



## **Factors that influence success in Turning Boring Applications.**

### **Internal or Turning-Boring:**

Most of the turning operations that are classified as external turning are also to be found in boring, which is performed with stationary turning tools.

In external turning, the tool overhang is not affected by the length of the workpiece; the size of the tool holder is selected to withstand the forces and stresses which arise during the operation.

With boring i.e. internal turning - the choice of tool is very much restricted by the component's hole diameter and length; the depth of the hole determines the overhang required for the tool holder or boring bar.. Therefore in Boring applications, the choice of the tool holder and how to best apply it become more critical than in external turning. A general rule, which applies to all machining is to always minimize tool overhang and to select the largest possible tool size in order to obtain the best possible stability and thereby accuracy. The stability is increased when a larger boring bar diameter is used, but possibilities are often limited, since the space allowed by the diameter of the hole in the component must be taken into consideration for chip evacuation and any radial movement.

The limitations with regard to stability in boring mean that some extra care must be taken with tooling preparations. Selecting the right boring bar for the operation, and applying it correctly as well as clamping it properly has considerable effect on keeping tool deflection and vibrations to a minimum, and consequently improve the quality of the hole being machined.

To be able to make the right tooling selection for Boring applications it is important to consider the forces that act on the cutting edge in Boring.

### **Cutting forces in boring operations**

When the tool is in cut, a tangential cutting force and the radial cutting force will tend to deflect the tool away from the workpiece. The tangential force will try to force the tool downwards and away from the centre line, in so doing it will also reduce the tool clearance angle. When boring small diameter holes, it is particularly important that the clearance angle of the insert is sufficient in order to avoid contact between tool and wall of hole. (Fig 1)

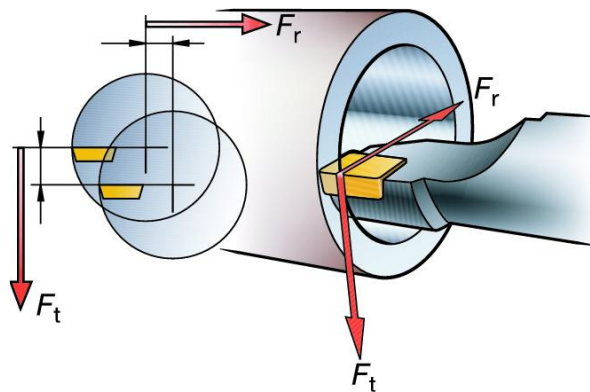


Fig 1

## Cutting tool deflection

The strength of the cutting forces, in both the radial and tangential directions, is also affected by the entering angle of the boring bar, the depth of cut,  $a_p$ , and the insert nose radius,  $r_e$  of the insert.

The radial deflection affects the machined hole diameter and the tangential deflection moves the insert cutting edge downwards, away from the centre line. (Fig 2)

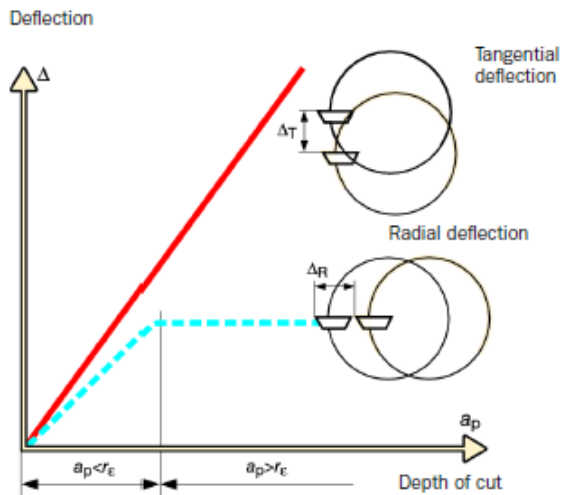


Fig 2

Any radial deflection means that the cutting depth as well as the chip thickness is reduced, which can lead to vibration tendencies. The stability of the tool and clamping will then be crucial as to the magnitude of the vibration and whether this is amplified.



Cutting Tool deflections are mainly influenced by:

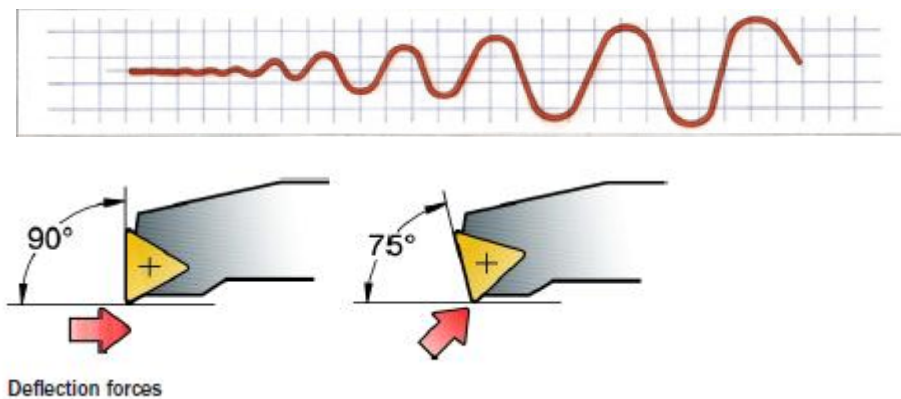
1. Tool/insert geometry
2. Chip evacuation
3. Tool requirements

Turning Boring, today is done mainly on Turning Centres, or CNC machines which enable us, to address the various Factors that are responsible for success in boring like Chip control, chip evacuation, vibrations, size control & surface finish far more efficiently than what would have been possible on conventional Lathes or Boring Special Purpose machines.

This is mainly because we can apply the right Tool Holders, inserts, insert geometry, Coatings, coolant flow adjustments, constant cutting speed cycles, programmable feed rates etc...

## 1. Tool Insert/Geometry:

### 1.1 Entering Angle: Fig 3.



**Fig3.**

The entering angle of the boring tool affects the direction and magnitude of axial and radial cutting forces and the resulting deflections. A large entering angle produces a large axial cutting force component while a small entering angle results in a larger cutting force in the radial direction.

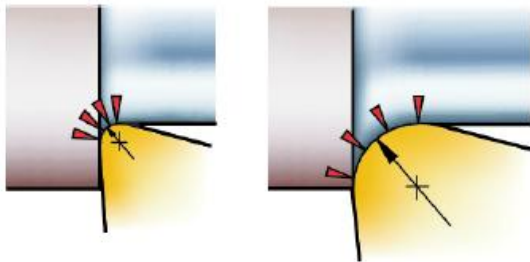
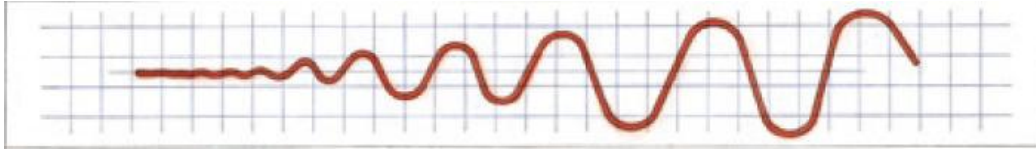
However, the axial cutting force does not normally have a large effect on the operation since the force is directed along the boring bar. It is advantageous therefore to choose a large entering angle. It is also recommended that the entering angle be as close to 90 degrees as possible and never less than 75 degrees as this means a

dramatic increase in the magnitude of the radial cutting force.



## 1.2. Nose radius and nose angle: Fig 4.

Generally in boring, a small nose radius should be first choice. The larger the nose radius, the larger will be the radial and tangential cutting forces and the risk of vibration.



**Fig 4**

The deflection of the tool in a radial direction on the other hand is more affected by a combination of the cutting depth and the size of the nose radius.

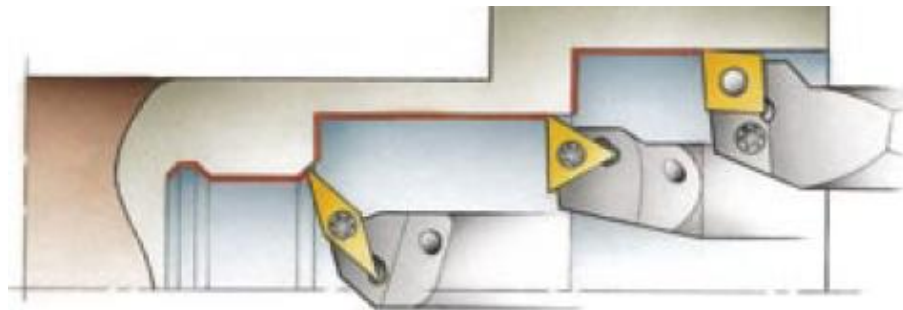
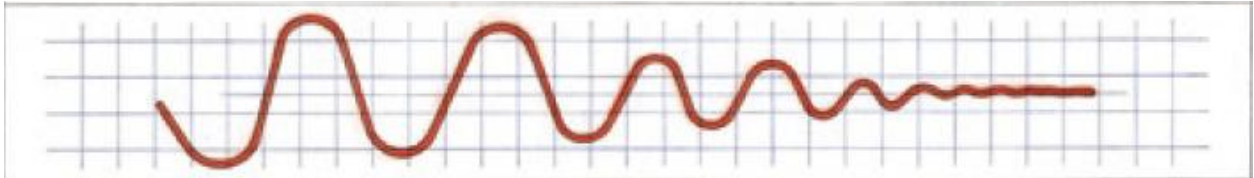
The radial cutting forces will increase with increased cutting depth. As soon as the cutting depth is the same or greater than the size of the nose radius, the radial deflection will be determined by the entering angle.

A rule of thumb is to choose a nose radius which is somewhat less than the cutting depth. 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 finish and more even pressure on the cutting edge.



### 1.3. Insert point angle:

Choose insert shape dependent on the entering angle and accessibility requirements of the tool.



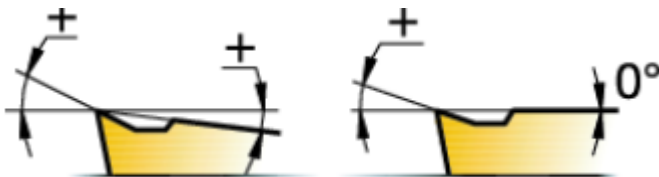
**Fig 5a**

In general, the largest possible point angle should be used to maximize insert strength and reliability.

A large point angle needs more machining power and has a higher tendency to vibrate due to a large cutting edge engaged in the cut; Conversely a large point angle which has a favourable approach angle for finish boring is many times discarded due to the economics of two edges versus three edges .

### 1.4. Insert Macro Geometry:

The geometry of the insert has a decisive influence on the boring process because a more positive geometry means a lower tangential force....



**Fig 5. Positive basic inserts**



**Fig 6. Negative basic inserts**

In Finish Boring, positive basic-shape inserts are preferred (Fig. 5), as they provide lower cutting forces compared to basic negative inserts.



A basic negative insert can be made positive by the chip breaker geometry; The basic negative insert made positive with a good chip breaker geometry is useful in rough boring applications to withstand heavy cutting forces encountered in rough boring.

### 1.5. Micro Geometry(Fig 7,8,9)

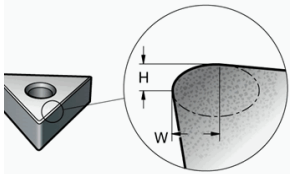


Fig 7.



Fig 8



Fig 9

The edge rounding (ER) of the insert also affects the cutting forces. In general, uncoated inserts have smaller edge rounding (Fig 8) than coated inserts (Fig 9) and this detrimental with large tool overhangs and small holes.

The Cutting Edge of an insert needs to be sharp for finish boring and hence uncoated inserts or inserts with thin coatings, which retain their edge sharpness will generate lower cutting forces compared to thickly coated inserts, and are therefore preferred for finish boring;

While a higher value of Edge rounding is used for inserts which are used for rough boring.

### 2. Chip evacuation:

Chip evacuation during internal turning is critical to performance and to the security of

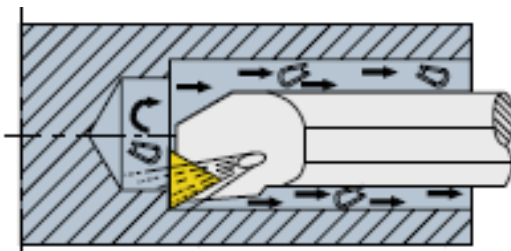


Fig.10.

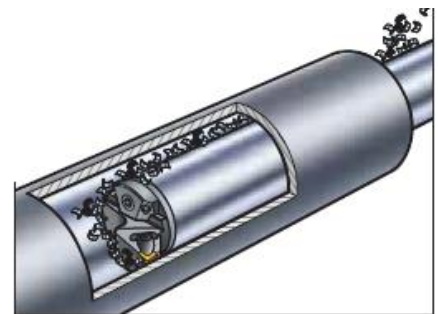


Fig11.

the operation; short and spiral chips the goal for internal turning boring. These are easy to evacuate and do not cause a lot of stress on the cutting edge during chip breaking. Long chips can also cause problems for chip evacuation.

To achieve efficient chip evacuation in Boring it's important to understand the factors

that influence Chip evacuation:



Centrifugal forces presses the chips outwards and keep the chips inside the hole. The chips can be pressed onto the surface and damage the component and the tool(Fig 12& 13).

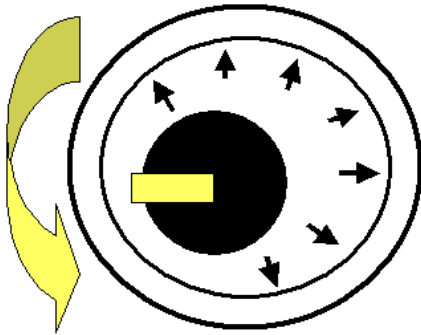


Fig 12.

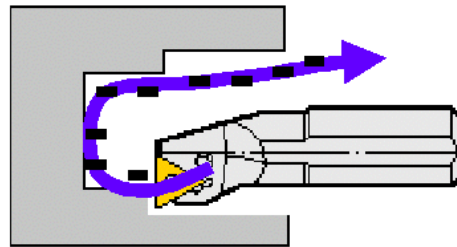


Fig 13

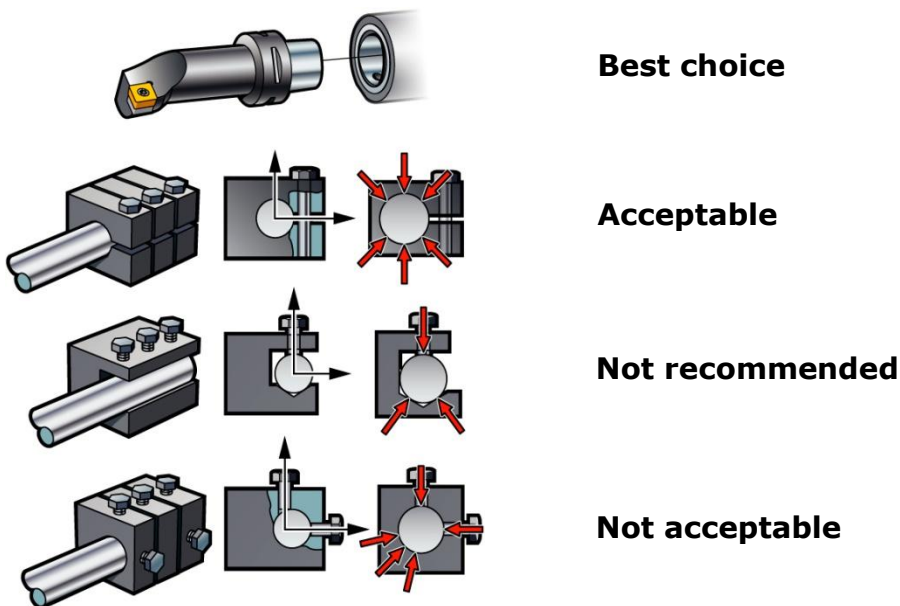
To avoid this it is necessary to:

1. Increase the coolant flow.
2. Choose an insert with a sharp cutting edge.
3. An insert geometry that is able to curl the chips in a spiral manner not too short and not too long; coiled chips 50-60 mm long are considered to be good.
4. Choose a depth of cut larger than the nose radius; If the depth of cut is less than the nose radius the chip breaker geometry is not effective to coil the chips.

### 3. Boring Bar Clamping:

The method of clamping the boring bar plays an important role in Boring applications. Modern high-performance boring tools are to be clamped with high stability so as not to introduce a weak link in the set-up. To start with, it is important that the internal surfaces of the tool clamping arrangement are clean and have high surface finish and sufficient hardness to exert a uniform clamping force on the boring bar. (Fig 14)

Fig.14





Further it's important for stability of the Boring bar and thereby its performance that the bar is clamped on 3-4 times its diameter:

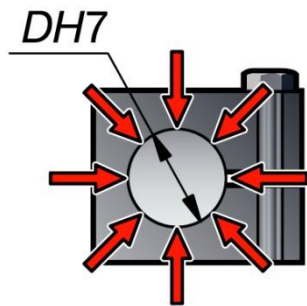
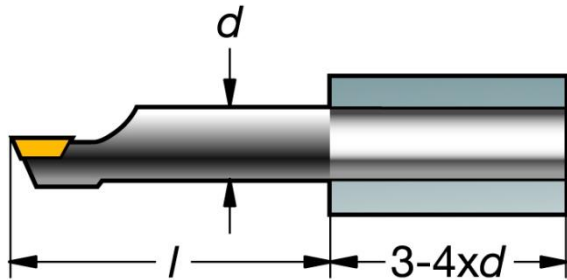


Fig 15

#### 4. Turning Boring has four main application areas:

A. Longitudinal Boring:

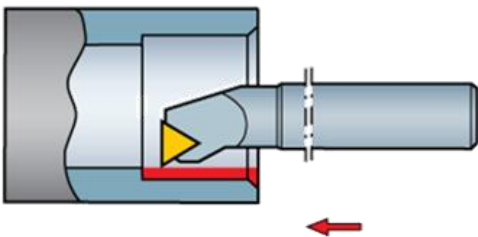


Fig 16

B. Longitudinal Boring/Facing:

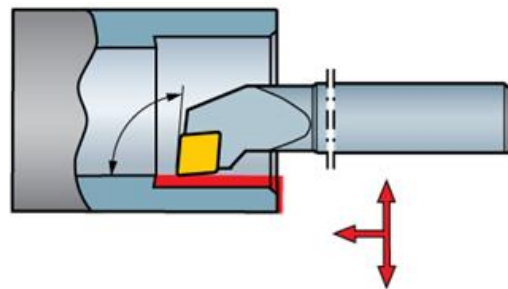


Fig.17

C. Profiling

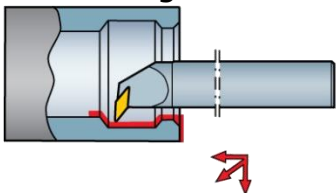


Fig 18

D. Profiling and Back boring

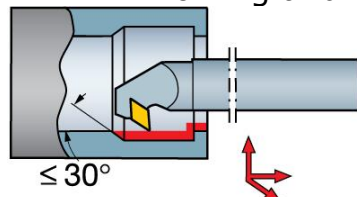


Fig 19.



For example let us look at Vibrations as an issue which is quite common in Boring:

**5. Vibrations:** see fig 19 below: Vibration tendencies grow towards the right.

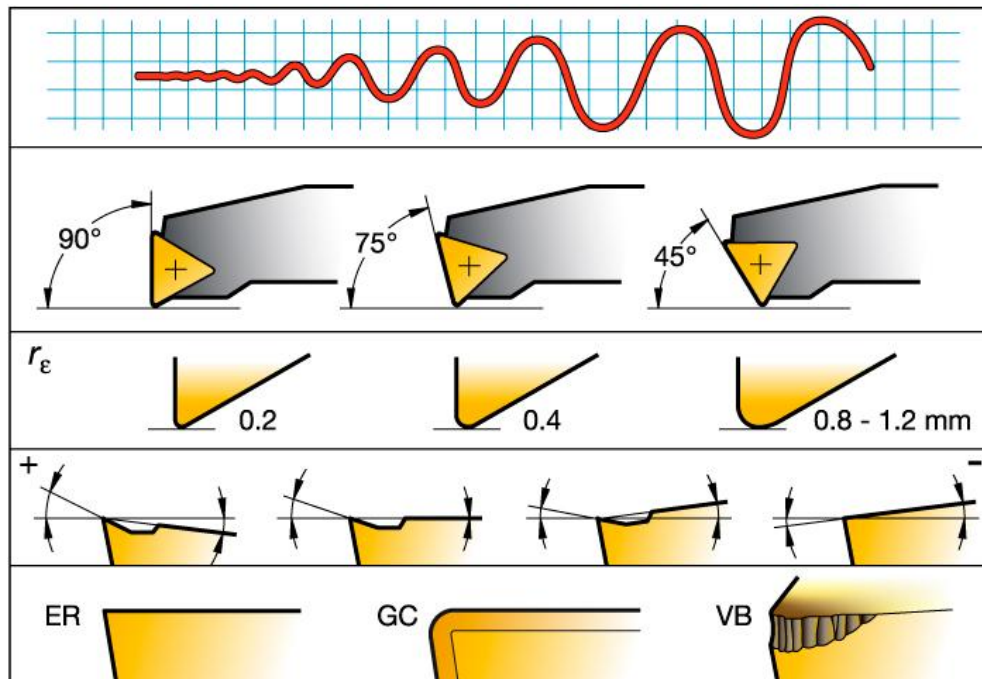


Fig 19.

Eliminating vibrations in boring is an important feature of successful boring and the above fig. indicates the approach in tool selection, insert geometry etc..

Insert selection, approach angle etc all help in eliminating vibrations.

But there is another important factor that influences vibrations – which is Tool Overhang.

The above factors help in eliminating vibrations using conventional steel boring bars for Boring depth up to a L/D (Length: Diameter) ratio of 4.

Boring depths above this L/D ratio need Boring Bars of denser materials as well as different damping mechanisms , which when combined with the above approach of.

Below we give an overview on these types of Boring Bars which can differ with different Tool manufacturers based on the technologies available with them:



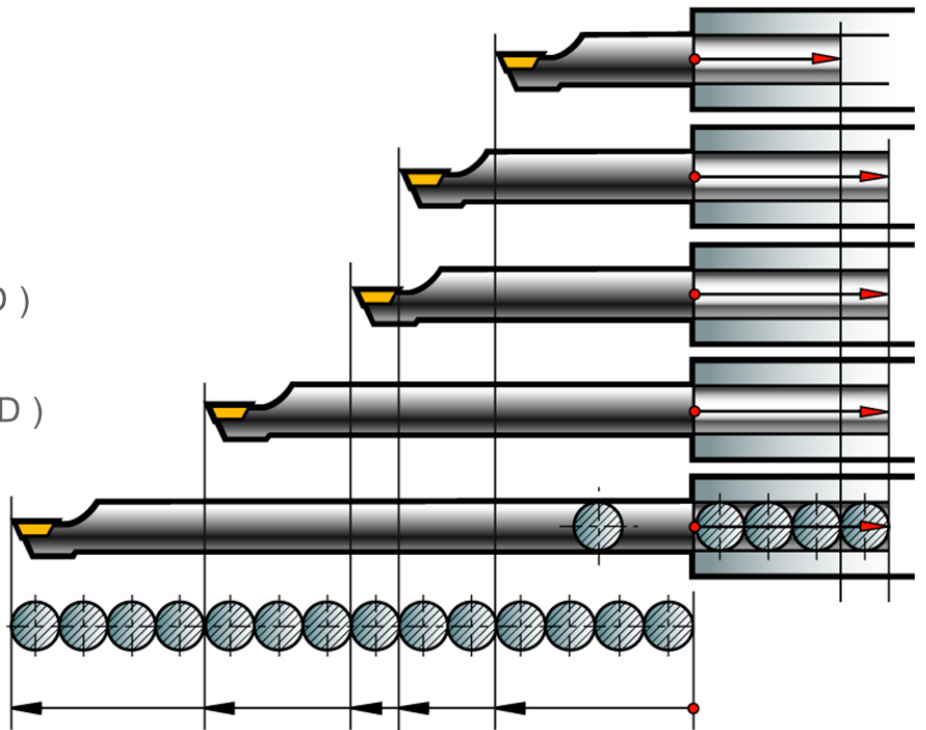
1. Steel bar ( Up to  $4 \times D$  )

2. Carbide bar ( Up to  $6 \times D$  )

3. Short, damped bar ( Up to  $7 \times D$  )

4. Long, damped bar ( Up to  $10 \times D$  )

5. Carbide reinforced damped boring bar ( Up to  $14 \times D$  )



The above is an overview of the factors that influence successful boring...