Metal cutting Physics

Idealized Chip Formation

The figure below depicts an idealized, two dimensional view of the metal cutting process. The assumptions in this model are that the tool is perfectly sharp, that the cut depth t and the cutting speed V are constant, and that the cut depth is small compared to the cut width. In this idealized model, the material layer at the top is formed into a chip by a shearing process in the primary shear zone at AB. The chip slides up the rake face undergoing some secondary plastic flow due to the forces of friction. This idealized model correctly predicts that cutting force increases with cut depth, material hardness, and friction coefficient. Cutting forces are inversely proportional to rake angle. Power required increases with the feed rate.

Built Up Edge

One important effect that is not considered in the model above is built up edge. Under most cutting conditions, some of the cut material will attach to the cutting point. This tends to cause the cut to be deeper than the tip of the cutting tool and degrades surface finish. Also, periodically the built up edge will break off and remove some of the cutting tool. Thus, tool life is reduced. In general, built up edge can be reduced by:

- Increasing cutting speed
- Decreasing feed rate
- Increasing ambient workpiece temperature
- Increasing rake angle
- Reducing friction (by applying cutting fluid)

Calculating Speeds and Feeds

Cutting speed refers to the speed at which the tool point of the cutter moves with respect to the work measured in feet per minute. Feed is the rate at which the work moves into the cutter measured in feed per tooth revolution. Feeds and speeds affect the time to finish a cut, tool life, finish of the machined surface, and power required of the machine.

The cutting speed is mostly determined by the material to be cut and the material of the tool. To find the right speed for any task, refer to the *Machinery's Handbook* or other reference. To calculate the proper spindle speed, divide the desired cutting speed by the circumference of the tool (or of the part if it is rotating) expressed in feet. The feed rate depends on the width and depth of cut, finish desired and many other variables. To calculate the desired feed setting from the feed rate, multiply feed per tooth per revolution by number of teeth and rpm of the spindle.