5.10 SELECTION OF CUTTING CONDITIONS

For each machining operation, a proper set of cutting conditions must be selected during the process planning. Decision must be made about all three elements of cutting conditions,

1. depth of cut
2. feed
3. cutting speed

There are two types of machining operations:

1. *roughing operations*: the primary objective of any roughing operation is to remove as much as possible material from the workpiece for as short as possible machining time. In roughing operation, quality of machining is of a minor concern.

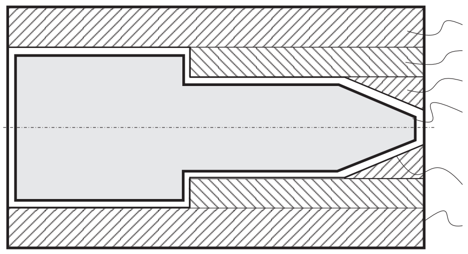
2. *finishing operations*: the purpose of a finishing operation is to achieve the final shape, dimensional precision, and surface finish of the machined part. Here, the quality is of major importance.

Selection of cutting conditions is made with respect to the type of machining operation. Cutting conditions should be decided in the order *depth of cut - feed - cutting speed*.

Selecting depth of cut

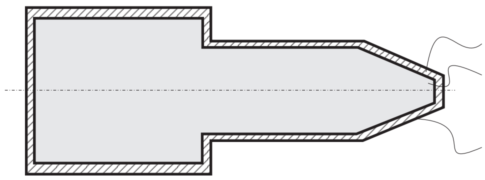
Depth of cut is predetermined by workpiece geometry and final part shape.

In *roughing* operations, depth of cut is made as large as possible (max depths are in the range of 6~10 mm) with respect to available machine tool, cutting tool strength, and other factors. Often, a series of roughing passes is required. Roughing operations must leave a thin layer of material (~0.5 mm on a side) required for the subsequent finishing operation.



Example of selection of roughing passes in a turning operation.

In the *finishing* cut, depth is set to achieve the final dimensions with a single pass removing the excessive material left after roughing.



Finishing pass in a turning operation.

Selecting feed

In *roughing* operations, feed is made as large as possible to maximize metal removal rate. Upper limits on feed are imposed by cutting forces and setup rigidity. Feeds in roughing can be as big as 0.5 mm tr^{-1}.

If the operation is *finishing*, feed should be small to ensure good surface finish. Computations like those in *Section 5.7 Surface Finish* can be used to estimate the feed that will produced a desired surface finish. Typical feeds in finishing are in the range of 0.05~0.15 mm tr^{-1}.

Optimizing cutting speed

As with most engineering problems, in machining we want to minimize costs, while increasing productivity. Efficiency is the key term - it suggests that good quality parts are produced at reasonable cost and at high production rate. Unfortunately, it is almost impossible to combine these contradictable requirements - cutting at high speed increases productivity but reduces tool life, therefore increases the production cost as more cutting tools will be necessary to finish the job. Hence, the optimal cutting speed has to be calculated for two objectives:

❶ cutting speed for maximum production rate, V_{max}, and
❷ cutting speed for minimum unit cost, V_{min}.

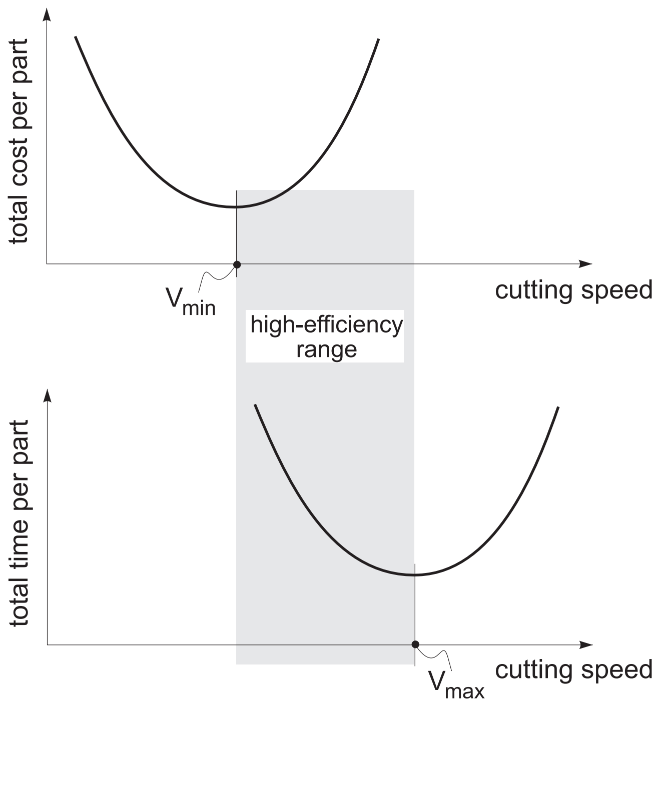
Both objectives seek to achieve a balance between material removal rate and tool life.

Maximizing production rate

Fox maximum production rate, the speed that minimizes machining time per unit part is determined. Minimizing cutting time is equivalent to maximizing productivity. It can be shown, that the cutting time for one part T_c is minimized at a certain value of cutting speed denoted as V_{max}.

Minimizing cost per unit

For minimum cost per unit, the cutting speed that minimizes production cost per part is determined. Again, the total cost of producing one part is minimized at a value of cutting speed denoted as V_{min}. In all cases, V_{max} is always greater than V_{min}. Since it is difficult to precisely calculate either values, a general recommendation is to operate within these two values, an interval known as the *high-efficiency range*:



Total cost per part and total time per part versus cutting speed. Both parameters are minimized at certain values of cutting speed.