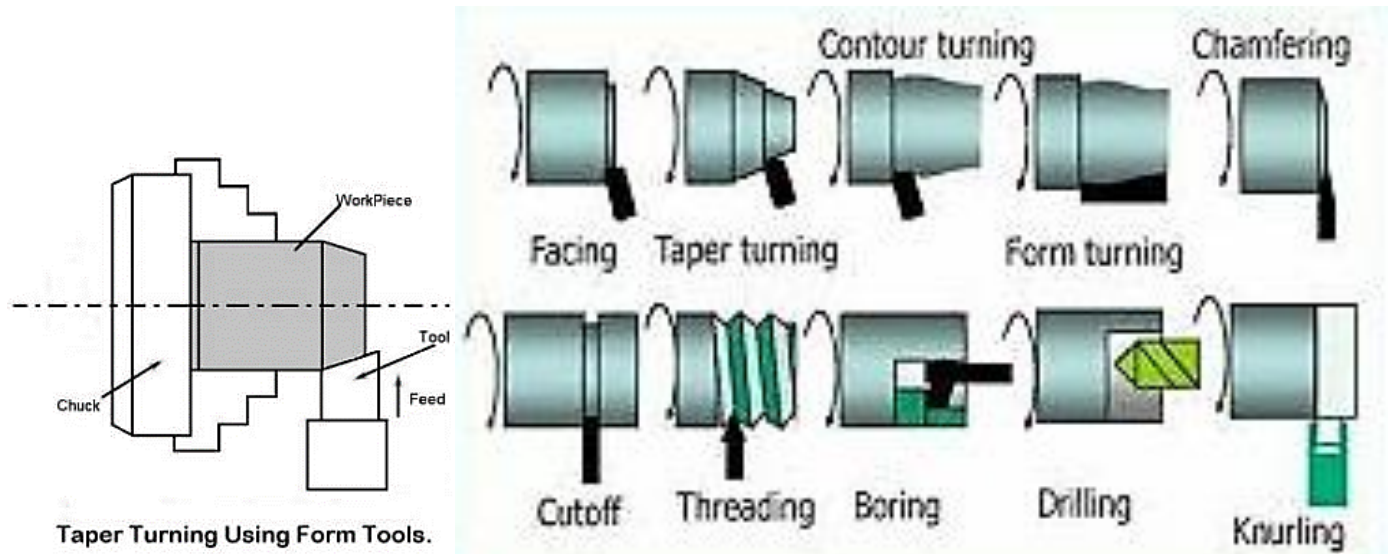


بسمه تعالی  
 الجامعة المستنصرية – كلية الهندسة- قسم الهندسة الميكانيكية  
 مادة عمليات التصنيع  
 ا. د. ناظم مجبل فالح

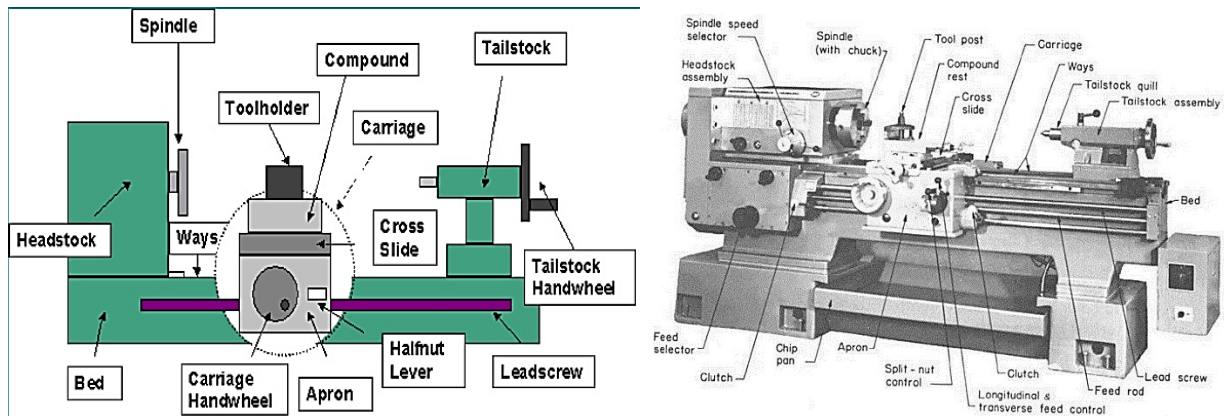
## TURNING

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix tool path by moving more or less linearly while the work-piece rotates.

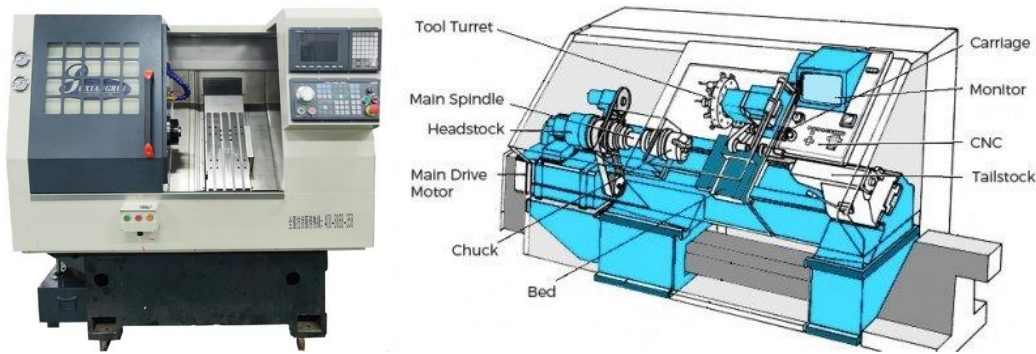


### Type of turning machine m/c

Turning can be done manually, in a **traditional** form of lathe, which frequently requires continuous supervision by the operator, or by using an automated lathe which does not. Today the most common type of such automation is **computer numerical control**, better known as **CNC**.



**Lathe machine**



**CNC Lathe machine**

## Types of turning operations

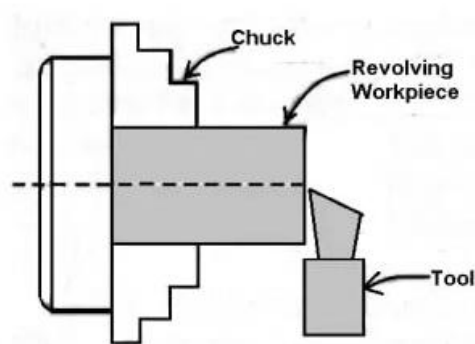
The **lathe machine operations** are classified into three main categories and are as follows.

Following are the **Lathe machine operations** done either by holding the workpiece between centres or by a chuck:

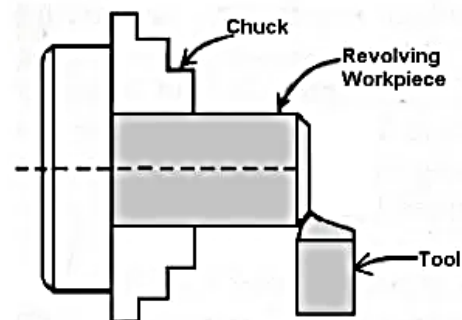
### 1. Turning Operation

- Plain or Straight Turning
- Rough Turning
- Shoulder Turning
- Taper Turning
- Eccentric Turning

### 2. Facing Operation



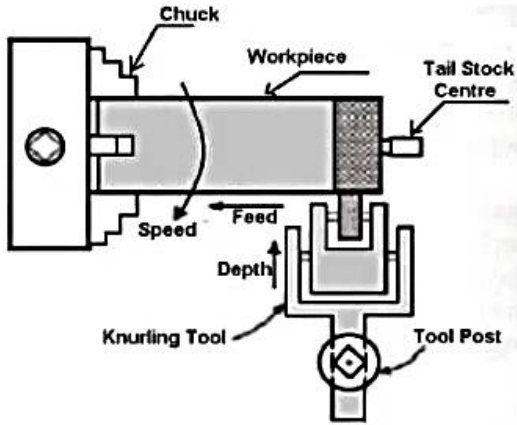
**Facing Operation**



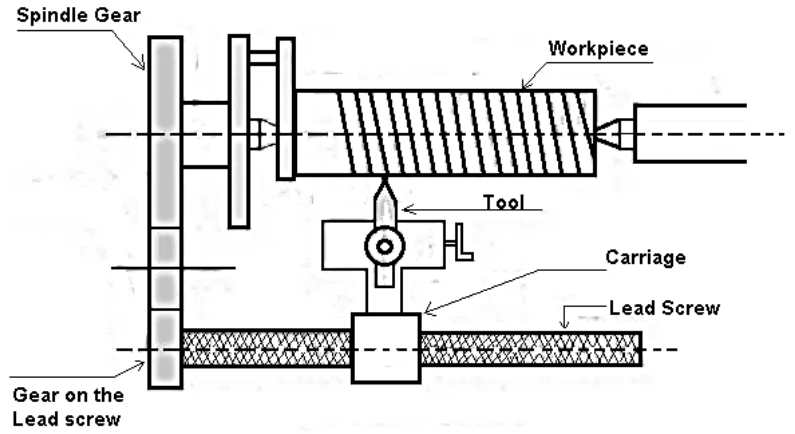
**Chamfering**

### 3. Chamfering Operation

### 4. Knurling Operation



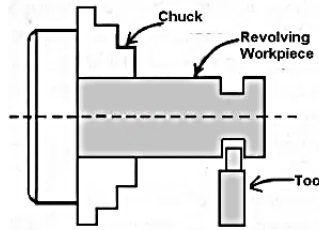
Knurling



Thread Cutting

5. Thread cutting Operation

6. Grooving Operation<sup>1</sup>



Grooving

## Turning Tools

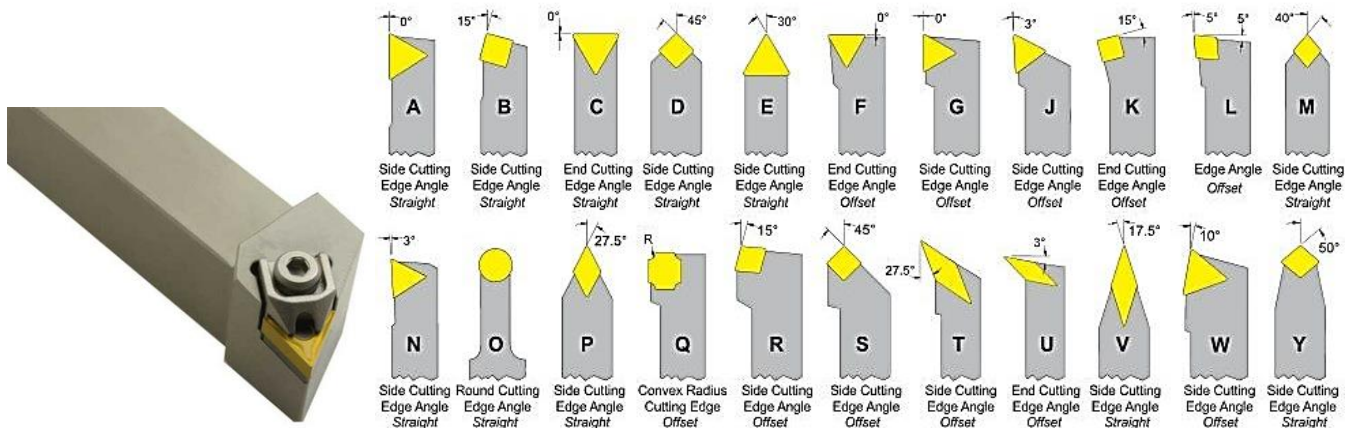
Turning tools are used on lathes for cutting or finishing the outside diameter of a workpiece. Turning tools can be used to produce cylindrical parts. In its basic form, turning can be defined as the machining of an external surface with the workpiece rotating, or with a single-point cutting tool.

1. Traditional turning tools



<sup>1</sup> هذه بعض انواع الخراطة في الماكائن التقليدية. اما في مكانن التحكم الرقمي، تكون العدة عبارة عن اقراص (لقم) ولا نحتاج الى عدد خاصة.

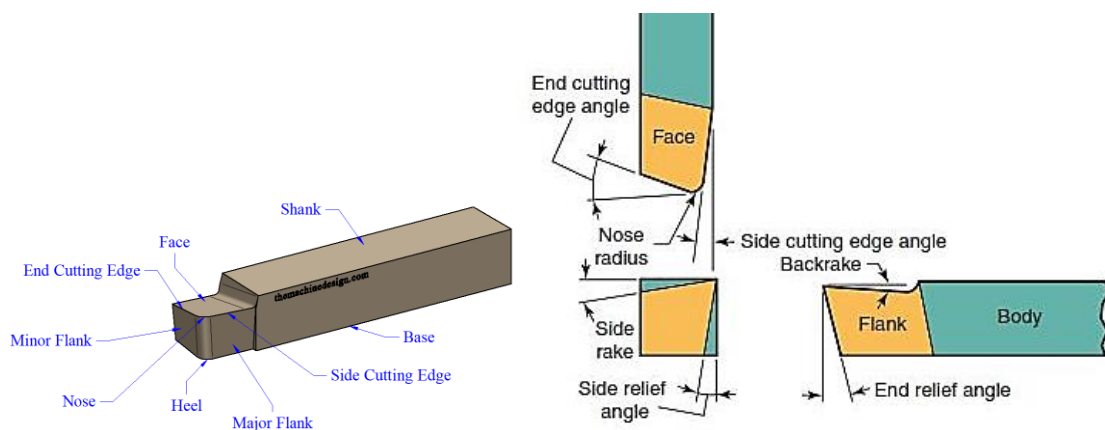
## 2. CNC turning tools



### Turning tool geometry

What is Single Point Cutting Tool?

Cutting tool in Mechanical Engineering is a tool used to **cut or remove** any other material by application of **force**. In our daily life, we use knives and scissors are also examples of cutting tools. Where Single Point Cutting Tool removes chip or cut the material from work-piece by means of single-point or edge attached with shank. Cutting tools are most widely used in industries for creating the required shape of the product by facing, turning, chamfering, shaping, drilling, boring, etc operations. Lathe machine and shaper machines having single-point cutting tools in most of the operations. In industries most widely examples of single-point cutting tools are turning tool, boring tool, shaping tool, planing and slotting tool.



By means of cutting tool Nomenclature is the systematic naming of various parts and angles of cutting – tool. The above image shows the complete nomenclature of a single-point cutting tool. These are Shank, base, face, flank, heel, nose, back rake angle, side rake angle, side clearance, wide cutting edge, end cutting edge, and lip angle.

1. **Shank** – Shank is the main body of cutting tool which grabbed by tool holder on the
2. of the nose which helps to achieve better surface finishing as well as increases tool life.
3. **Heel** – A line of intersection of flank and base surfaces is known as Heel of a single-point cutting tool.
4. **Flank** – Cutting tools having two flank surfaces, i.e; Major Flank and Minor Flank. *Major flank* is a vertical surface adjacent to the side cutting edge. And *Minor flank* is a vertical surface adjacent to the end cutting edge. But, both surfaces are not actually vertical, they slightly inclined towards the base. ***Cutting Face*** is another name of Flank.
5. **Cutting Edge** – Edges which used to remove material during the machining process called as machine. It is a larger part of the tool in aspects of volume.
6. **Face** – Face is the surface of the tool where chips slide towards to up and outward side, during the machining process.
7. **Base** – The bottom surface of the tool is known as the base, on which tool stands.
8. **Nose or Cutting Point** – A point where side and End cutting edges are meets in front of the tool. It is also known as the Cutting Point of tool. And [Nose radius](#) is the radius cutting edge. Face and cutting surfaces makes Cutting Edges. Single point cutting tools having two cutting edges as side cutting edge and end cutting edge.
- #. **Side Cutting Edge** – Edge or line made by face and minor flank or minor cutting surface.
- #. **End Cutting Edge** – As like side cutting edge, end cutting edge made by face and major flank or major cutting surface.

## Tool life

### Taylors tool life equation.

Wear and hence tool life of any tool for any work material is governed mainly by the level of the machining parameters, i.e., cutting velocity, ( $V_c$ ), feed, ( $s_o$ ) and depth of cut ( $t$ ). cutting velocity affects maximum and depth of cut minimum. The usual pattern of growth of cutting tool wear (mainly  $V_B$ ), principle o assessing tool life and its dependence on cutting velocity are schematically shown in Fig.1.

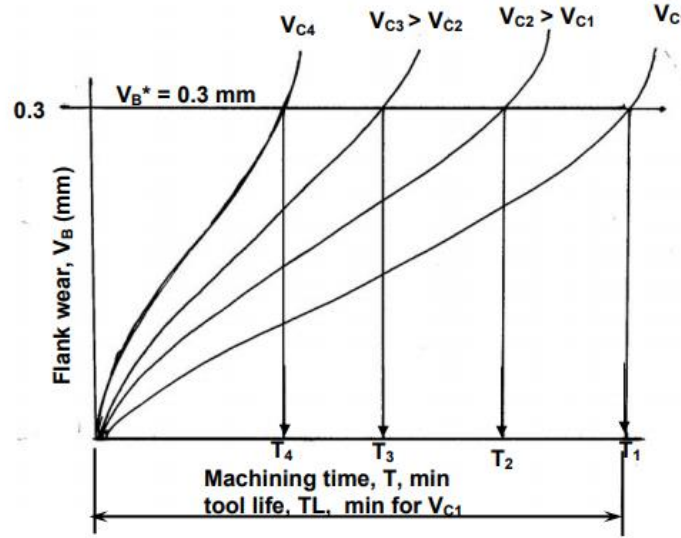


Figure 1: Growth of flank wear and assessment of tool life

The tool life obviously decreases with the increase in cutting velocity keeping other condition's unaltered as indicated in Fig.1.

If the tool lives,  $T_1, T_2, T_3, T_4$  etc. are plotted against the corresponding cutting velocities,  $V_1, V_2, V_3, V_4$  etc as shown in Fig.2, a smooth curve like a rectangular hyperbola is found to appear. When F.W.Taylor plotted the same figure taking both  $V$  and  $T$  in log-scale, a more distinct linear relationship appeared as schematically shown in Fig.3.

With the slope,  $n$  and intercept,  $c$ , Taylor derived the simple equation as

$$VT^n = C$$

Where,  $n$  is called, Taylor's tool life exponent. The values of both ' $n$ ' and ' $c$ ' depend mainly upon the tool-work materials and the cutting environment (cutting fluid application). The value of  $C$  depends also on the limiting value of  $V_s$  undertaken (i.e., 0.3 mm, 0.4 mm, 0.6 mm etc.)

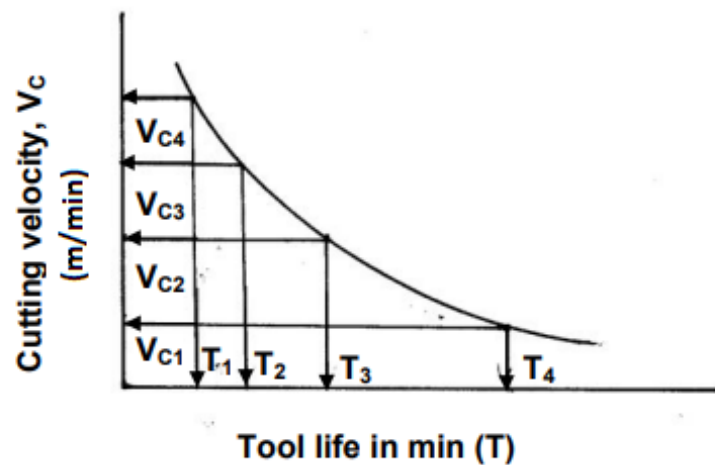


Figure 2: Cutting velocity - tool life relationship

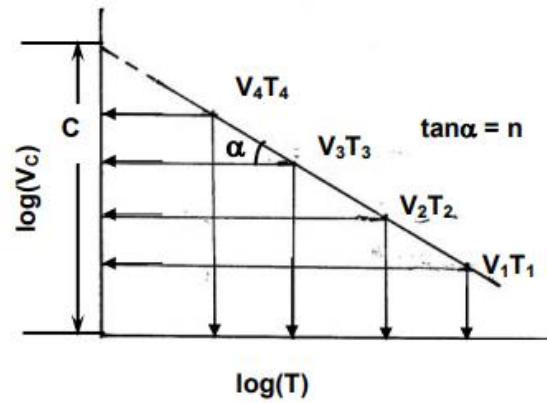


Figure 3: Cutting velocity vs tool life on a log-log scale

### Example of use of Taylor's tool life equation.

If in turning of a steel rod by a given cutting tool (material and geometry) at a given machining condition ( $S_o$  and  $t$ ) under a given environment (cutting fluid application), the tool life decreases from 80 min to 20 min. due to increase in cutting velocity,  $V_c$  from 60 m/min to 120 m/min, then at what cutting velocity the life of that tool under the same condition and environment will be 40 min?

Solution :

Assuming Taylor's tool life equation,  $VT^n = C$

$$V_1T_1 = V_2T_2 = V_3T_3 = \dots = C$$

Here,

$$V_1 = 60 \text{ m/min}, T_1 = 80 \text{ min.}$$

$$V_2 = 120 \text{ m/min}, T_2 = 20 \text{ min.}$$

$$V_3 = ? \text{ (to be determined)}, T_3 = 40 \text{ min.}$$

Taking,

$$V_1T_1^n = V_2T_2^n$$

$$\text{i.e. } \left(\frac{T_1}{T_2}\right)^n = \frac{V_2}{V_1}$$

$$\text{or } \left(\frac{80 \text{ min}}{20 \text{ min}}\right)^n = \left(\frac{120 \text{ m/min}}{60 \text{ m/min}}\right)$$

from which,  $n = 0.5$

$$\text{again } V_3T_3^n = V_1T_1^n$$

$$\text{or } V_3 = \left(\frac{80}{40}\right)^{0.5} \times 60 = 84.84 \text{ m/min ANS}$$

### Problem:

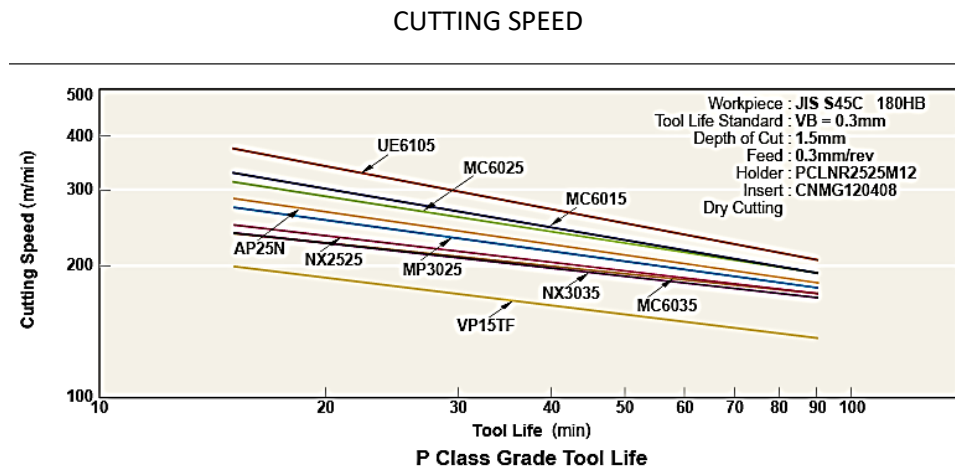
If in turning of a steel rod by a given cutting tool (material and geometry) at a given machining condition ( $S_o$  and  $t$ ) under a given environment (cutting fluid application), the tool life decreases from 100 min to 40 min. due to increase in cutting velocity,  $V_c$  from 80 m/min to 140 m/min, then at what cutting velocity the life of that tool under the same condition and environment will be 60 min?

## Cutting Conditions

### Effects of Cutting Conditions for Turning

#### EFFECTS OF CUTTING CONDITIONS

Ideal conditions for cutting are short cutting time, long tool life, and high cutting accuracy. In order to obtain these conditions, selection of efficient cutting conditions and tools, based on work material, hardness, shape and machine capability is necessary.



#### Effects of Cutting **SPEED**

1. Increasing cutting speed by 20% decreases tool life by 50%. Increasing cutting speed by 50% decreases tool life by 80%.

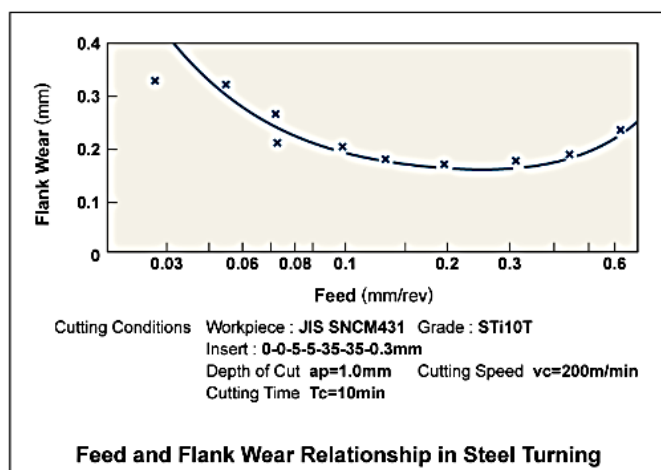
2. Cutting at low cutting speed (20–40m/min) tends to cause chattering. Thus, tool life is shortened.

#### Effects of **FEED**

When cutting with a general type holder, feed is the distance a holder moves per workpiece revolution. When milling, feed is the distance a machine table moves per cutter revolution divided by the number of inserts. Thus, it is indicated as feed per tooth. Feed rate relates to finished surface roughness.

##### Effects of Feed

1. Decreasing feed rate results in flank wear and shortens tool life.
2. Increasing feed rate increases cutting temperature and flank wear. However, effects on the tool life is minimal compared to cutting speed.
3. Increasing feed rate improves machining efficiency.



Depth of cut is determined according to the required stock removal, shape of workpiece, power and rigidity of the machine and tool rigidity.

## Effects of Depth of Cut

1. Changing depth of cut doesn't effect tool life greatly.

2. Small depths of cut result in friction when cutting the hardened layer of a workpiece. Thus tool life is shortened.

3. When cutting uncut surfaces or cast iron surfaces, the depth of cut needs to be increased as much as the machine power allows in order to avoid cutting impure hard layers with the tip of cutting edge to prevent chipping and abnormal wear.

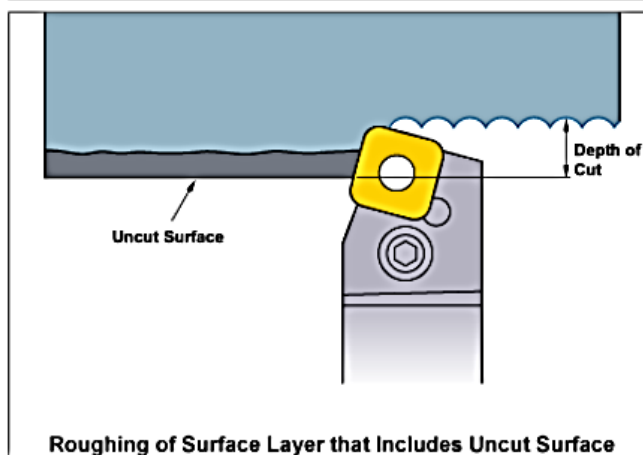
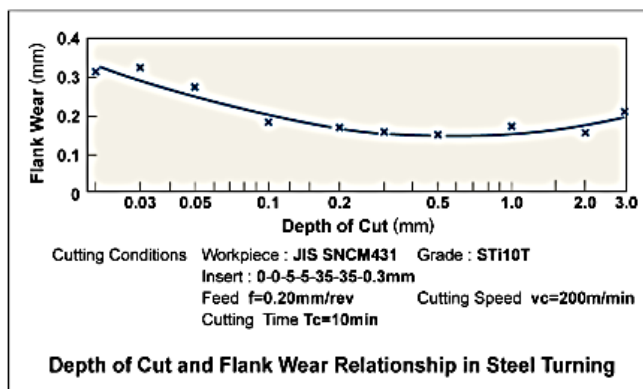


**Table1:** Roughness ,Tolerance and Operating conditions

| R <sub>a</sub><br>micrometer<br>$\mu\text{m}$ | Roughness<br>Grade Numbers | Operation<br>(Technical method)            | Tolerance mm       |                 | Operating conditions |                                             |                                            |
|-----------------------------------------------|----------------------------|--------------------------------------------|--------------------|-----------------|----------------------|---------------------------------------------|--------------------------------------------|
|                                               |                            |                                            | $\leq 10\text{mm}$ | $> 10\text{mm}$ | depth<br>mm          | feed<br>( $\frac{\text{mm}}{\text{rev.}}$ ) | speed<br>( $\frac{\text{m}}{\text{min}}$ ) |
| $> 70$                                        | $\sim$                     | Casting, Forging,<br>sawing, flam cut.     | $\pm 0.5$          | $\pm 1.0$       | 3                    | 0.3                                         | 50                                         |
| $> 50$                                        |                            | Precision casting                          | $\pm 0.3$          | $\pm 0.7$       |                      |                                             |                                            |
| 50<br>25<br>12.5                              | $\nabla$                   | Roughing (milling,<br>turning , drilling)  | $\pm 0.1$          | $\pm 0.2$       | 1                    | 0.1                                         | 100                                        |
| 6.3<br>3.2<br>1.6                             | $\nabla\nabla$             | Finishing (milling,<br>turning , drilling) | $\pm 0.07$         | $\pm 0.1$       |                      |                                             |                                            |
| 0.8<br>0.4<br>0.2                             | $\nabla\nabla\nabla$       | Grinding, Honing<br>Broaching              | $\pm 0.01$         | $\pm 0.02$      |                      |                                             |                                            |
|                                               |                            |                                            |                    |                 | 0.2                  | 0.05                                        | 130                                        |

**NOTE :** This virtual table is valid for this exam only For LOW CARBON STEEL and Operating conditions for milling, turning, drilling useful for carbide tool