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▶ BY OREST PROTCH

Fluid Cutting

An easy-to-conduct test aids in cutting-fluid selection.

Valenite Inc.

Efficient application of machine horsepower is critical to profitable cutting, especially during long production runs. The goal is to minimize the horsepower required at the cutting tool's tip. One way to do that is by choosing the best cutting fluid for the task.

To aid in the selection process, you can conduct a simple test to gauge cutting-fluid efficiency. It can be performed with common shop tools and a basic tool-force dynamometer (see sidebar, page 43). Although the test is not guaranteed to be absolutely repeatable in every case, it's a quick way to assess the relative merits of different metalcutting fluids.

For this article, I limited discussion to a single-point tool run on a lathe. Once you become familiar with the basic methodology, though, it will be easy to conduct tests using other types of machines and cutting tools.

Pretest Steps

The first step is to ensure that your data-collection procedures are scientifically sound. To generate accurate results, test variables must be fixed. Conduct tests on one machine and the same material, preferably from the same bar stock. The time in the cut should be constant throughout the testing period.

There are two variables that must be rigorously controlled from the outset: tool grinding and maintaining constant speeds and feeds.

Freshly ground tools must be prepared using identical methods (i.e., ground by the same operator on one grinder), and they should have identical geometries.

Remember, the only variable that should change is the cutting fluid. Speed-and-feed fluctuations of more than ±2.5 percent will alter the thermal profile in the cutting zone. If speeds or feeds increase or decrease beyond the nominal 2.5 percent, more heat will develop and the metal-removal rate (in.^{3}/sec.) cannot be considered "constant."

Next, develop a standardized test form similar to the one shown in Figure 1. Using a form like this ensures the test is repeatable.

Test Procedures

Now it's time to test the fluids. Follow the steps below and fill in the data sheet with the corresponding values.

1. Install a cutting tool in the dynamometer.
2. Select Cutting Fluid A.
3. Position the fluid nozzle to ensure total immersion of the cutting zone with fluid during test cuts.
4. Run the lathe according to recommended speeds and feeds for the workpiece material being cut.
5. Make three to five passes with one cutting tool and, after each pass, record the vertical force (F_C) that registers on the dynamometer. (The F_C is in the direction of the tool face and opposes the motion of the chip sliding along the tool face. This is the friction force and it can be varied by altering the surface finish on the tool face, adding more lubrication between the chip and tool, changing the viscosity of the cutting fluid or altering the load—the horizontal force—which causes frictional resistance.)
6. Total the force readings and divide by the number of passes to find the average. Record the results on the testing form.
7. Change out the tool.
8. Run the test with Cutting Fluid B.
9. Repeat steps three through six.

Test #__________

Date	
Location	
Operator	
Supervisor	

Cutting Fluid

Manufacturer	
Dilution Ratio	
pH	
Viscosity	

Cutting Fluid Temperature @

15 min.	
30 min.	
45 min.	
60 min.	

Tool Sharpening Method

Manual	
CNC	

Cutting Tool

Type	
Manufacturer	
# Cuts Per Tool	
End Relief Angle	
Back/Top Rake Angle	
Side Relief/Clearance	
Side Rake	
Side Cutting Edge Angle	
End Cutting Edge Angle	

Cutting Fluid #__________

Machine #	
Model Type	
Workpiece Material	
Grade	
Brinell Hardness	
Diameter	
Length	

Results Pass #1

Cutting Speed (sfm)	
Feed Rate (ipr)	
Depth of Cut (in.)	
F_C: Tangential Cutting Force (lbs.)	

Results Pass #2

Cutting Speed (sfm)	
Feed Rate (ipr)	
Depth of Cut (in.)	
F_C: Tangential Cutting Force (lbs.)	

Results Pass #3

Cutting Speed (sfm)	
Feed Rate (ipr)	
Depth of Cut (in.)	
F_C: Tangential Cutting Force (lbs.)	

Average Fc for 3 Passes	

Fill in or check mark appropriate boxes.

Figure 1: A sample form for documenting coolant-test data.

Cutting Fluid A

	Pass #1	Pass #2	Pass #3	Avg.
Cutting Speed (sfm)	150	150	150	150
Depth of Cut (in.)	0.100	0.100	0.100	0.100
Feed Rate (ipr)	0.012	0.012	0.012	0.012
F_C (lbs.)	318	322	320	320

Cutting Fluid B

	Pass #1	Pass #2	Pass #3	Avg.
Cutting Speed (sfm)	150	150	150	150
Depth of Cut (in.)	0.100	0.100	0.100	0.100
Feed Rate (ipr)	0.012	0.012	0.012	0.012
F_C (lbs.)	255	267	261	261

Figure 2: Summation of data for two cutting fluids that the author tested.

When you are finished, you will have the average F_C for two different cutting fluids.

Figure 2 shows data I gathered when comparing two cutting fluids. I made three passes on the lathe with each fluid. No attempt was made to measure the effects of dull tools.

Would the results for the two cutting fluids be the same on a second or third lathe? Perhaps. But, in my case, it didn't matter. I was only interested in increasing efficiency on a lathe that was about to be used for a long production run in

Simple device offers valuable information about metalcutting process

Once, all tool-force dynamometers were simple instruments that incorporated one or two pressure gages that measured horizontal (F_t) and vertical (F_c) forces generated at the cutting tool tip.

Modern dynamometers take advantage of fiber optics, transducers, or temperature- and pressure-sensitive electronic strips that instantaneously send information to a computer. They usually mount on the cross slides of lathes and milling machines.

A dynamometer—even a simple one—can make the average shop more profitable. As detailed in the main article, a dynamometer allows a shop to select the best cutting fluid by gauging the horsepower required at the tool tip when different fluids are applied. Knowledge of the power needed to cut is also important when planning machining operations, designing new fixtures and tooling, and purchasing new equipment.

Any company that cuts metal should be concerned about the horsepower required at the tool tip, because that's where its profits are generated.

Power Loss and Profits

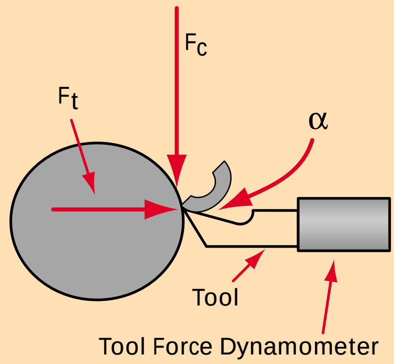
With a metalcutting machine, power loss occurs between the motor and the cutting tip. Power from the motor dissipates as it travels through the drive shaft, reducing gears, worm gears, drive belts and other machine components.

The undissipated power is transformed into the cutting action, leading to the development of heat. Heat causes the tool tip to deteriorate and wear, which, in turn, means more power is needed to cut the workpiece.

The lost power reduces the horsepower available at the cutting tip. (There's always more power at the motor than at the tool tip.) To maximize profits generated by cutting metal, it's necessary to maximize horsepower available at the cutting tip. A tool-force dynamometer can help a shop accomplish this by letting personnel test how specific elements of the metalcutting system—such as tool geometry—impact horsepower available at the workpiece.

Even though a shop is limited by what it can do about power loss caused by belts and worm gears, it can control cutting tool angles, tool sharpness, the cutting fluid used and the amount of heat generated in the cut. And if these can be controlled, then the shop can maximize feed and speed rates, reduce the frequency of tool changes and, as a result, increase profits.

—O. Protch



α = clearance angle

F_c = the vertical cutting force acting on the tool.

F_t = the horizontal force, which tends to push the tool away from the work.

A basic tool-force dynamometer measures vertical and horizontal forces.

which speeds and feeds would remain within recommended guidelines.

Setting up a regime for testing cutting fluids is a simple exercise that pays off in increased productivity dividends. The key element is to follow rigorous, consistent data-collection guidelines.

About the Author

Orest Protch is a welding metallurgist and analytical chemist who lives in Grande Prairie, Alberta.