CENTRAL FILTRATION SYSTEMS FOR METALWORKING FLUIDS

Filtration is a process employed in the metalworking industry to remove contaminants from fluid mixes so they can be reused in a circulating system. Contaminants reduce the performance and shorten the life of a metalworking fluid mix. Among those commonly found in the fluid reservoir are:

1. Metal chips, grinding grit or both (swarf).
2. Hydraulic and lubricating oils (extraneous oil or tramp oil).
3. Debris such as shop rags, scraps of food, paper, etc.

Filtration implies the use of filter media (porous cloth or paper; metal screens) to remove solid matter from fluid. This, indeed, is the case in positive filtration. The metalworking industry, however, also applies the term "filter" to equipment, which settles solids or separates them from a fluid mix.

Current filter design is toward decreased volume of filter tank and increased flow rates. The increased flow rates can create potential foam problems and foam related problems due to the short fluid retention time.

Types of Filters

Separators and positive filters are the two basic types of filtration equipment and there are several variations of each type on the market today.

SEPARATORS

1. Settling Tank System

This is the simplest type of filter system and a modification of the individual machine sump in which the metalworking fluid mix is pumped into a tank where swarf settles to the bottom. See Figure 1.
The number of machines on the system and chip size is the criteria to consider in tank size and its design. In most cases, a drag-out chain is needed to scrape the bottom of the tank and move the settled swarf up a ramp into a tote bin.

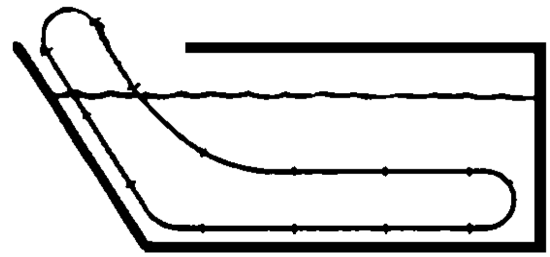


Figure 1

The settling tank is best suited for machining operations where chip size is large. A simple settling tank can be improved by dividing it into two compartments: a clean side and a dirty side separated by a weir or metal dam. The metalworking fluid mix is pumped into one compartment (dirty side) where heavy swarf settles and is removed by a drag-out chain. The partially "cleaned" fluid mix then flows over the weir to the clean side where a drag-out chain removes finer particles that settle in this compartment.

Advantages: • Low construction costs • Inexpensive to operate and maintain because no filter media are required. **Disadvantages:** • A large tank, which is needed to insure adequate settling time in high production operations, occupies costly floor space. • Ineffective in settling small cast, nodular and gray iron fines, and some graphite particles.

2. Multiple Weir System

The multiple weir, or folded weir as it is sometimes called, is a more sophisticated version of the simple settling tank. The tank contains a series of troughs or metal tubes, arranged in parallel. See Figure 2. The metalworking fluid mix feeds into the "dirty" compartment where mechanical devices skim floating fines and free oil from the surface into a tote bin. The metalworking fluid then flows under a retaining wall, up the other side, and rises at a low flow rate over the weirs into the discharge troughs. From there, it flows into the "clean" compartment.

This type of system allows a maximum amount of settling time in a relatively small tank. The weirs moderate surface turbulence (which disrupts settling) and, because of their parallel arrangement, provide as much as ten times the overflow area of a single weir. A drag-out chain, below the entire skimmer and weir area, removes the settled fines. The clean section may also have a drag-out chain to remove additional fines that settle during system downtime.

Advantages: • Very efficient settling unit. • Generally effective on nodular and cast iron and any type of machining operation. • Inexpensive to operate and maintain because it does not require filter media.
Disadvantages: • Weirs provide excellent conditions for mold growth. • A product with good settling properties is required. • Large in size.

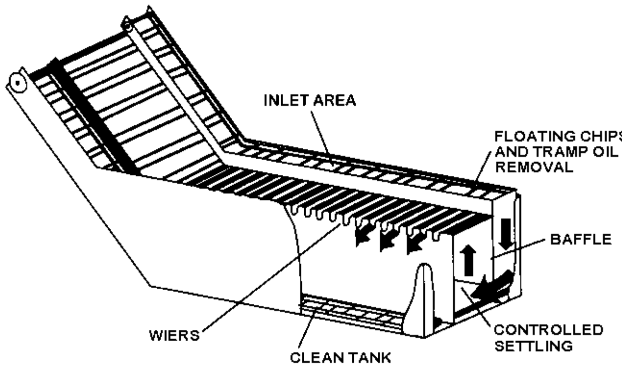


Figure 2

3. **Magnetic Separators**

Magnetic separators remove ferrous swarf (iron particles) from the metalworking fluid mix by attracting it to the magnetized surface of a rotating drum. The "cleaned" fluid returns to the machine, and a scraper blade removes the particles from the drum.

Magnetic separators are used predominantly with individual machines or in combination with positive filters.

Advantages: • Very little maintenance, low cost, and minimal floor space. • No filter media are required.
Disadvantages: • Will remove only ferrous or magnetic contaminants.

4. **Centrifuge**

This type of unit generally is used in conjunction with positive filters to remove extraneous oil and small fines from metalworking fluids. The fluid mix feeds into a spherical open-type bowl, which spins at a high rpm. Centrifugal force pushes the swarf to the outside of the bowl. The clean fluid spills over the top of the bowl and is fed back to the machine. As sludge builds up in the bowl, the centrifuge automatically ejects it; if not, the centrifuge must be stopped manually and cleaned or replaced.
Advantages: • Excellent for removal of extraneous oil. • No disposable filter media.
Disadvantages: • A centrifuge may break the emulsion in coarse or weak emulsion products.
• Cannot handle a large quantity of fluid because of the low flow rate.

5. **Cyclone**

Another type of separator is the cyclone. In this filter system, the metalworking fluid mix is returned from the machine to a settling tank or reservoir where large swarf or chips settle to the bottom. The partially cleaned fluid is then pumped to the cone-shaped cyclone filter unit (see Figure 3) where it enters tangentially at the top of the widest portion of the unit. The fluid spirals downward, and as it accelerates in velocity, the shape of the cone causes a tremendous increase in radial force (2000 times the force of gravity). With the increasing force, particles of swarf move downward along the outside of the unit. At the apex of the cone, the fluid mix starts to move up the center of the cone, while the swarf is forced out at the bottom through a discharge orifice and into a settling tank or reservoir. The clean fluid moves up the center to the top of the cone and is piped from there to the machine.

A cyclone filter promotes emulsification in contrast to a centrifuge, which can cause emulsion breaks. It is ideal for individual machine applications because of its small size.

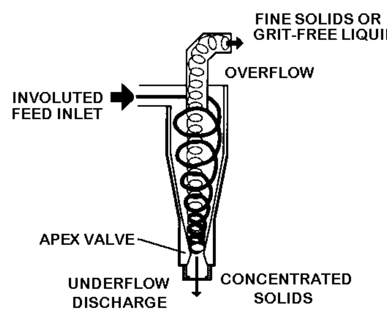


Figure 3

The larger the capacity of a cyclone, the lower its efficiency. Therefore, small units usually are connected in banks for large central system applications.

Advantages: • Simplicity and ease of operation. • No moving parts - little or no maintenance. • No disposable media costs.
Disadvantages: • Large particles of swarf or other large contaminants must be removed to prevent plugging of the cyclone • The apex of the cone must be inspected daily and kept clean to prevent dirt recirculation. • Does not remove the very small fines, leading to dirt recirculation and metalworking fluid mix depletion • Can cause foam problems • High Maintenance time and costs

POSITIVE FILTERS

• High maintenance time and costs.

In positive filtration, the metalworking fluid mix passes through porous filter media by gravity, pressure or vacuum, leaving solid particles (swarf) on the filter media. The most common filter media used in the metalworking industry are cloth, paper, or wire screens.

Positive filters operate on the same principle as the gravel and sand filter media used for clarifying water. The large swarf collects on the filter media and forms a "filter cake" which, in turn, filters smaller swarf and grit from the fluid. The thicker the cake becomes the finer the filtration. The cloth, paper or wire screen now acts as a support for the filter cake.

The efficiency of the unit increases as the cake builds up. Eventually the density of the cake reaches a point where the resistance to flow exceeds the vacuum or pressure that is required to maintain the flow. As a predetermined point, the pressure or vacuum is topped, or a level is reached, where the filter media index, exposing fresh media and the cycle starts again.

All positive filters provide better fluid clarity than separators. There are many different designs, but the following discussion provides a general description of how each of the basic types function.

1. **<u>Gravity Filters</u>**

In this type of unit, the weight of the metalworking fluid is relied upon for passage through the filter media. The fluid mix returns from the machines to the filter area where it passes through the disposable filter media (supported by a steel belt or wire screen) and leaves the swarf on the media. The weight of the fluid holds the media against the screen or belt and, after filtration, the cleaned mix is pumped back to the machines.

As the cake builds up, resistance to flow increases and causes the liquid level to rise. A float control activates the belt or conveyor, which moves the media toward the discharge end and exposes a clean section.

Advantages: • Initial cost is relatively low. • Easy to operate
Disadvantages: • Floor space requirement is high.
• Disposable media add to the cost of operation. • A fluid with low foaming properties is required to prevent excessive media usage.

2. **<u>Pressure Filters</u>**

A typical pressure filter contains two horizontal compartments; a movable top compartment and a stationary bottom compartment. In operation, air pressure seals the two compartments together.
The filter media may be a continuous nylon belt alone, stretched between the shells, or disposable media can be used on top of continuous nylon belt.

Generally, this type of filter consists of a filter unit, a settling tank or sump, and a drag-out chain. The metalworking fluid mix returns to the sump from the machines and is pumped to the top shell under pressure, which forces the mix through the filter media. The swarf deposits on the filter media to form a cake, while the clean fluid mix passes to the bottom shell, is pumped to a clean supply tank, and then on to the machines.

At a predetermined setting, usually 6 to 9 psi, the index cycle begins, the pump that supplies the fluid mix stops; compressed air blows the fluid from the top shell through the filter medium to the bottom shell; at a predetermined pressure, the upper shell rises; the filter medium advances, exposing new surface; the shell closes; and filtration continues.

With disposable media, the cake is fed to a tote bin; with a continuous nylon belt, compressed air blows the swarf into a tote bin.

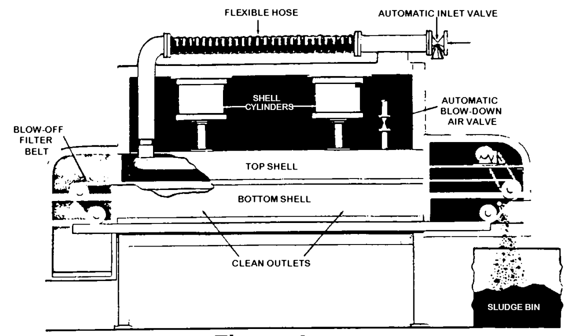


Figure 4

Advantages: • Removes small fines efficiently • Handles large fluid volume with minimal floor space.
Disadvantages: • Metalworking fluid used must be able to emulsify extraneous oil or plugging of the media will result. • Extraneous oil or hard water soaps can plug a nylon belt or increase disposable media costs. • For efficient operation, chips as well as the smaller fines should be agitated and pumped to the filter unit. • Disposable media usage is high because it is advanced the entire length of the shell. • Disposable media are required for low rms finish. • Maintenance is necessary to maintain efficiency.

3. **<u>Vacuum Filters</u>**

The most common positive filter operates on the vacuum principle and is often referred to as the suction filter. It is composed of a fluid tank with a filtering chamber at the bottom, which is covered with either disposable or permanent filter media.
The unit with the disposable media is designed so that the metalworking fluid is piped to the filter area where it passes through the media, leaving the swarf behind. As the cake thickens, resistance to flow increases, causing vacuum to increase. At a predetermined point, the vacuum switch activates a conveyor, which moves the media toward the discharge end, exposing a clean section. During this index cycle, the clean fluid is piped from the clean tank to the machines. See Figure 5.

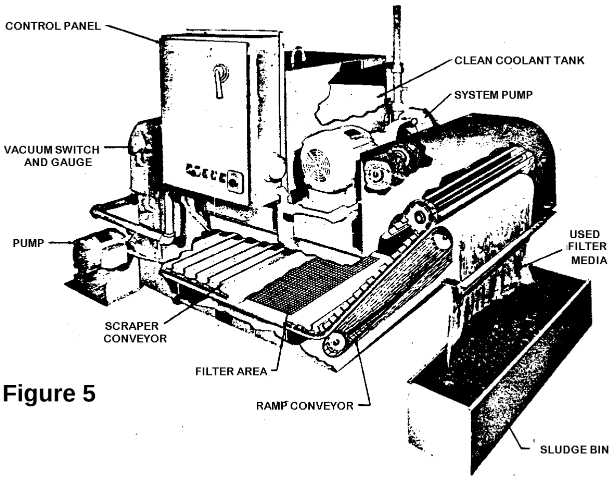


Figure 5

Advantages: • Initial cost relatively low. • Efficient filtration - from 10-25 microns. • Metalworking fluid selection not critical.
Disadvantages: • Floor space requirements relatively high. • Disposable media add to cost of the operation. • Hard water soaps may cause plugging of filter media.

The positive filter with the permanent media works on the same principle as the unit using disposable media (see Figure 6). The fluid is pulled through the media by

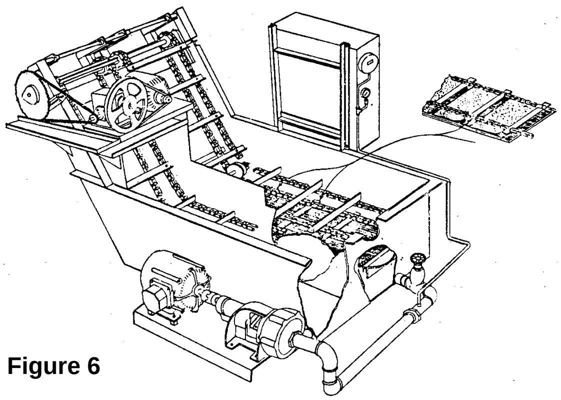
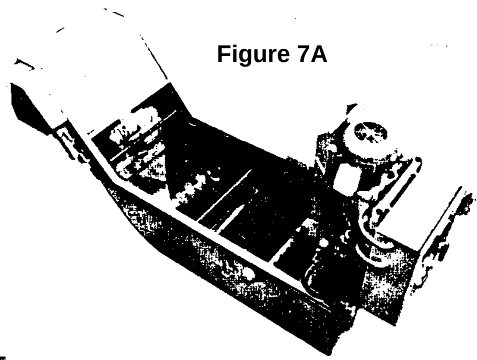


Figure 6

vacuum and a cake is formed on a wire screen. A scraper bar, attached to a drag-out chain stretches across the wire screen media. When the resistance to flow reaches a predetermined point, the vacuum is turned off (which is known as dwell cycle), the conveyor bar is activated and moves about 1 ½ to 2 inches, scraping the swarf off the screen in that area. The vacuum is again applied and the cycle is complete. The swarf is carried out on the drag bars to a tote bin.

To reduce floor space or increase fluid capacity, drum type wire screen filters are slowly replacing the larger wire screen types. See Figure 7A and B. The fluid is drawn through the wire screen drum until a set vacuum is obtained. At this time, the clean fluid is pumped to the machine from the clean tank thus permitting the drum to index by means of an air actuated ratchet mechanism.

Figure 7A



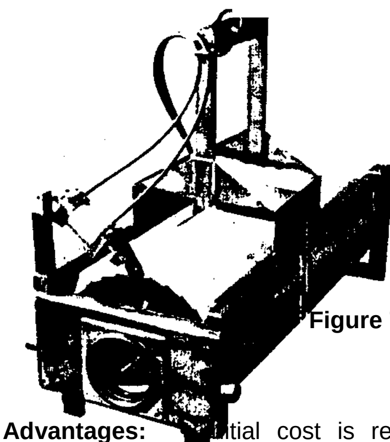


Figure 7B

Advantages: • Initial cost is relatively low • Efficient filtration - from 10-25 microns • No disposable media costs

Disadvantages: • Floor space requirements are relatively high • Fluid selection can be critical • Not suitable for cast iron grinding

4. <u>Tube Filters</u>

Tube filters may operate either by pressure or vacuum. These are similar to the oil filter in a car except the elements are self-cleaning and do not need to be replaced.

The metalworking fluid mix is pumped to a compartment containing the filter tubes. These elements usually are tubular nylon or woven wire. Swarf is deposited on the outside of the filter elements as the fluid flows, by pressure or vacuum, up the inside of the elements to the clean section of the system. As a cake forms on the filter elements, the flow is restricted, causing a rise in pressure or liquid depending on the design of the unit.

At a predetermined pressure setting or liquid level, the filter automatically goes through a blow-down or back-flushing index cycle, where compressed air or the clean fluid lifts the cake off the outside of the elements and drops it into a conveyorized compartment. See Figure 8.

When very clean fluid is needed (down to ½ micron clarity) or when swarf is fine and loose, precoating material can be added to filter elements to improve filtration. This is done most often with the tube or leaf type filters, but is not restricted to them.

There are many different types of precoat materials used. The most commonly used are diatomaceous earth and fumed cellulose. When precoating with diatomaceous earth, a slurry is pumped through the filter to form a cake on the filter element. When fumed cellulose is used it is injected into the filter element area and carried to the filter element via the fluid. After precoating, the filter operates as usual. The filter must be recoated after each blow-down or back-flushing cycle.

Diatomaceous earth is a super-efficient filter media which not only removes swarf from the fluid, but can also remove metalworking fluid components; especially from soluble oil and semi-synthetic type fluids. In general, diatomaceous earth precoat does not remove product components from synthetic fluids. Stripping of fluid components will depend upon the type of diatomaceous earth and precoat thickness. Always conduct tests for fluid stripping when diatomaceous earth is used.

In general, fumed cellulose precoat materials will not remove metalworking fluid components from any type of fluid. However, simple tests can be conducted to assure that fluid components are not removed by fumed cellulose.

Advantages: • Extremely efficient. • Recommended for operations where low Ra finishes are required.

Disadvantages: • Expensive. • Metalworking fluid selection is critical with diatomaceous earth precoat and in general, synthetic type fluids should be used - conduct tests. • Plugs easily.

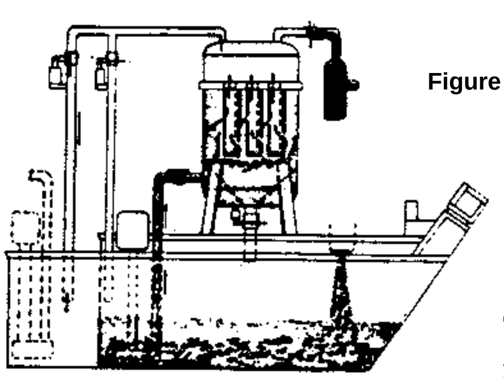


Figure 8

CENTRAL SYSTEM CONCEPT

The need for more efficient production and compliance with increasingly stringent government regulations on disposal are compelling reasons for the use of central filtration systems in supplying fluid to metalworking operations.

The primary advantages of central filtration systems are:

1. Reduced Downtime
Cleaning and recharging costs are infrequent. All machines can be cleaned at one time.

2. Better Control
One person controls the concentration and makeup additions for all machines instead of each operator having the responsibility for his machine.

3. Increased Metalworking Fluid Life
The removal of swarf plus the aeration of the fluid reduces the growth rate of anaerobic bacteria, which produce offensive odors.

4. Cost Savings
Clean metalworking fluid means wheels load less, wheel dressings are less frequent, and grinding wheels last longer. Clean fluid means longer tool life, less problems with rancidity, and therefore less cleaning and longer fluid life.

5. Increased Metalworking Fluid Cleanliness
Results in better finish and tool life by preventing recirculation of grit.

Central filtration systems do have some disadvantages. One is that they reduce flexibility in machine placement. Another is that the fluid must be able to perform satisfactorily on a variety of machines and operations. The latter limitation can be minimized by grouping machines of one type (grinders) on one central system, and machines of another type (lathes, mills, etc.) on a separate system. There are good reasons for doing this.

1. Grinding operations require more efficient filtration than machining operations because the chip size is smaller.

2. Machining operations generally require a metalworking fluid with greater friction-reducing ability than that needed in grinding operations. Therefore, separate systems permit the selection of the most suitable fluid for each operation rather than a compromise, which may not be entirely satisfactory for either.

CENTRAL SYSTEM DESIGN FACTORS

There are several critical factors that should be considered before installing a central system. One of these is how to get the metalworking fluid mix from the machines to the central system tank. Trenches are recommended in most cases, and the way they are constructed is very important.

In order to keep chips and swarf from accumulating in the trenches, a minimum draft of one foot per 100 feet of straight-line trench should be maintained. Sharp curves and corners should be avoided. A steeper draft is sometimes required or it may be necessary to install pressurized washdown nozzles to keep the fluid moving. The size and shape of the chip or swarf and its settling characteristics also affects design of fluid trenches.

Machines must be positioned for maximum economy in terms of floor space and for optimum length of the fluid trench. It should be long enough to service all the machines, but short enough to minimize the depth of the tank that receives the fluid.

The shape or cross section of the trench is also important. As the amount of mix carried by the trench diminishes, the area of the trench that is covered by the mix also diminishes. To maintain a constant flow rate and washing action, which prevents the formation of meandering channels on the bottom of trenches, in-floor trenches should be designed with a hyperbolic cross section.

Large pipes can be used to return the fluid mix from machines to the central system tank. They are less expensive than trenches and provide greater flexibility in moving machines from one place to another. In the long run, however, maintenance costs are high since dirt builds up inside pipes and they must be cleaned periodically.

A combination of trenches and pipes is another alternative. This involves the use of a sump pit with a filter tank at the floor level. The metalworking fluid mix flows to the sump pit by gravity through trenches and is then pumped through pipes to the central system tank.

METALWORKING FLUID CONTROLS

Prolonging the life of the metalworking fluid and optimizing its performance are very dependent on the control of the metalworking fluid system. This control includes maintenance of the mechanical components as well as the metalworking fluid and is as important as the selection of the proper fluid. The problems that beset metalworking fluids in central system applications are the same as those in individual machines, only the magnitude is greater.
A program to accomplish this control should include the following steps.

1. Assign the responsibility for control. If a coordinated program is not established to control the system, it will result in no control. One department or one individual should be responsible for checking fluid concentration and other specified parameters and for making any additions of water, concentrate, or additives to the system. These additions should be recorded for future reference.
When a control program is not utilized, excess usage resulting in increased costs can easily occur since no one really knows the status of the system. This person or department will also be more mindful of additions, know the reason for making them, and not use concentrate or additive additions as the only means to resolve a production problem.

2. Clean the system thoroughly before charging with a fresh mix. Refer to the CIMCOOL® Technical Report, "Cleanout Procedure for Central System and Individual Machine Reservoirs" for more details. Dirt and oil can accumulate in relatively stagnant pockets or quiet areas in the central system or individual machine. If not removed, such accumulations not only cause dirt recirculation in a fresh charge, but also provide an excellent breeding ground for bacteria. Recirculating dirt can lead to unsightly buildup on the machines and plugged coolant lines. Chip buildup in reservoirs can drastically reduce the volume of the system and deplete product ingredients. Oil will not only act as a food source for bacteria but also make machines dirty.

3. Maintain the concentration of the metalworking fluid at the dilution recommended for the particular operation. Dilutions are indicated on the label and in the product literature or will be recommended by a Products Division representative.

Many plants run daily concentration checks on central systems. Individual machines are usually checked on a less frequent basis. Concentration can be checked with a refractometer, a mini titration kit specific to that product, or the standard laboratory titration procedure.

Your Consumable Products Division representative can discuss the advantages and disadvantages of each method. Concentration can be controlled by use of premixed fluid or a proportioning system such as the CIMCOOL® Mix Master. Reviewing this concentration information can indicate trends and possible problems long before they show up on the production line. Lean concentrations can lead to rust, rancidity, tool life, lubricity, and other problems. Maintaining a stronger than recommended concentration can result in foam, skin irritation, residue, increased costs, and other problems.

The fluid mix is lost from the system by both evaporation and carry-off or splashing. Depending on the type of operation, type of fluid, and part configuration and handling, the amount of mix lost by either of these means can vary. Evaporation results in water losses. Splashing or carry-off creates both water and metalworking fluid (chemical) losses. Therefore, each time water is added to the system, metalworking fluid concentrate should also be added at a ratio that has been selected to maintain the proper dilution in the system. This will keep product components in their proper balance and minimize any selective depletion of these components.

4. Keep the metalworking fluid free of chips and grit. This is a major factor in fluid life. Positive filters with some type of disposable media do a better job of removing small fines than settling tanks. On individual machines, regular cleanouts of the reservoir or sump should be utilized to keep this buildup under control. Dirt in the fluid can lead to poor finish in grinding operations and tool wear in machining. Use better filtration or fluid recycling to improve fluid life.

5. The quality of water used to make a metalworking fluid mix is a very important factor in performance. Most metalworking fluids are diluted for use at concentrations of 3% to 5%; they will therefore contain 97-95% water. Use water that has a low dissolved solids content. The CIMCOOL® Technical Report, "The Effects of Water Impurities on Water-Based Metalworking Fluids", explains the details of water quality.

The ideal hardness of water for making a metalworking fluid mix ranges from 80 to 125 ppm. Water is said to be soft if it has a total hardness of less than 100 ppm or hard if total hardness exceeds 200 ppm. Mixes made in soft water will have a tendency to foam which should dissipate after exposure to chips, dirt, and tramp oil. Hard water causes deterioration of the lubricant system as well as scum on the machines and the central system filter or sump. High chloride and sulfate content can lead to corrosion problems. High sulfate content by itself promotes rancidity.

As a metalworking fluid mix is used, dissolved mineral content increases from the evaporation of water and the addition of makeup. Over a period of time, chloride and sulfate ions can build up and hardness problems can develop even when using water that is not that hard.

6. Aerate the metalworking fluid mix by keeping it circulated. The circulation prevents the growth of anaerobic bacteria that cause offensive odors. Many central systems continually circulate even when production is not running, others utilize timers to circulate the fluid for a short time on a set schedule during any non-production hours or days. In individual machines, an air hose can be used to bubble air through the mix while the machine is not operating.

Atmospheric oxygen is detrimental to the growth of odor producing anaerobes. During circulation, oxygen enters the metalworking fluid at a maximum rate, but at a much lower rate when the system is shut down. Since oil floats bar the passage of oxygen into a metalworking fluid, keep oil leaks from the machine tools at a minimum. Remove oil before it builds up using skimming or centrifuging equipment.

7. Provide good chip flushing at the machines and in the trenches. If chips do not reach the filter, they deplete certain constituents of the metalworking fluid and furnish an excellent breeding ground for bacteria. It is essential that chips reach the filter in order that they might effectively be removed. Trenches, return lines, system capacity, retention time, flow rates and other design parameters must all be adequately sized to provide this good filtration. Washdown nozzles may need to be installed on the machines or in the trenches to keep the metalworking fluid moving back to the sump or filter. Check that these nozzles are set at flow rates sufficient to keep the chips moving but not excessive which could result in foaming.

8. Employ good housekeeping practices. Foreign matter that is allowed to accumulate in a metalworking fluid has a drastic effect on its life and performance. While a good, high-quality metalworking fluid is formulated to cope with a certain amount of contamination, the greater the amount of contamination, the shorter the life and the more erratic the performance of the fluid. Avoid using reservoirs as a "garbage" disposal. Cigarette butts, food scraps, sputum, and candy wrappers, for example, inoculate the metalworking fluid with bacteria and furnish food for their growth. Refer to the CIMCOOL® Technical Report on "Contamination of Metalworking Fluids", for more details. Do not dump floor-cleaning solutions into the reservoir. Many contain chemicals, such as phosphates, which may contribute to skin irritation, promote the growth of odor producing microorganisms, or cause the product to foam.

9. Remove extraneous tramp oils. Minimize the leakage of oils into the system through proper maintenance of seals and lubricity systems. If excess quantities of oils leak into the system, the metalworking fluid performance can be reduced. Lubricating and hydraulic oils contain food for bacteria. They may also blanket the fluid, excluding air, and thereby provide ideal conditions for the growth of odor producing bacteria. If allowed to build up, extraneous oil causes smoking and increases residue around the machine area. Oil removing devices such as skimmers, coalescers, oil wheels or centrifuges can be used to prevent oil buildup. The CIMCOOL® Oil Wheel does an excellent job of removing tramp oil from individual machine sumps.

By following this program it is possible to achieve improved production and long, trouble-free metalworking fluid life in central systems and individual machines. ■