FEBRUARY 2004 / VOLUME 56 / NUMBER 2

Taking Control

▶ BY BRIAN HOVIK, VANSON HALOSOURCE

A guide to managing and maintaining metalworking fluids.

Coolant can be grungy, oily and smelly. But without an effective fluid management and maintenance program, coolant can also be overly expensive. Some methods for testing coolants and developing a successful program are presented here.

Concentration Check

The concentration, or the amount of coolant in a given amount of water, can be measured several ways. The following are three reliable methods for measuring coolant concentration.

The most common testing method is with a refractometer, which is a hand-held device used to measure how the coolant solution affects light passing through it. Refractometers are based on the principle that as the density of a substance increases, its refractive index rises proportionately.

The refractometer reading is compared directly to a concentration calibration chart for soluble-oil coolants, or multiplied by a factor to obtain the concentration of the coolant sample. The refractometer is perhaps the easiest and quickest way to measure coolant concentration, because it can be used at the machine tool. Training someone how to obtain an accurate reading takes an hour—at most.

The calibration curve and multiplication factors are different for different coolants, and they change depending on modifications to the coolant concentration. Because testing with a refractometer often becomes routine, the individual performing the test needs to be alert to any changes so he can calculate the concentration correctly.

The refractometer is the least accurate of the common methods of measuring concentration. As the coolant ages or becomes tainted with tramp oil, dirt and other contaminants, it becomes more difficult to read the refractometer, increasing the likelihood of error.

The second testing method is for a soluble-oil or semisynthetic coolant. Oil content can be used as the indicator of coolant concentration. A sample of the coolant is placed in a graduated centrifuge tube and sulfuric acid is added. The mixture is centrifuged for about 10 minutes at 1,000 rpm. The volume of free oil floating at the top of the mixture is compared to a concentration calibration chart. This provides the coolant concentration.

Because sulfuric acid and a centrifuge are needed to conduct this test, it cannot be performed at the machine tool. Rather, the test must be conducted in a laboratory. The presence of tramp oil can also give false readings with this test, because the test does not discriminate between the desired oils and those resulting from contamination.

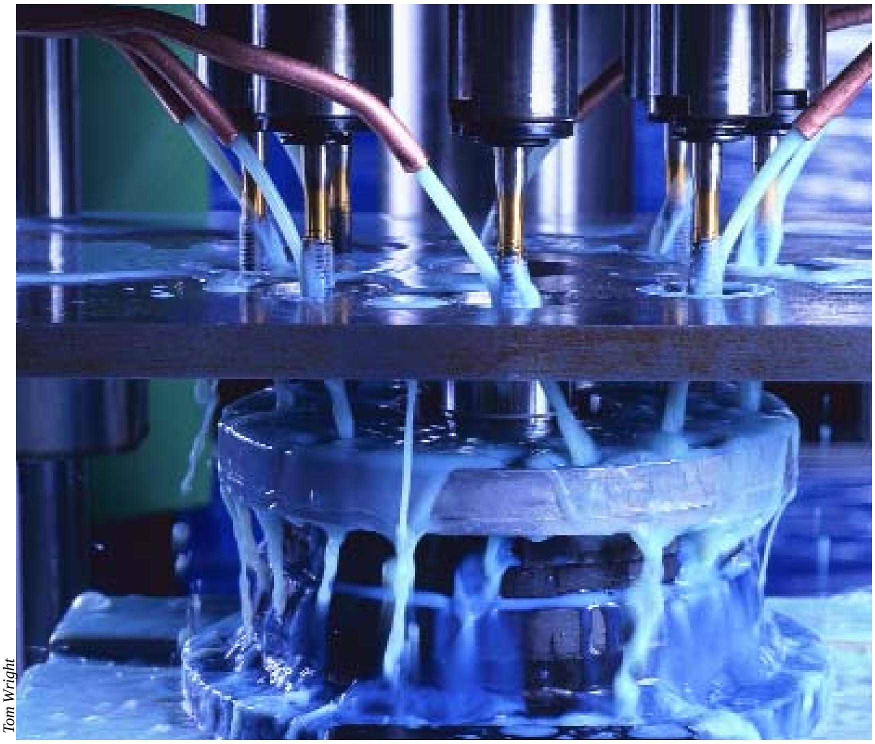
The third method, chemical titration, must also be conducted in a laboratory. In chemical titration, a known volume of coolant is placed in a clear container. A water-insoluble solvent and a colored indicator are added to the container, and then a titrating solution is added slowly until the indicator changes color. The coolant concentration can be calculated from the volume of titrate solution added.

Chemical titration provides a more accurate measure of the coolant concentration than the refractometer or oil-content methods. However, contamination and age (particularly the buildup of carbonates from water salts) can cause inaccurate readings.

The titration solution and indicator that is used depends on the specific coolant. The coolant supplier can tell you which chemicals are needed for specific coolant.

Appearance and Odor

A coolant's appearance and odor are im-



Tom Wright

Minimizing the amount of dirt and metal fines suspended in a metalworking fluid can improve part finishes, help keep machine tools clean and reduce bacteria-related problems.

portant indicators of its condition. Appearance should be monitored daily and any change recorded.

It is wise to store a sample of unused coolant in a clear bottle for reference to compare to the coolant's appearance as it ages. A healthy fluid appears milky (soluble oil), clear (synthetic) or transparent to milky (semisynthetic).

An increasingly milky appearance in synthetic or semisynthetic fluids indicates the presence of either entrained oil or emulsified tramp oil. On standing, entrained oil rises to the surface while emulsified tramp oil remains emulsified. The presence of free oil indicates that there is tramp oil in the solution or, possibly, destabilization of the coolant. Free oil present in soluble oil indicates instability.

In addition, grinding swarf, metal fines or microbial contamination can cause a gray and black coloration.

Aqueous coolants are typically formulated to be odorless or have a mild scent, such as pine or almond. Most operators and coolant maintenance personnel have a good idea what fresh coolant smells like. Any coolant that has a foul odor most likely contains bacteria or microorganisms. It's important to remember that a foul odor doesn't necessarily indicate that the coolant is no longer able to lubricate and protect against corrosion.

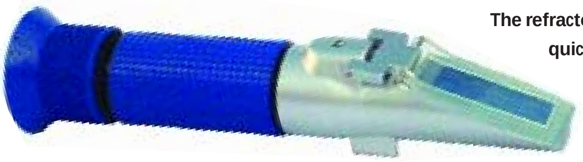
A rotten-egg odor is caused by anaerobic bacteria that produce hydrogen sulfide (H_2S) gas. With a sump pump running for a period of time, oxygen is slowly introduced to the coolant and naturally reduces the amount of H_2S gas. On initial startup of the pump, a Draeger-tube system can be used to quantify the presence of H_2S and, once the H_2S level is known, changes can be monitored weekly to quantify any reduction in gases.

Acidic or Alkaline

On a daily basis, it is important to record the pH of a coolant—its acidity or alkalinity—to monitor any changes. Coolants are formulated to be slightly alkaline with a pH range of 8.4 to 10.0. A change in the pH indicates a change in the coolant.

The pH can be measured using pH paper or dip strips (color-matching strips), but an inexpensive, hand-held electronic pH meter is the preferred method. The meter should be calibrated—or verified constant with a standard solution, such as pure water with its pH of 7.0—before measuring the coolant pH.

Adding cleaners can cause the pH to become more alkaline, even higher than 10.0. The addition of fresh coolant will normally bring the pH back into the desired range.



The refractometer is perhaps the easiest and quickest way to measure coolant concentration as it can be used at the machine tool.

Once you've returned the fluid pH to normal levels, investigate what may have caused the change so you can prevent the problem from occurring in the future.

A reading below 8.4 often indicates bacterial growth, which is a byproduct of the consumption of the organic substances in the coolant by the bacteria. In other words, the organic oils are the food for bacteria. Bacteria may increase corrosion, cause foul odors, decrease corrosion protection, plug filters and destabilize the coolant.

The high water content of an aqueous coolant can be conducive to bacterial growth. The level of bacteria or fungi, such as mold and yeast, should be monitored regularly to ensure an optimal performance. Many municipal water supplies are rich in many of these contaminants and start the "soup" right from the get-go.

Bacterial and fungal levels can be measured using biological test dip slides consisting of a plastic paddle coated with agar, a type of microbial growth medium. One side of the plastic paddle is specifically for bacteria while the other is specifically for fungi.

As the name implies, the dip slide is dipped into the coolant, withdrawn and sealed in a clear, airtight vial. The vial is then incubated near room temperature for 24 to 36 hours. During incubation, bacteria and/or fungi grow on the agar. At the conclusion of incubation, the amount of growth is compared to a chart that gives an approximate indication of the amount of bacteria present in the coolant.

Bacteria counts should not exceed 1×10^5 bacteria/mL and fungus levels should not reach 1×10^3.

Tramp Oil

Tramp oil is any oil present in the metalcutting fluid that is not part of the original coolant concentration. Sources of tramp oil are way oil, hydraulic oil, spindle oil or lubricating grease. Tramp oil is either free oil or emulsified. Tramp oil has an impact on the cleanliness of the coolant, which can alter its ability to flow through the filter, as well as its resistance to bacteria and ability to prevent corrosion.

A soluble-oil coolant with a stable emulsion rejects tramp oil readily. The tramp oil droplets are significantly larger than the coolant droplets. The rejected tramp oil is, therefore, sent to the surface in the coolant sump where it can be removed with a wheel or coalescence skimmer.

The test for tramp oil is identical to the one for oil content and involves centrifuging the sample or splitting a given volume with acid and subtracting the amount of oil that would be present in a clean sample or identical concentrate. Again, it is impossible to distinguish between the tramp oil and the desired oil with this test.

Dirt or metal fines suspended in a metalworking fluid can result in unacceptable part finishes, dirty machines and eventual bacteria problems. Assessing the amount of dirt or fines in the fluid is a way to determine the effectiveness of the filtration system. This can be measured by centrifugation or other tests provided by the coolant supplier.

Conductivity and Chip Corrosion

Conductivity gives some information on the quality of the coolant. The coolant conductivity depends on buildup of water hardness due to evaporation, dissolved metals and other contaminants. Conductivity data should be trended and compared to coolant concentration values to aid in determining contamination.

Conductivity-measuring equipment is available from laboratory equipment suppliers. In some cases, inexpensive handheld meters are available. Outside laboratories also offer testing.

Several options for chip-corrosion testing exist, but one popular method is to spread about 2g of clean cast iron chips into a petri dish and then place fluid onto the chips for given period of time. Drain the fluid and place the chips on a filter paper. Damp chips will stain the paper if the corrosion control of the fluid is insufficient. The filter paper can be saved for comparison to later test results.

By saving the filter-paper tests results, as well as documenting other coolant tests over time, changes to metalworking fluids can be managed and an effective maintenance program can be sustained.

About the Author

Brian Hovik is technical product manager for Vanson Halosource, Redmond, Wash. For more information about its fluid treatment system, as well as other chitin/ chitosan- and N-halamine-based technologies, call (888) 282-6766, or visit www.vanson.com.