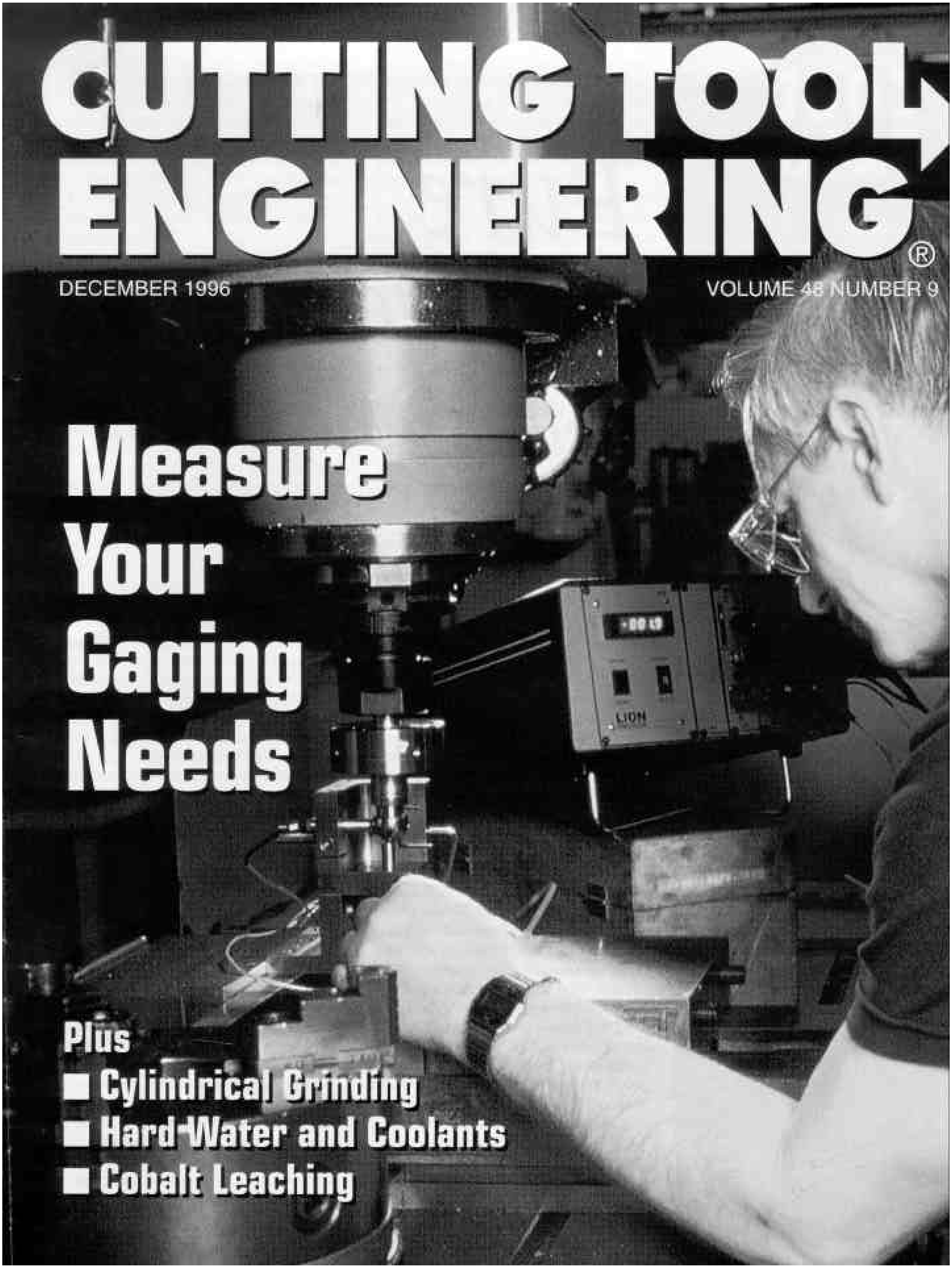
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LION
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COOL TALK

BY
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Pure Water

Isn't Hard to Find

Hard water badly degrades coolant performance. To maximize the efficiency and longevity of coolant, pure water is essential - and not as hard to come by as you might think.

All water is not created equal. The purity of water used in a manufacturing process can dramatically affect the quality of the end product, the efficiency of the process, the maintenance costs of the machinery, and the useful life of metalworking fluids.

Even the cleanest of shop water is not pure. Water throughout the United States is hard - that is, contaminated with certain minerals and salts. These contaminants are a detriment to the cutting - and grinding-fluid concentrates mixed with the water.

Rain water is soft, containing virtually no minerals. Water obtained from lakes or rivers may be relatively free of minerals or may be heavily contaminated, depending on whether or not the waters have dissolved minerals in the course of their flow from their source. Mineral levels in well water also can vary greatly.

Minerals - both nonhardness salts such as sodium and potassium and hardness salts such as calcium and magnesium - dissolve in water as it flows from where it falls as rain to where it is collected for use. When water flows through rock, the type of rock determines the kinds and amounts of minerals the water will dissolve. Limestone, which accounts for much of the rock in the United States, is very soluble, and hence contributes greatly to the predominance of hard water in the United States. It's estimated that more than 70% of U.S. public water supplies are considered hard.

Minerals in coolant water can corrode machine tools and

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machined parts, leave residues on machine tools, and increase the growth rate of bacteria and fungi in the coolant - thereby shortening coolant life. Water used in coolant mixtures should be made as pure as possible to ensure economical and trouble-free use.

TESTING THE WATERS

Water-hardness levels are calculated on the basis of how many "grains" of hardness minerals the water contains; a total of 17.1 parts per million of calcium carbonate per U.S. gallon constitutes 1 grain. Calcium and magnesium ions constitute virtually all the hardness minerals found in water. Other elements such as iron and aluminum are minor sources, but they can cause problems far out of proportion to their concentration. While not as corrosive as sodium and potassium salts, iron and aluminum - even in concentrations as weak as a few parts per million - produce very noticeable surface discoloration of steel and aluminum parts that many render the parts unacceptable. Hardness also may be exacerbated by zinc that has been dissolved from new galvanized pipes.

Hard water wastes coolant concentrate by forcing it out of solution; it coagulates the concentrate into an insoluble scum floating on the surface of the coolant. The net effect is that a portion of the coolant concentrate put into the water does not contribute to cutting efficiency. Instead, this portion is used up in softening the water, and it will usually appear as a gummy deposit or residue on the machine and parts.

Salts such as sodium chloride and sodium sulfate, which may also be found in hard water, contribute to corrosion or rust. The greater a solution's salt content is, the more coolant concentrate is needed to prevent corrosion.

A machine coolant sump evaporates water much the way a tea kettle does. As water evaporates, the concentration of minerals in the water phase increases, since the minerals do not evaporate. Thus, the longer the coolant is run between changes, the greater the chances for corrosion and residue problems. Makeup water added to the machine sump is typically 5% to 20% of the sump volume per day, depending on the coolant flow rate and the amount of heat generated in the cutting or grinding operations. As makeup water is added, it too evaporates, leaving behind still more minerals. Over a period of a few weeks, the buildup of dissolved solids in the fluid mixture can reach four or more times that of the original water.

It stands to reason that the purer the original water used for making coolant mixtures, the longer the fluid can be used before gumming and corrosion problems crop up. No matter what, though, mineral buildup will eventually lead to significant coolant degradation. For example, even a relatively soft water of 3-grain hardness can have a hardness of 12 to 14 grains at the end of 1 month and 24 to 27 grains in 2 months of use. Starting off with 12-grain-hardness water would yield 48 to 52-grain hardness in 1 month or 96 to 104-grain hardness in 2 months.

To get an idea of the amount of dissolved minerals in your plant's water supply, fill a 1/2" X 2" petri dish with a sample of the water, place it in an oven at 105^{o} C, and heat the dish until it is dry. Repeating this procedure four times will demonstrate the level of mineral accumulation resulting from the replacement of your coolant water lost over a 2-month period.

Some water has such a high mineral content that it won't even mix properly with coolant concentrate. The water may be so bad that one would have to change coolant-tank water every week to forestall gumming and corrosion problems.

Minerals in water also accelerate bacterial growth. There are three mechanisms responsible for this phenomenon, which, though not fully understood, can be demonstrated in a laboratory setting:

1) Bacteria, like all living organisms, need trace amounts of minerals in their "diet" for optimal growth.

2) Sulfates promote the growth of sulfate-reducing bacteria (Desulfovibrio desulfurican). These bacteria split oxygen off sulfate ions and utilize it chemically as their oxygen source. This process liberates hydrogen sulfide, which produces a rotten-egg stench.

3) In the case of soluble-oil coolants, the mineral content of hard water reduces the effective concentration of the emulsifiers in the working solution. Reduced emulsifier concentration produces a coarse emulsion

with large oil droplets, just as though the oil were mixed with pure water. Bacteria are "size-specific;" they find it easier to attack the large oil droplets of a course emulsion than the smaller oil droplets of a tight emulsion. The easier the attack, the more quickly the bacteria can extract nutrition and, hence, grow.

One method of ridding water of hardness minerals is to run it through a water softener. Softening removes calcium and magnesium ions but replaces them with sodium ions. As a result, though residues will not build up as before, corrosion will become more of a problem. For this reason, softened water is not recommended for use with water-miscible coolants.

If your shop has a boiler, then boiler water condensation may be a good source of pure water. Residues and corrosive elements are nonexistent in this type of water, provided the water has not been treated with softening and anticorrosion agents prior to being fed into the boiler. If you are considering the use of boiler condensate for diluting your coolants, ask your coolant supplier to analyze the condensate and make a recommendation about its suitability.

DEIONIZED WATER

For most shops, the best source of pure water is a deionizer, which removes all dissolved minerals via ion exchange, so that the treated water is the equivalent of distilled water.

In a water softener, the ion-exchange "bed" is regenerated with a saturated solution of sodium-chloride salt. The negatively charged resin beads are coated by sodium ions (Na^+). As water flows through the exchange bed, calcium and magnesium ions (Ca^{++} and Mg^{++}), with their double-positive charges, are more strongly attracted to the resin beads than are the sodium ions, so they are given off and the calcium and magnesium ions are taken up in their place.

A deionizer consists of two exchange beds - a cation exchanger with negatively charged resin and an anion exchanger with positively charged resin. Resins are minute, irregularly shaped plastic particles that, in aggregate, have a tremendous surface area per cubic foot. Cation resin is red/golden-brown in color and is made from a special type of polystyrene plastic that gives the resin particles a negative static charge. The cation resin is normally regenerated with hydrochloric acid and the resin then is charged with hydrogen ions (H^+). In the process, mineral salt cations are released by H^+ ions from the acid. Anion resin is ivory-white in color and is made from a different form of polystyrene that gives these particles a positive static charge. The anion resin is regenerated with sodium hydroxide and the resin is coated with hydroxyl ions ($OH^=$). As water flows through the deionizer, positively charged ions (cations) are taken up by the cation resin and $H+$ ions are given off. Negatively charged ions (anions) are taken up by the anion resin and $OH+$ ions combine to form a few additional water molecules. As a result, all dissolved solids are taken up by the deionizer, and the product water contains only water molecules.

Since deionized water is free of all dissolved solids, no residues are left after evaporation and corrosion effects from salts are eliminated. Many shops with plating operations already have deionizers on-site. Assuming that the deionizer has an adequate capacity, this water source can be used for coolant mixing.

Many people are, at first, wary of spending the money necessary to install a deionizer. But once they take the time to compute how much more economical it is to have trouble-free coolants, compared to the cost of repairing gummed-up and rusted machines and corroded workpieces, they're likely to change their minds. For that reason, the use of pure water for diluting coolant concentrate is becoming much more common in American machine shops.

At Master Chemical, we have observed that with the adoption of pure, demineralized water for diluting coolant concentrates, concentrate consumption is reduced approximately 1% for every grain of hardness removed from the water supply. Using this rule of thumb, a shop using a 10-grain-hardness water and buying $100,000 worth of coolant concentrate annually would reduce its yearly expenditure by approximately $10,000 by using pure water.

Reduced concentrate usage, longer coolant life, and less coolant disposal are not the only savings to be had from using pure water. Since the coolant mixes properly in pure water, the resulting solutions cut and grind more effectively.

There are several types of deionizers on the market. The simplest unit is the exchange-tank deionizer system that includes resin tanks furnished in sets. After one set is depleted, it is replaced by the second fresh set and the spent tanks are picked up, regenerated, and returned by the deionizer supplier. Thus, the user has no acid or alkali to handle and no equipment to operate or maintain. All the user has to do is change the tanks when instructed. These are normally the more economical systems for smaller shops.
Automatic deionizers regenerate coolant automatically, with required chemicals connected directly to the resin tanks. Shop personnel are required only to make certain the drums of acid and alkali are full. These systems generally are more economical for medium-size to larger shops. The initial investment in automatic deionizers is greater than that required for an exchange-tank system. However, the additional cost is more than offset by the fact that the overall cost per gallon is lower than with an exchange-tank system.

Other water-purifying devices, such as reverse-osmosis systems, operate on principles other than ion exchange. With a reverse-osmosis system, shop water is forced through special membranes by means of mechanical pump pressure. These units remove about 90% to 97% of the dissolved solids and minerals, but as much as 50% to 65% of the water supplied to the unit goes down the drain as waste. Reverse-osmosis is perfectly adequate in many cases for improving water quality for better coolant performance, particularly when the water is in relatively good condition to begin with. But, with extremely hard water (over 20 grains/gal.), a reverse-osmosis system may need to be combined with an exchange-tank deionizer. This system will provide the high water purity needed for long-term optimal coolant performance and recycling.