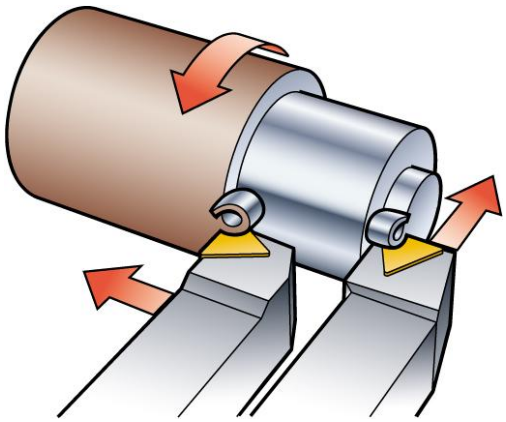
Selecting the Right Tool In Turning Applications-Part 2

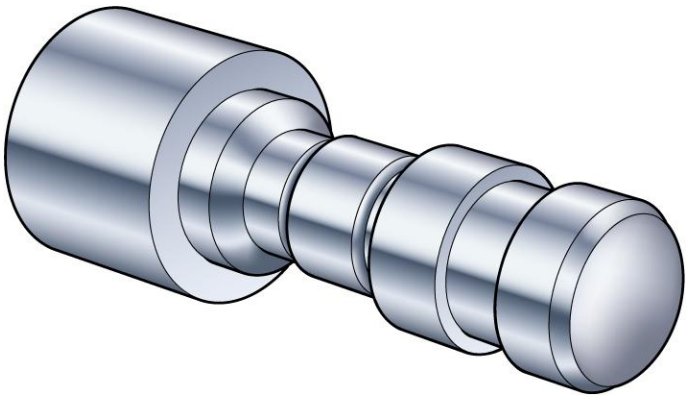
1. Factors influencing Turning Operations:

Turning is the combination of two movements viz. Rotation of the workpiece and feed movement of the tool.

In some applications, the workpiece can be stationary with the tool revolving around it to make the cut, but basically the principle is the same.

The feed movement of the tool can be along the axis of the workpiece, which means the diameter of the part will be turned down to a smaller size. Alternatively, the tool can be fed towards the center (facing off), at the end of the part. Often feeds are combinations of these two directions, resulting in tapered or curved surfaces which today's CNC turning center control-units, with their many program possibilities, are able to more than cope with.





As we know Cutting speed is equal to Vc has the formula:

$$v_c = \frac{D_m \times \pi \times n}{1000}$$

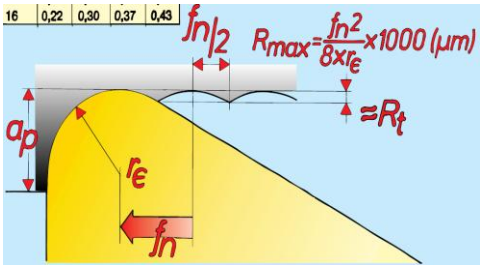
Vc= cutting speed in metres/min.

Dm= machined Dia.

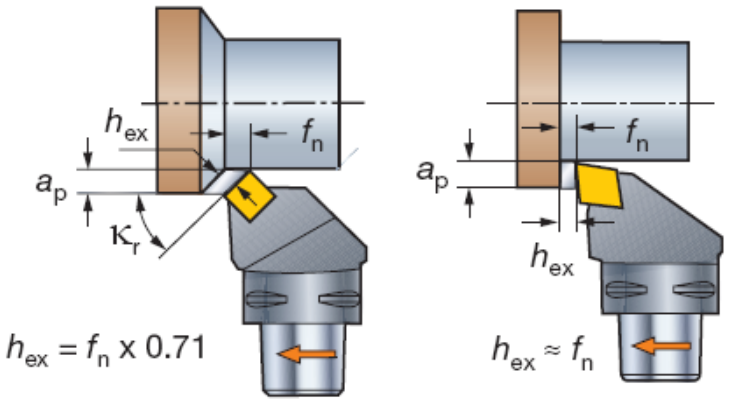
Chip formation varies with depth of cut, entering angle, feed, material and tool geometry

The entering angle and nose radius of the tool affects the chip formation in that the chip cross-section changes.

The nose radius influences the feed per revolution that is selected:



The entering angle influence the chip formation, it also affects factors such as the direction of forces involved, the length of cutting edge engaged in cut, the way in which the cutting edge makes contact with the workpiece and the variation of cuts that can be taken with the tool in question.



The entering angle usually varies between 45 to 95 degrees but for profiling operations, even larger entering angles are useful.

The chip thickness is reduced and the width increased with a smaller angle.

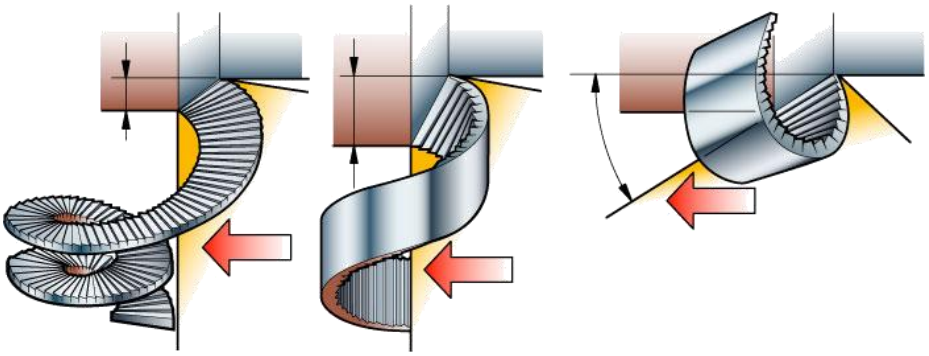
The direction of chip flow is also changed, usually advantageously, with the spiral pitch

being increased.

1.1. Depth of Cut and its influence on Chip Formation:

The cutting depth a_p is the length the edge goes into the workpiece

Depending upon the depth of cut (D O C = a_p), the shape and direction of chips also vary with the nose radius on the cutting edge.



When the D O C is small in relation to the nose radius the radius part is the main part of the cutting edge and spiral chips will be generated.

A larger depth leads to less influence from the radius and more from the actual entering angle of the edge with an outward directed spiral chip as the result.

The feed rate, however, also affects the width of the chip cross-section and the chip flow.

2. On the above background we now look at the Tool Selection process for Turning.

2.1. Component and the workpiece material:

Component:

- Analyze the dimensions and quality demands of the surface to be machined
- Type of operation (longitudinal, copying)
- External, internal
- Roughing, medium or finishing
- Tool paths
- No of passes
- Tolerances

Workpiece material:

- Machinability
- Cast, Forged or pre machined
- Chip breaking characteristics
- P/M/K/S/H type
- Hardness
- Alloy elements

2.2. Important machine considerations:

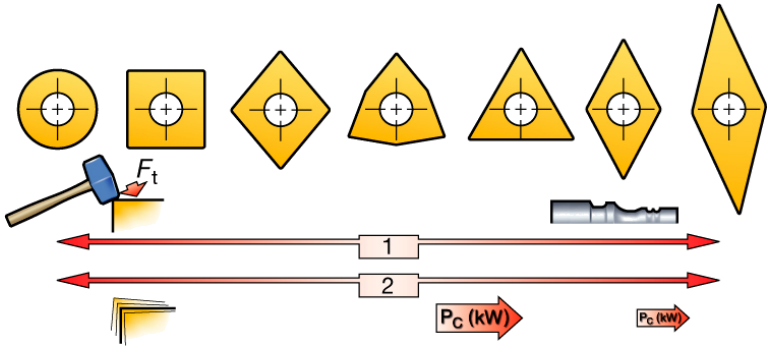
- Stability, power and torque especially for larger diameters
- Component clamping
- Tool position
- Tool changing times/number of tools in turret
- rpm limitations, bar feed magazine
- Sub spindle, or tail stock available?
- Use all possible support.
- Easy to program
- Cutting fluid and coolant

2.3: Choice of Tool Holders:

The selection of Tool holder will depend on the shape of the insert selected.

- The insert shape and point angle vary considerably from the smallest, at 35 degrees, to the round insert. There are also 55, 60, 80 and 90 degrees.
- Each has unique properties: Some provide the highest roughing strength; others give the best profiling accessibility.
- Each also has unique limitation: (for example) High edge accessibility during machining leads to a weaker cutting edge. See figure below:

Cutting edge strength- S increases to the Left



Vibration tendency V reduces to the right, accessibility improves; Power requirement reduces

But insert strength reduces

The insert shape and point angle vary considerably from the smallest, at 35 degrees, to the round insert. There are also 55, 60, 80 and 90 degrees.
Each has unique properties: Some provide the highest roughing strength; others give the best profiling accessibility.
Insert shapes to the right have a higher edge accessibility for machining profiles, but leads to a weaker cutting edge, while a stronger insert shapes are to the left but need to be applied based on set up rigidity as they have stronger vibration tendencies and consume more power. However stronger inserts- even round inserts are preferred for machining HRSA materials like Inconel that have prominent notch wear characteristics.

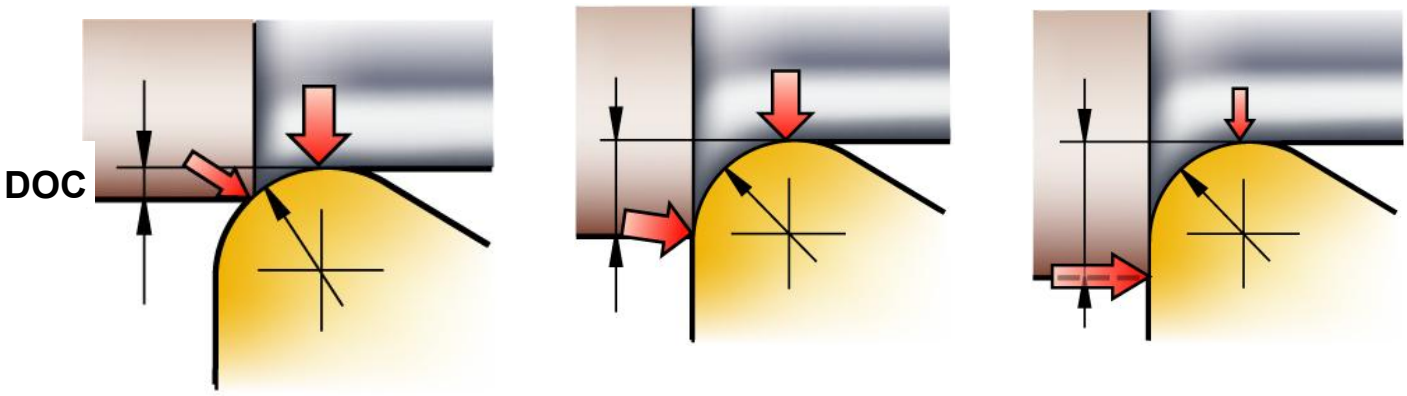
Therefore Insert shape should be selected relative to the entering angle accessibility required for the tool.
The largest possible point angle should be applied to give insert strength and reliability. But this has to be weighed against the variation of cuts needed to be taken.
A large point angle is strong but needs more machine power and has a higher tendency to vibrate; the small point angle is weaker and has a small cutting edge engagement, which can make it more sensitive to the effects of heat.

3.1 Selection of Nose Radius of Insert:

The nose radius is a key factor specifically in turning operations.
Inserts are available in several nose radii.

- A small nose radius has a weaker point than a large nose radius, but it is ideal for fine cuts.
- A large nose radius provides a strong edge, but requires a high feed rates for proper metal removal.

We elaborate a bit on this below:



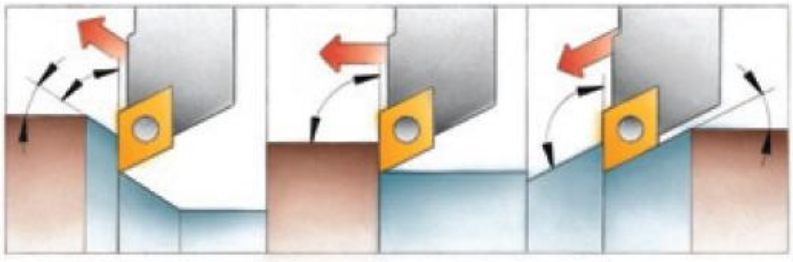
A rule of thumb is to choose a nose radius which is somewhat less than the Depth of Cut (DOC). In this way the radial cutting forces can be kept to a minimum while utilizing the advantages of the largest possible nose radius leading to a stronger cutting edge, better surface texture and more even pressure on the cutting edge.
A second rule of thumb for rough turning says that the feed selected should be @ half the nose radius value.

3.2. Choice of Tool Path:

The tool path has a significant impact on the machining process and in the selection of Tools .
It influences

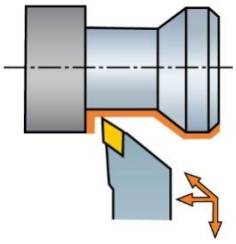
- Chip control
- Insert wear
- Surface quality
- Tool life

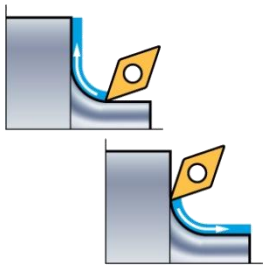
The effective entering angle needs to be considered for satisfactory machining when the operation involves profiling.



In turning tool paths that generate a profile instead of plunging it give a higher level of

process security and consistency and also induce lower stresses in the component and such strategies are successfully used in difficult to machine HRSA materials.





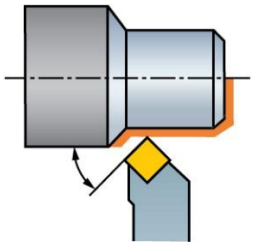
To take an overview:

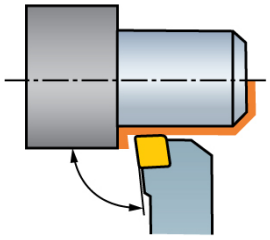
the recommended right tools sequence for Turning applications can be summarized as below:

Recommended turning tool selection sequence

- Tool holder
- Index able insert
  - shape
  - size
  - nose radius
  - geometry
  - grade
- Cutting data

The main objective of this article is not to supplant any recommendations of Tool manufacturers but to try and provide a generic perspective from an application point of view.





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