Clean oil cuts metalworking costs

Filtered oil boosts machine-tool hydraulic and mechanical performance, and cleaner cutting fluids improve effective machinability of steel and other workpieces.

Two before-and-after samples. The after shots (right in each group) show a contaminant level of about 1 micron. In each case, the filter consisted of a customized mix of chemical compounds shown in foreground.

Everybody credits lubricating oils with a vital role in metalworking. They affect tool life, cutting precision, work finish, operation of the machine tool, machine energy requirements, and engineering behavior of the work after its installation.

But there isn't as much discussion on the role of really clean oil. Why is it needed, where is its use necessary, and what price is paid if it's disregarded?

Clean oil, "purified" oil, takes on different definitions. It used to be considered a necessity in rather rarefied circumstances, but shop superintendents and maintenance people today are taking a new look at what clean oil can mean to operations. They are lowering the threshold of acceptable contamination in the oil. The reasons are:

- Higher customer expectations on tighter specs and on quality work.
- Better equipment maintenance resulting from higher quality oil.
- Savings in purchases of new oil.
- Savings in overall labor costs because of reduced handling of dirty oil, and because there is less equipment downtime related to oil problems.
- Environmental considerations. Disposal of waste oil is affected by control of very small particles in the oil. The human eye can't see contaminant particles smaller than 40 microns; particles of 2-, 5-, and 10-micron size often are not even considered. Thus a concern of those in charge of metalworking operations is a change in maintenance attitudes and procedures, understanding what the "invisible" contamination means in their activities.

Clearing tight clearances

Extra-fine particles in the range of 1 to 10 microns have the capacity of accumulating, "packing up," or silting in hydraulic oil. When the gap between components separated by an oil film is bridged by contaminants, wear can occur. This generates further particles. Particle contamination is said to feed on itself and initiate dirt development within the system.

To improve performance within machines and to keep leakage and power losses to a low level, the servo valves in these systems have to work with small clearances, which subject them to contamination. An example would be these typical critical clearances in fluid system components: gear pump, gear to side plate: 0.5 to 5 microns; piston pump, valve plate to cylinder: 0.5 to 5 microns; servo valve, spool sleeve: 1 to 4 microns; control valve, spool sleeve: 1 to 23 microns; antifriction bearings: 0.5 micron and up.

Although large particles are obviously undesirable, very small particles in the range of 1 to 5 microns are most often responsible for hysteresis in valves and for a gradual deterioration in performance. Only these small particles can enter and get jammed in the clearance between the spool and the sleeve. Though the wear and friction of an individual particle is small, the number of these particles is large, and their cumulative effect in the silting process becomes significant.

In addition to this clogging action, abrasive particles entering the space between moving parts can score and hone the surfaces to greater clearances.

Clean cutting fluids extend tool life

In cutting oils, fine particles down to a few microns in size separate from both the chip and the workpiece during cutting action. These particles in the oil can become trapped between the tool and the work or between tool and chip. They are subjected to heavy loading, and the resulting friction causes a rapid temperature rise in the particle. The high heat can cause welding to the tool tip, and the accumulation of these instances is one of the major causes of cutting-edge breakdown.

Fine filtration down to 2 microns and less has been shown to give substantial increases in tool life. As an example, in oil-filtration tests conducted on multi-spindle machines using drills, reamers, and boring tools, fine filtration to 2 microns showed increases in tool life averaging 60 percent.

Failure to remove debris from cutting oil can cause a deterioration in surface finish on parts. Engineers often do not realize the degree to which filtering must be taken to gain a specified surface finish. Micro-sized contaminants in the cutting oil can cut into the most carefully honed surface finish. Specialists in honing work consistently point to clean oil as a major factor in achieving a fine honed finish.

Chemical changes

In some processes, chemical changes in the oil as well as physical contamination can critically influence coolant performance and economics. This applies particularly to those processes where the coolant is subjected to thermal abuse, which can cause chemical change to occur rapidly. EDM work is one example.

Fortunately, the chemical causes of oil failure can be removed by fine filtration. You can thus avoid increased oxidation rate of the oil, which would result in acidity and interfacial tension. Water, air, copper, or iron oxide from the working environment can have negative effects when mingled with lubricating oil in high-speed and high-temperature operations. Filtering can reduce the harmful effects.

Sludge and oxidation deposits resulting from the oxidation of hydraulic oil represent another source of internal contamination. The resulting gummy residue on valves and spools is one of the leading contributors to faulty operation of hydraulic equipment.

Oil-industry specialists say that clean oil, kept clean, is good forever. And the best way to ensure this is a schedule of preventive-maintenance testing. In recent years, environmental factors have required more emphasis on testing of oil. But a valued side effect of this testing has been the finding that it's also important for ensuring production continuity and savings in labor and material costs—and for ensuring, ultimately, high quality in the workpiece. ■

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