons. Coolants break down in process. They accumulate foreign substances including tramp oil, swarf, dissolved minerals, and/or dirt from the process. These substances prevent the coolant from working. Selective depletion of a fluid component could also reduce coolant effectiveness. For example, swarf is particulate metal created during the grinding or cutting of metals. The presence of swarf creates friction, defeating both the lubricating ability and cooling capabilities of the coolant. The increased concentration of tramp oil similarly interferes.

Water Requirements

Some coolant manufacturers state that their coolant can use any type of water while others specify deionized water or mineral free water. Deionized water does not contain minerals that in time may interfere with the coolant's efficiency. Tap water has minerals and ions in it as well as bacteria. Water based coolants will evaporate while sitting in the sump and vaporize while the coolant is being applied to the metal working process. The minerals present are not evaporated and accumulate in the sump increasing the concentration of minerals in the coolant. If tap water is continually used, the mineral content of the coolant continues to increase. Concentrated minerals can form deposits and soaps, gumming up the metal working process. Tap water may be acceptable for the initial preparation of the coolant but any additional water should be mineral-free (deionized or reverse osmosis processed).

Coolant Deterioration

During the metal working process, the heat of operation and the chemical reactivity of swarf fines initiates degradation of the metal working fluid. The particles chemically interact with the oils in the emulsions, weakening the emulsion and breaking the fluid down to its separate constituents. Swarf also facilitates the growth of the bacteria and fungi that feed on the coolant by providing a substrate for them to grow on. Bacteria use the emulsions, additives and oil for food and similarly contribute to coolant degradation. This is called coolant spoilage. Coolant degradation results in a reduction of the ability of the coolant to lubricate and transfer heat away from the metal working process.

Microbial Activity

Bacteria and other microbial organisms thrive in the environment created by the impurities in the coolant. They feed upon mineral oils, fatty acids, emulsifiers, corrosion inhibitors, other additives and waxes in oil based and synthetic coolants. The corrosion inhibitors of synthetic coolants, for example, are consumed. Aerobic bacteria require oxygen for metabolism and efficiently destroy the coolant. Anaerobic bacteria grow in environments lacking oxygen. They feed upon the coolant and produce noxious byproducts such as hydrogen sulfide. This is commonly referred to as the Monday morning odor.

Problems Associated With Microbial Spoilage

Microbial action directly affects the coolant resulting in the splitting of emulsions, decreased pH, increased corrosion, degradation of the ingredients in the coolant and a loss of lubricating ability within the coolant itself. Odors may develop including hydrogen sulfide as a product of the bacteria's metabolism. Bacteria may also expose workers to pathogens and contribute to respiratory irritation and skin irritation, like dermatitis. Workpiece quality decreases, resulting in increased surface blemishes, decreased tool life, and increased down time to treat for bacteria and repair the equipment. The bacteria may also cause increased foaming and oil separation in the system and cause clogged lines, filters, and valves.

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Swarf and tramp oil should be removed in process. Chemicals are available that can be added to the coolant to protect emulsions from reactive metal fines and extend the life of the coolant. The presence of swarf and tramp oil creates a habitat that promotes the growth of bacteria. Aerobic and anaerobic bacteria and fungi eat the organic components of the oil and/or emulsions reducing the effectiveness of the coolant. Therefore bacteria and fungi should be removed from the coolant or prevented from growing in the coolant.

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A coolant management system can be incorporated by a business to increase the effectiveness of the coolant by extending its life. In summary:

1. Remove chemically reactive compounds;
2. Remove substances that physically interfere with the coolant;
3. Remove organisms that degrade the coolant;
4. Remove substances that create habitats for destructive organisms; and
5. Initiate a coolant management system for the long term.

Swarf and Tramp Oil Removal

A variety of filter media, filtering devices and oil skimmers exist to remove impurities including swarf and tramp oil from the coolant. Filtering devices include gravity filters or settling tanks, centrifuges, coalescers, reverse osmosis filtration units, and hydro-cyclones. Drum, disc, belt and rope oil skimmers and oil absorbing pillows are commonly used to remove tramp oil from coolant in the sump. A sump and coolant cleaning process are also necessary for long coolant life.

Microbial Control

There are many ways of controlling bacteria. The best method is to not create a habitat conducive to microbial growth. This includes keeping the coolant and the sump free from impurities that create habitats conducive to microbial growth. Microbes can find shelter in crevices, corners, and porous materials that may be hard to clean. The corners of the sump can be rounded to make cleaning easier. A coolant and sump cleaning program helps extend the life of the coolant. Cement sumps and coolant system components should be avoided because bacteria can establish themselves in the pores of the cement and continually infect the coolant. In such a situation, it is impossible to maintain uninfected coolant without replacing the cement sump or blocking it off with a nonporous (and nonreactive) material such as stainless steel. Epoxy coatings may also create a barrier to the bacteria.

One common method to control microbes is by adding biocides to the coolants. Biocides are toxic and kill the bacteria. Many biocides are consumed while killing the bacteria. Therefore, biocides may need to be periodically added to the coolant. If coolants are treated with biocides, additional requirements may exist to govern the coolant's eventual disposal.

Coolants with biostatic properties also may be purchased. They are coolants that are not affected or eaten by bacteria. Many coolants that are labelled biostatic by producers require biocides and therefore are not truly biostatic.

Some coolants may be pasteurized to kill bacteria. Another method is adjusting the pH to neutralize the effects of the bacteria.

The effects of anaerobic bacteria can be reduced by maintaining an amount of oxygen in the coolant. Anaerobic bacteria are most active over the weekend when no processes are running. It is possible to prevent the growth of anaerobic bacteria by agitating or aerating the sump over periods of time when the process is not in operation, including weekends. Such aeration may cause problems in the coolant however and increase the foaming of some coolants.

Housekeeping Practices to Maintain Coolant Quality

The coolant should be filtered and recycled regularly. The machines also should be broken down and cleaned at least once each year. A regular and systematic cleaning of the sump and coolant should also be completed.

Therefore coolant management should include the following steps:

1. Continuously remove metal chips and tramp oil
2. On a regular basis, thoroughly clean the coolant system:
    - Pump coolant from the sump;
    - Remove all metal chips and fines; a vacuum simplifies the process;
    - Clean any oily residues that remain on any surface;

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- Fill the sump with a good cleaner using clean water and circulate the cleaner through the coolant system for several hours;
- Apply cleaning solution to machine surfaces that are not contacted by the coolant during machine operation;
- Pump cleaning solution from the sump;
- Wipe cleaning solution residues from the sump;
- Rinse the entire coolant system with clean water. Wipe off cleaned surfaces that are not contacted by the rinse water cycling through the system. Rinse the system again if necessary to remove all residues; and
- Recharge the system with reclaimed or new coolant immediately to protect metal surfaces against corrosion.

Collecting dirty coolant from the sump is made much easier and requires much less time when a sump cleaning vacuum is used. The cleaning is also made more effective if the sump has rounded corners, nowhere for microbes to hide, and is made of sheet metal construction. To prevent weekend growth of anaerobic bacteria, the coolant can be agitated and aerated to prevent anaerobic conditions from forming.

Cleaning should be thoroughly done. Machines with sumps beneath the machine can be difficult to clean because of the challenge in accessing the sumps. Therefore, cleaning is easier for machines with external sumps.

Going the Distance: Coolant Consolidation

Another consideration to be made when reviewing the use of coolants is to determine if all the coolants in use are necessary. After closer review, a company may discover that it needs only one or possibly two coolants. Coolant consolidation makes it easier to segregate wastes and recycle coolants. It also simplifies coolant record keeping.

Considerations for Associated Materials

Metal swarf and (tramp) oil may be able to be recycled. Oil may also be sold as a fuel.

Coolant Alternatives Limitations and Benefits

Three coolant alternatives that exist are to use other compounds that serve the same purpose (like drawing compounds), to use alternative cooling methods (such as an air gun), and to use alternative metal working processes that do not require coolants (low waste technologies). Low waste technologies include electrical discharge machining, waterjet cutting, plasma arc cutting, laser cutting, electrochemical machining, and electromagnetic forming. A problem with these low waste alternatives is that they may be cost prohibitive in the short term.

Source: Ohio Environmental Protection Agency