Metalworking

Nanofluids: Making Machine Shops More Competitive Through Science

James Langford | Jul 23, 2024

For decades, the U.S. Environmental Protection Agency has worked to curb the use of chlorine, sulfur and phosphorus compounds in metalworking fluids.

Known as extreme pressure agents, the chemicals help increase lubricity and reduce heat during machining operations, thereby extending tool life and improving surface finish, but they have been linked to a variety of health risks, from cancers to skin disorders.

Not only does the EPA consider fluids containing them to be "dangerous waste," they must be treated with biocide—another health concern—to ***prevent*** the putrid odors they can develop, known in machine shops as "Monday morning stink."

While these fluids and oils nonetheless work quite well when properly maintained, the hassle leaves some metalworking professionals wondering if there isn't a safer, simpler, more environmentally friendly alternative.

25% Cost Reduction

Jim English isn't a metalworking professional, but he knows an awful lot about the chemistry behind ***metalworking fluids***.

"I helped develop Rain-X, the stuff you spray on your windshield to prevent streaking," he says. The company behind Rain-X later "received a grant from Congress to make a similar product for the Air Force to use on the windscreens of jet fighters," he recalls

Today, English is the president of Tool-X, which also received a government grant—in this case, to make nanolubricants for the U.S. Army.

Afterward, a business group from New England questioned whether the technology would be useful for CNC machining. That was in 2006, and within four years, the team had developed an oil-based

nanofluid, followed by a water-soluble version.

Tool-X was born. While the company doesn't disclose exactly what's in its nanofluids, a *Science Direct* article says nanofluids generally comprise a mixture of a base fluid, such as water, oil or ethylene glycol, and a significant number of particles with nanometric dimensions of a solid material suspended in the base.

Tests have shown Tool-X's nanofluids can help machine shops substantially reduce costs and dramatically boost the productivity they've achieved with traditional metalworking fluids.

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When airplane engine-maker Pratt & Whitney worked with the Connecticut Center for Advanced Technology to test Tool-X's nanofluid on aerospace applications at their labs, they found that users could lower their manufacturing costs 25 percent by switching, English says.

Building on Success

That early success led to more. General Motors Co. and other large companies employing nanoscientists who understood what Tool-X was doing began using its nanofluids, too.

Like Pratt & Whitney, they reported significant gains:

- A Swiss-style turning shop making 316 stainless steel screws for the defense industry said tool life for its milling inserts increased 360 percent and cycle time dropped 35 percent.
- A manufacturer of low-carbon steel workholding products was able to boost production rates from 75 parts per shift on its horizontal machining centers to 125 parts. Tool life increased from 31 to 250 parts per sharpening.
- An automotive supplier reported 60 percent more 17-4 camshafts per 10-hour shift.
- A company gundrilling hot-rolled steel nearly doubled its inches per drill bit.
- And a grinding house saw a 23.6 percent overall improvement after filling the sumps of six machines with Tool-X MP-101 water-based fluid.

The Secret Sauce

Tool-X says its nanofluids contain roughly a dozen chemicals (compared with 40 or more for competing products) and that the nanoparticles are composed of inert carbon.

One nanoparticle, for example, helps create a slurry the metalworking tool rides on, which assists with tool longevity and the cutting process. Another is there to kill any bacteria that might form, although that poses less of a problem than with traditional metalworking fluids.

And some particles transfer heat away from the workpiece and into the sump. "Other products don't do that," English says.

Cost and Other Drawbacks

Nanofluids aren't a perfect alternative for every business.

For starters, they're more expensive than the alternatives.

While Tool-X didn't specify how much, even if the price tag were double, the productivity gains would

easily offset the investment—especially when you consider that cutting fluids (like cutting tools) account for roughly 5 percent of total machining costs.

Secondly, machines must be clean (as in brand-new machine clean) before switching to nanofluids.

"You can't just give it a quick wipe down and dump it in like you do with the paraffin wax-based coolants," English says. "You also have to commit to using the refractometer once or twice a week instead of once or twice a year. Those two requirements are probably our biggest challenge when converting someone."

Those who do change make a strong case in Tool-X's favor. Aside from the benefits listed earlier, Tool-X says, part quality improves, reducing customer rejection rates. And because the fluids are "self-cleaning," the rotten egg smell becomes nothing but an unpleasant memory.

"We just worked with a customer who was complaining about poor surface finish," English says. The customer reported R_a values, a measure of surface roughness, in the 45 to 50 range, he explains, "and we got them into the teens."

How could using nanofluids benefit your business? Tell us in the comments below.

