OVERVIEW
The three key mechanical inputs in metal removal operations are feed, speed, and depth of cut. Manipulating the feed, speed and depth of cut can maximize the benefits of a particular cutting fluid and can increase productivity. However, like most decisions, the choice of feed, speed and depth of cut must be based on the customer’s objectives. What is their goal in this application? Do they want to manufacture parts faster or maximize tool life? How important is the surface finish and dimensional accuracy of the part? Answers to these questions will drive their decisions on feeds, speeds and depth of cut.

DEFINITIONS

Speed: Speed is the rate of rotation of the spindle where the tool is held. It is measured in revolutions per minute (RPMs).

Feed: Feed is the rate at which the tool is moved into the part or the part into the tool. Feed is measured in feet, inches or millimeters per time period.

Depth of Cut (DOC): The measurement (normally in inches or millimeters) of how wide and deep the tool cuts into the workpiece.

FEEDS, SPEEDS & DEPTH OF CUT

Speed, feed and DOC work together to determine the Metal Removal Rate (MRR). MRR is calculated as follows:

\[ MRR = \text{Feed Rate} \times \text{Width of Cut} \times \text{Depth of Cut} \]

Speeds, feeds and DOC influence many aspects of machining performance:

- Tool life
- Surface finish
- Dimensional accuracy of the manufactured part
- Power required by the machine tool

The useful life of a tool is a measurement of how long the tool will function and still provide acceptable parts. Infinite tool life can be achieved by not using the tool at all. Of course, productivity would be zero and this would achieve nothing!

TOOL LIFE

Tool life, as measured by the amount of material removed, may actually increase when the DOC is increased. However, tool life, as measured by time, will likely decrease when the DOC is increased. Sometimes customers measure tool life by how many quality parts they produce before a tool change. How does your customer measure tool life?

Generally, increasing the feed rate reduces tool life. Removing more material creates more heat. Heat degrades the work piece and the tooling. If you reduce your feed rate, the tool life improves because it is not working as hard.
All of this assumes that the concentration of the metal removal fluid has remained the same. In order to cut faster or deeper (i.e. DOC), increasing the concentration provides more lubrication. There needs to be a balance. Spending a little more in coolant can produce tremendous savings in tooling.

Coolant is always cheaper than tooling. Ask your customer if there is interest in reducing tooling costs.

**SURFACE FINISH**

As we learned in our Surface Finish Skill Builder, surface finish or smoothness of the final work piece can be measured with various devices and recorded in various units of measure. Surface finish is important to many customers. Without sufficient lubrication (i.e. proper fluid and concentration), surface finish will generally decrease as you increase the spindle speed. It may be worth it to the customer to increase the cost of the coolant (with a slightly higher concentration or higher lubricity fluid) to improve the surface finish at higher speeds. Of course, this means that surface finish has to be worth something to your customer’s customer.

Increasing the DOC can promote chatter because of higher forces. The machine tool must be rigid enough to withstand these forces. Vibrations in the machine tool can have a large effect on surface finish. Machine tools designed and engineered for high speed machining have improved stiffness to minimize the vibration that impacts surface finish.

Ask your customer if their machine tool has sufficient stiffness to achieve the surface finish they’re seeking.

**DIMENSIONAL ACCURACY**

The overall accuracy of the part is defined as meeting all of the dimensions as required by the engineering diagram. Dimensional stress occurs when cutting forces and deflections are not controlled. Whereas surface finish is usually measured on a small section of a part, dimensional accuracy relates to a larger section or the entire part.

The Metal Removal Rate (MRR) is a key variable effecting part accuracy. As the MRR increases, the chances of decreasing part accuracy increases. In simpler terms, more power is required to remove more metal. Unless the stiffness of the tool is compatible with the higher horsepower, then deflection is likely to occur. Deflection leads to inaccuracy.

Thermal issues are also a consideration. Some machine tools are very susceptible to changes in their environment. It has been proven that many machine tools do not produce the same quality parts throughout the day unless the shop floor temperature is properly controlled. Also, the alloy being machined could be susceptible to temperature changes. Many operations that are sensitive to temperature changes will employ the use of “chilled” coolant. The fluid is maintained at a constant temperature with a heat exchanger. By holding the temperature of the fluid to a constant temperature, there is decreased deviation in the alloy.
FEEDS, SPEEDS & DEPTH OF CUT

POWER REQUIREMENTS
Horsepower is an important requirement when assessing the correct machine tool for a specific application. There are specific tables in machining data handbooks that provide "guidelines" as to how much horsepower is required to function in a certain application. The more work your customer is trying to achieve, the more power is required. As the metal removal rate increases, the horsepower to support it increases as well. Ask your customer if their machine tool has been confirmed as having the horsepower necessary to do the job. An important realization is that with different combinations of feed and speed, with the same MRR, the application with the highest feed rate will require less power.

CONCLUSION
In your next discussion with your customer, a review of speeds and feeds should be easier. There are several published guides that give recommended starting points for feed, speed and DOC for specific operations and metals. Depending on the customers' objectives, you may want to suggest deviating from the standard settings. Find out what the customer is trying to achieve to understand how altering speeds and feeds will help or hurt their application. Being part of this conversation will make you a more important part of your customer's team to success and will help you demonstrate the best performance your cutting fluid can deliver.

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Our Associates are on the ground in every region of the globe. That means our entire infrastructure (from sales to service, R&D to manufacturing) is designed to support our customers at a local level, whether in one facility or spread across multiple plants worldwide.

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