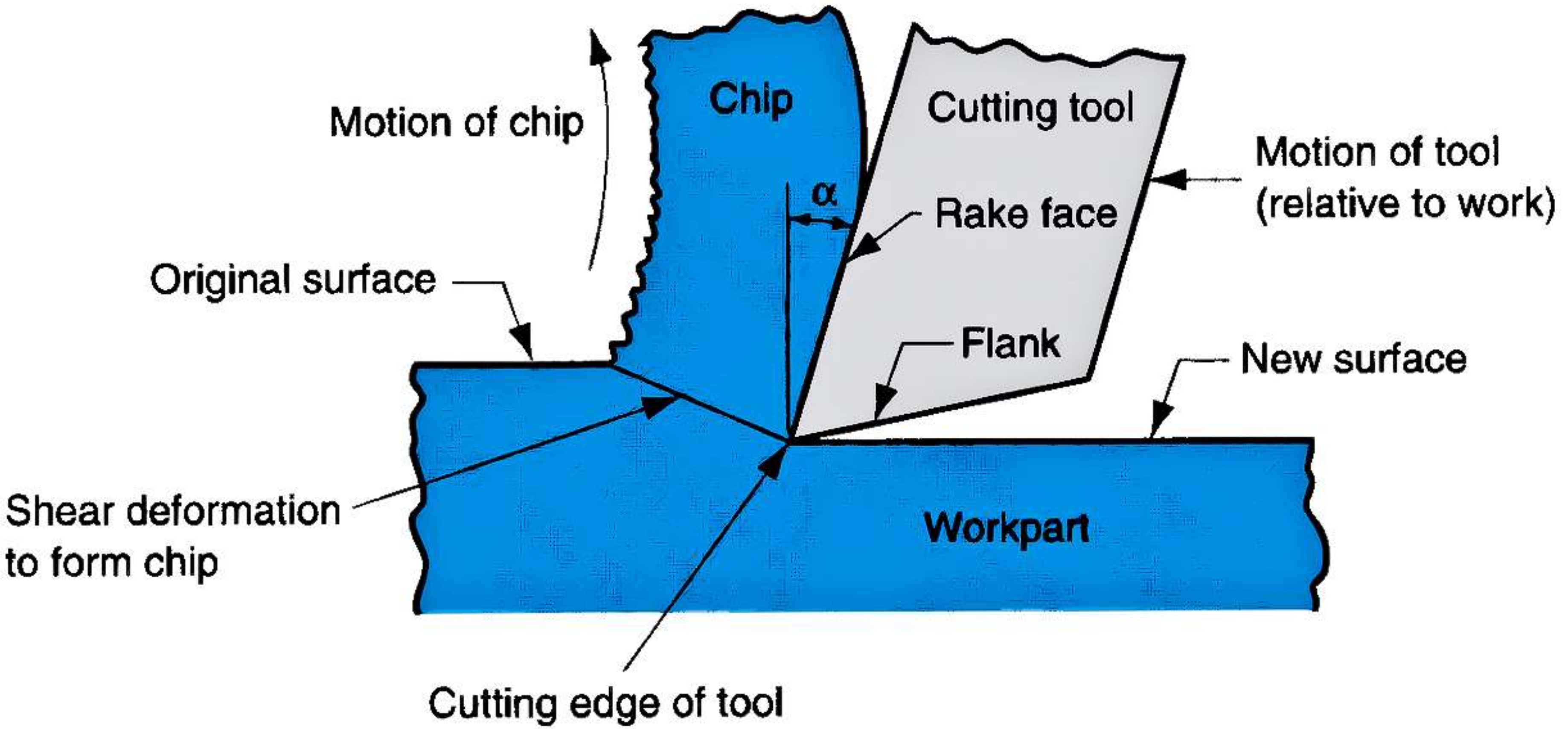
MANUFACTURING PROCESSES

TURNING

THEORY OF METAL MACHINING

- **Machining** is a manufacturing process in which a sharp cutting tool is used to cut away material to leave the desired part shape.
- The predominant cutting action in machining involves **shear deformation** of the work material to form a chip; as the chip is removed, a new surface is exposed.
- Machining is most frequently applied to shape metals.

A Cross-sectional View Of The Machining Process



THEORY OF METAL MACHINING

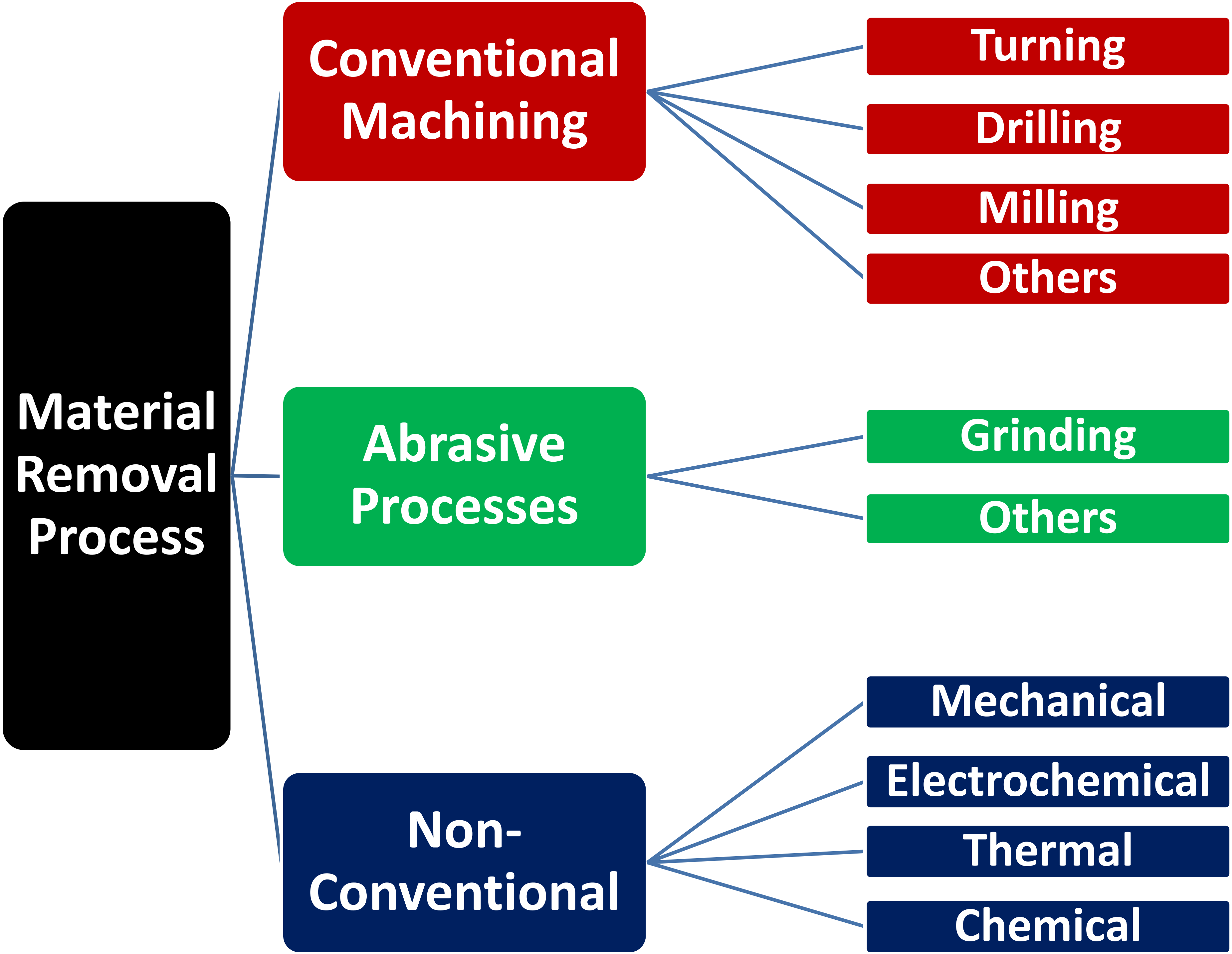
- Machining is not just one process; it is a group of processes.
- The common feature is the use of a cutting tool to form a chip that is removed from the workpart.
- To perform the operation, relative motion is required between the tool and work.

THEORY OF METAL MACHINING

- This relative motion is achieved in most machining operations by means of a **PRIMARY MOTION**, called the **CUTTING SPEED**, and a **secondary motion**, called the **feed**.
- The shape of the tool and its penetration into the work surface, combined with these motions, produces the desired geometry of the resulting work surface.

TYPES OF MACHINING OPERATIONS

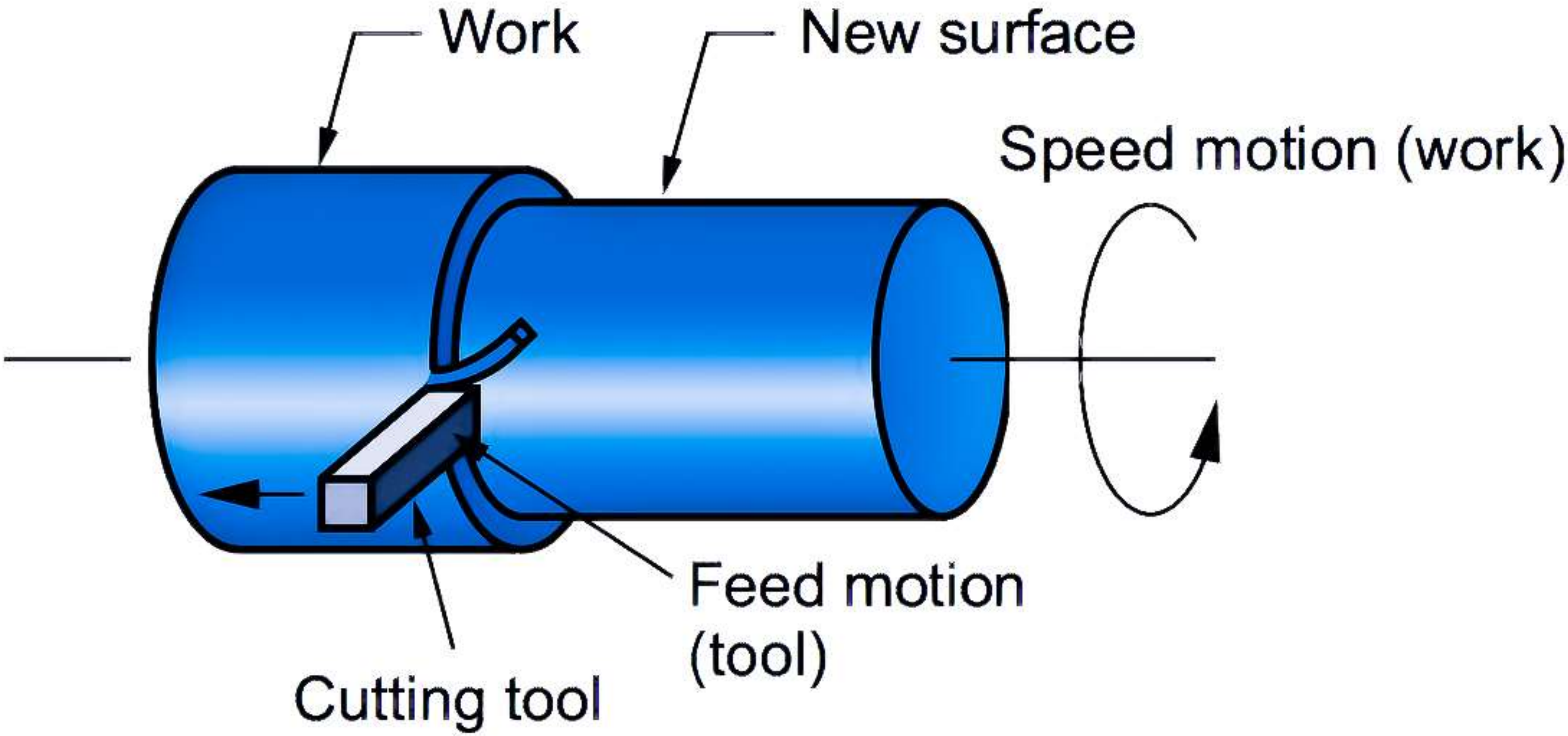
- There are many kinds of machining operations, each of which is capable of generating a certain part geometry and surface texture.


Material Removal Process
Conventional Machining
Turning
Drilling
Milling
Others
Abrasive Processes
Grinding
Others
Non-Conventional
Mechanical
Electrochemical
Thermal
Chemical

TURNING & RELATED OPERATIONS

- **TURNING** is a machining process in which a **single-point tool** removes material from the surface of a **rotating workpiece**.
- The tool is fed linearly in a direction parallel to the axis of rotation to generate a **cylindrical geometry.**
- Turning is traditionally carried out on a machine tool called a **LATHE**, which provides power to turn the part at a given **rotational speed** and to **feed** the tool at a specified **rate** and **depth of cut**.

TURNING



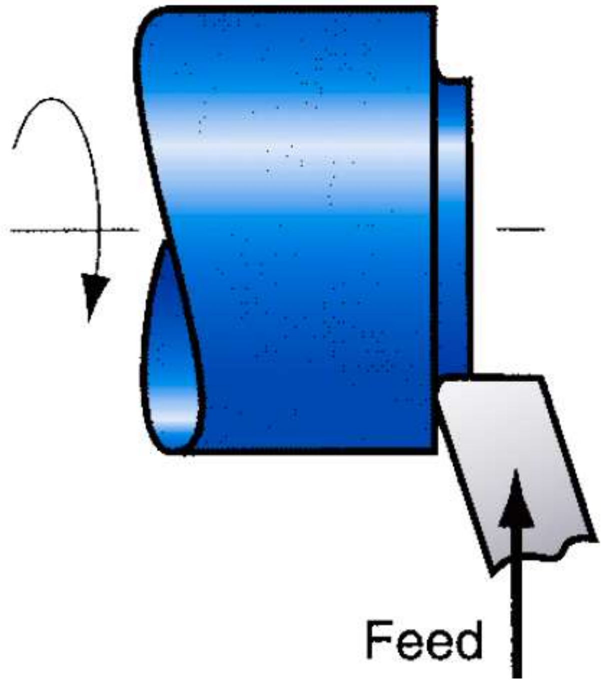
Work
New surface
Speed motion (work)
Feed motion (tool)
Cutting tool

OPERATIONS RELATED TO TURNING

- A variety of other machining operations can be performed on a lathe in addition to turning.
- Following slides will give a brief overview of these operations.

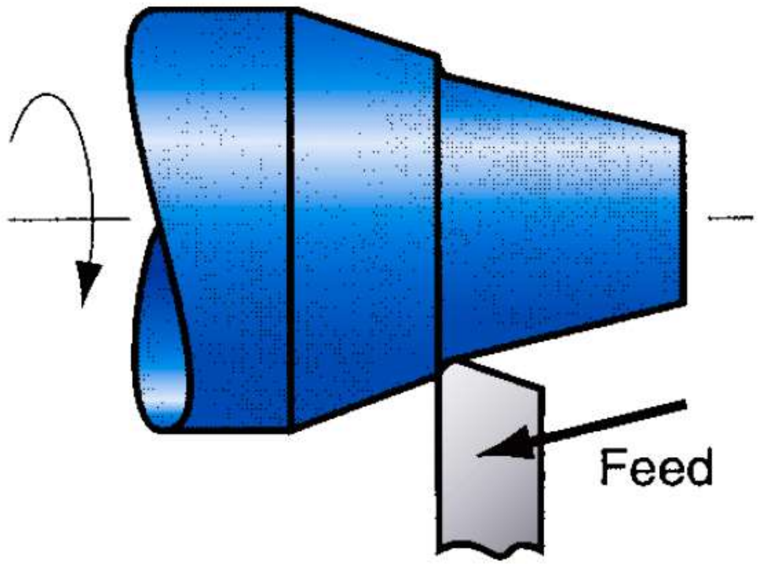
FACING

- The tool is fed radially into the rotating work on one end to create a flat surface on the end.

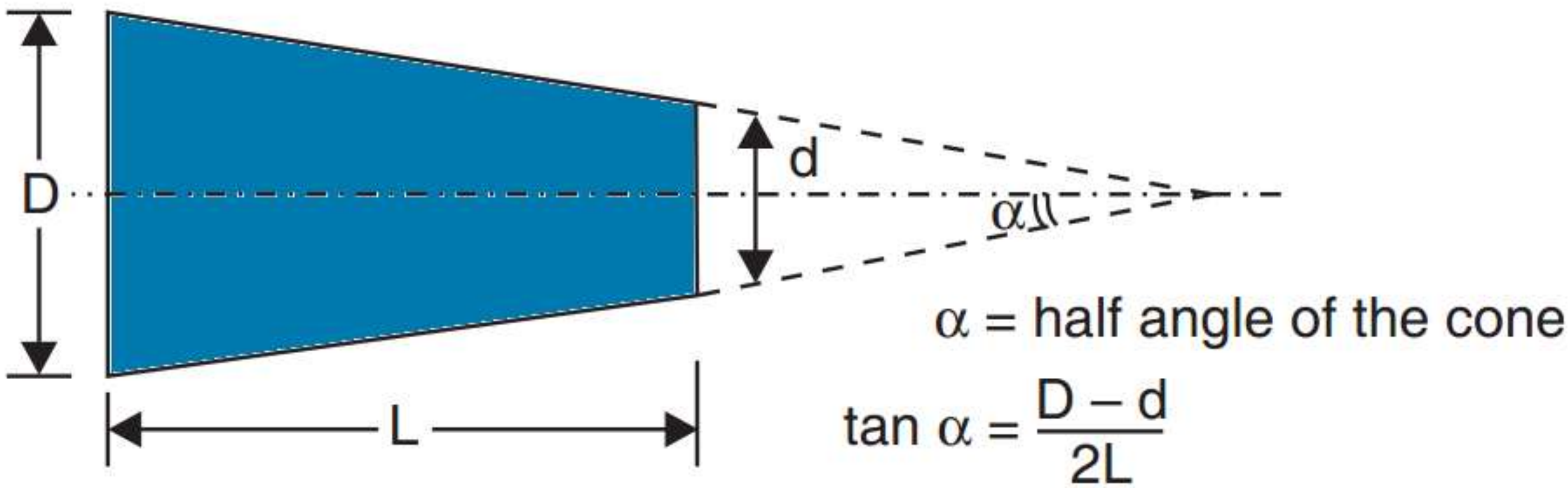


TAPER TURNING

- Instead of feeding the tool parallel to the axis of rotation of the work, the tool is fed at an angle, thus creating a tapered cylinder or conical shape.

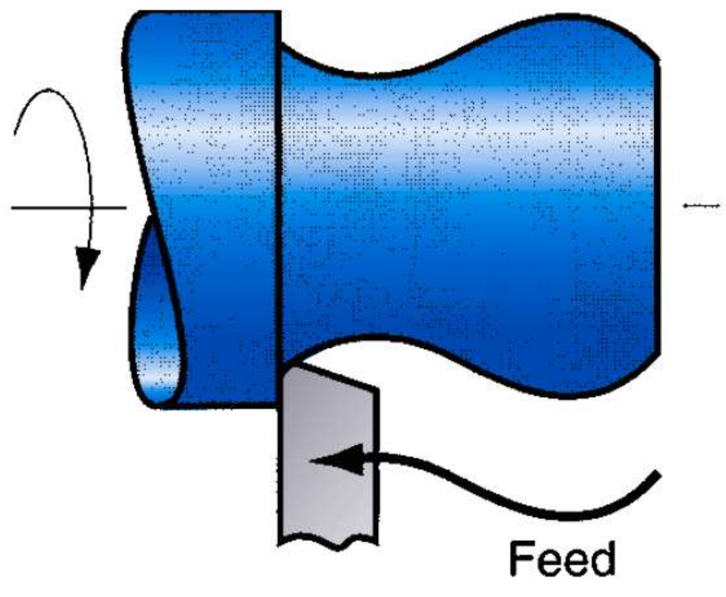


TAPER TURNING



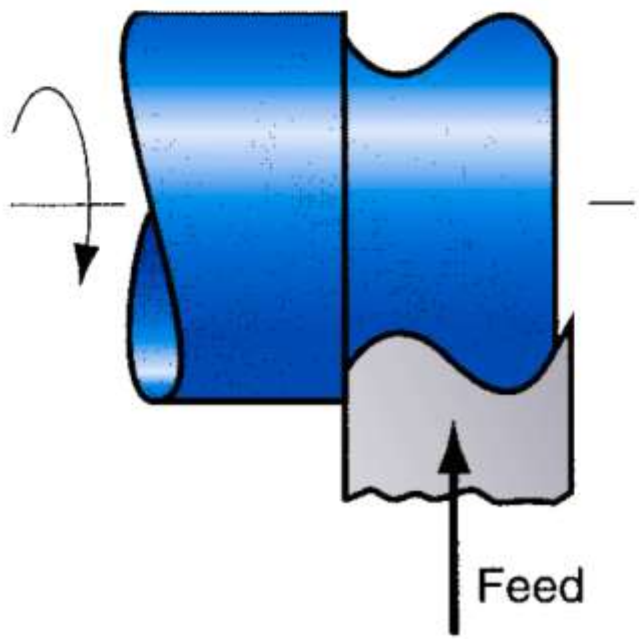
CONTOUR TURNING

- Instead of feeding the tool along a straight line parallel to the axis of rotation as in turning, the tool follows a contour that is other than straight, thus creating a contoured form in the turned part.



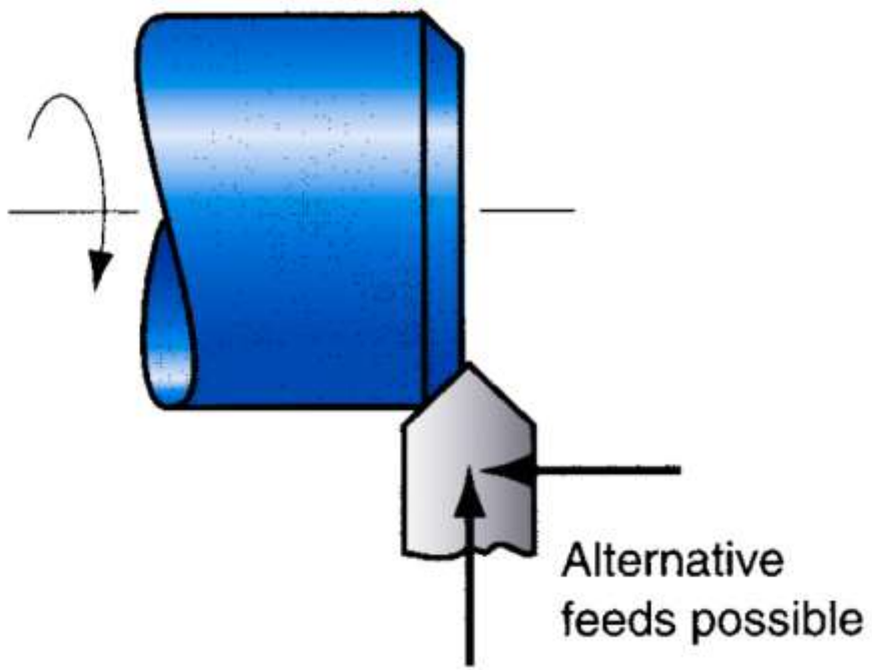
FORM TURNING

- In this operation, sometimes called forming , the tool has a shape that is imparted to the work by plunging the tool radially into the work.



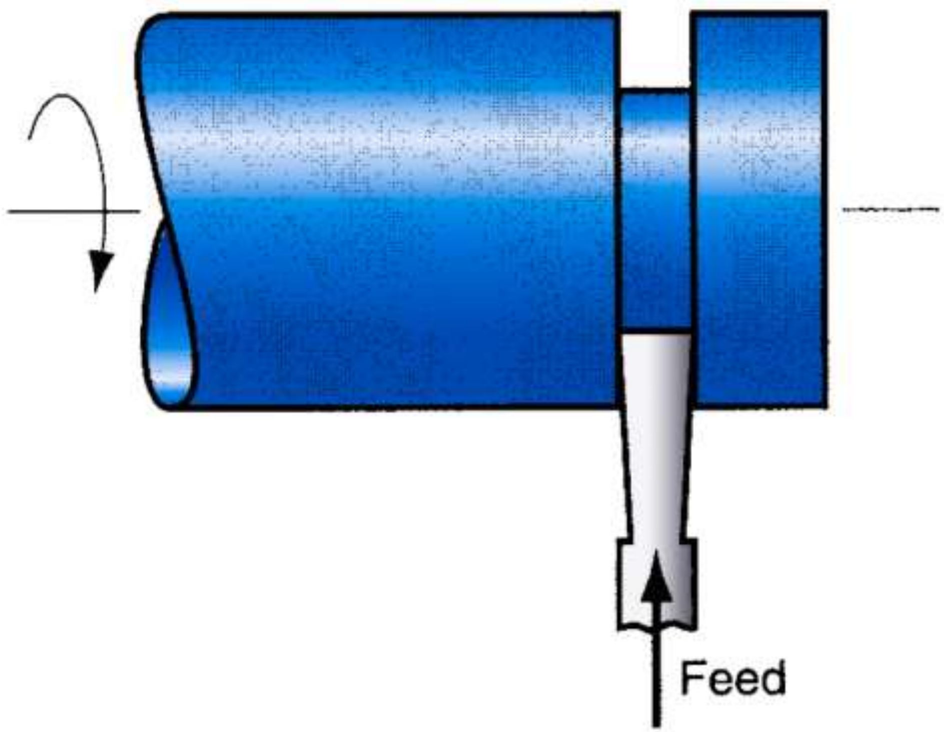
CHAMFERING

- The cutting edge of the tool is used to cut an angle on the corner of the cylinder, forming what is called a ‘‘ chamfer. ’’



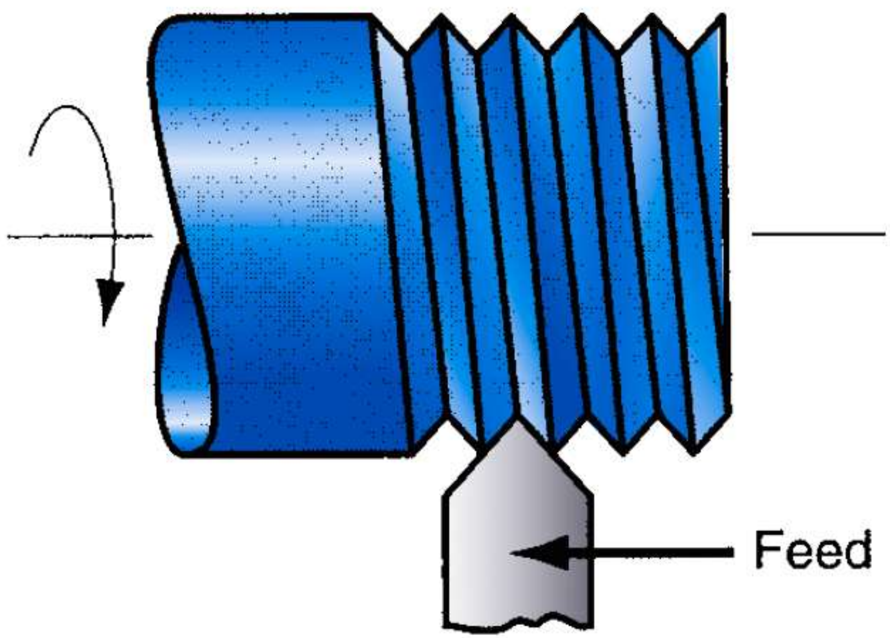
CUTOFF

- The tool is fed radially into the rotating work at some location along its length to cut off the end of the part. This operation is sometimes referred to as parting .



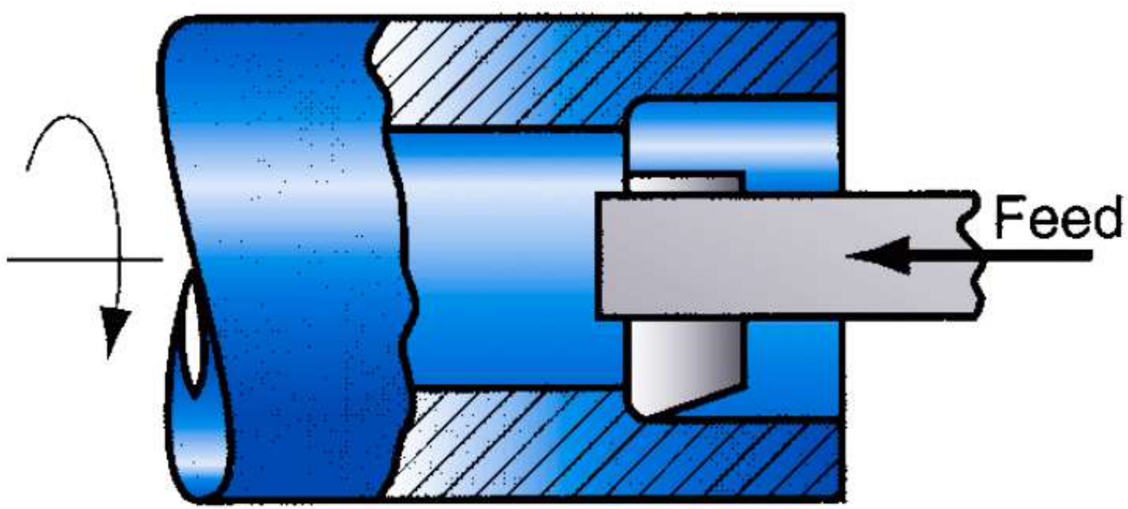
THREADING

- A pointed tool is fed linearly across the outside surface of the rotating workpart in a direction parallel to the axis of rotation at a large effective feed rate, thus creating threads in the cylinder.



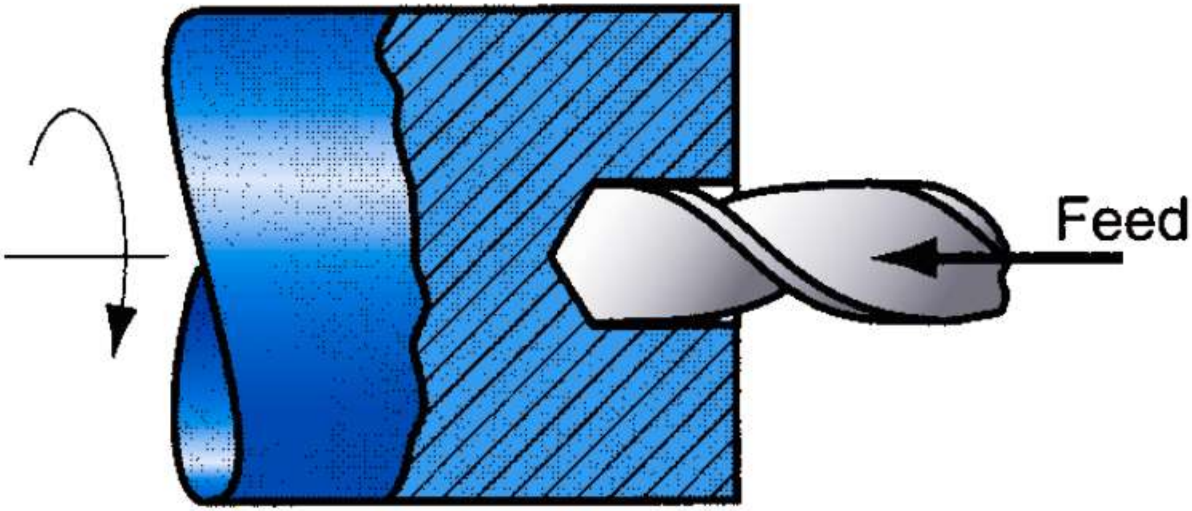
BORING

- A single-point tool is fed linearly, parallel to the axis of rotation, on the inside diameter of an existing hole in the part.



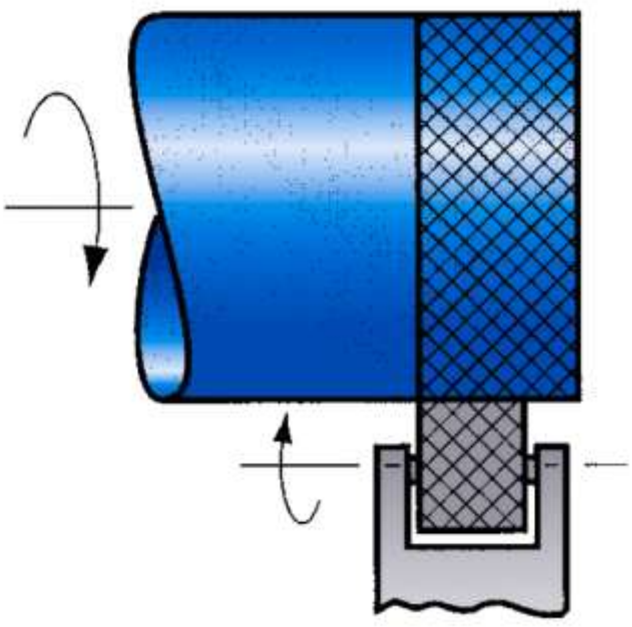
DRILLING

- Drilling can be performed on a lathe by feeding the drill into the rotating work along its axis. Reaming can be performed in a similar way.

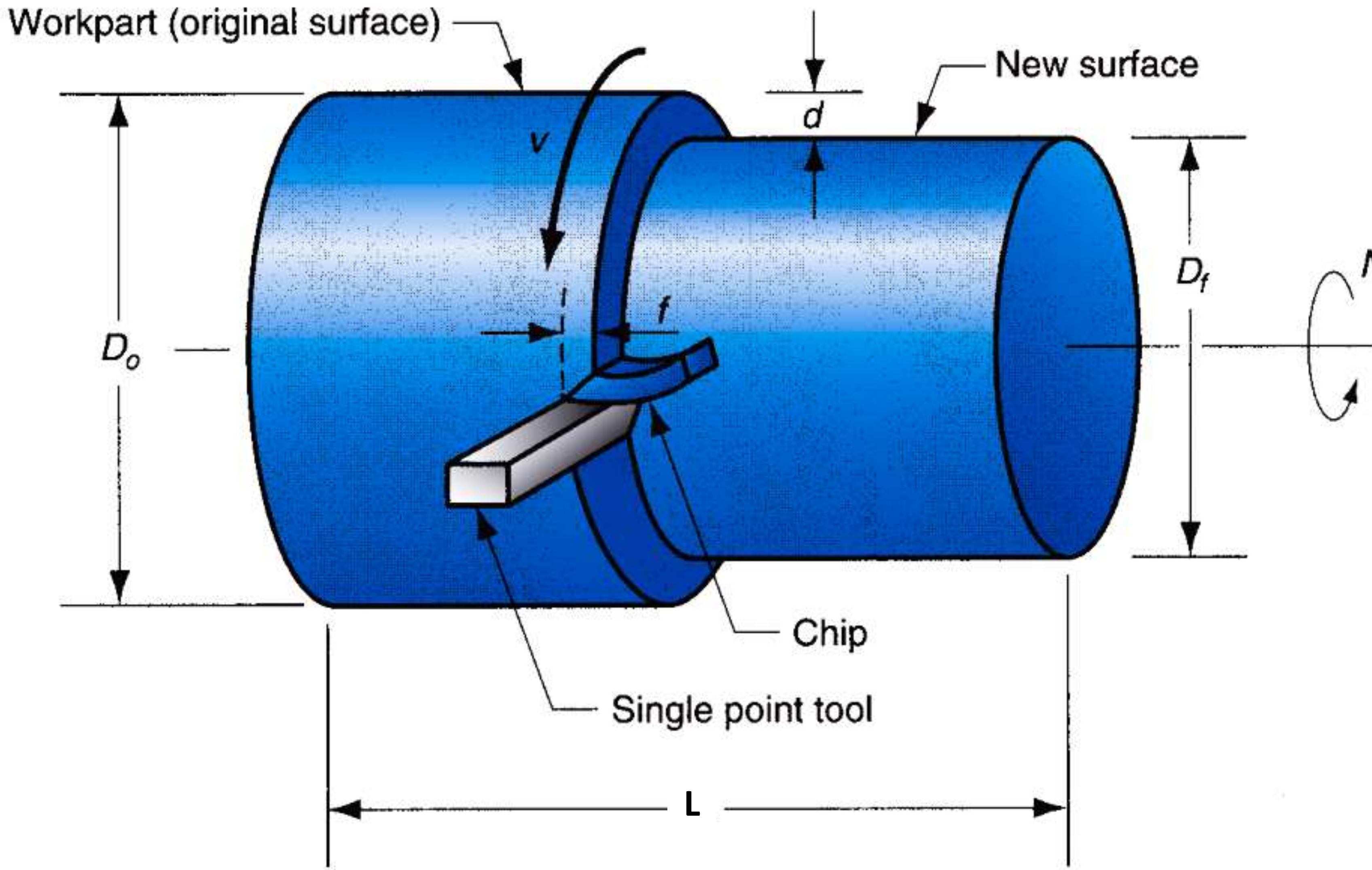


KNURLING

- This is not a machining operation because it does not involve cutting of material. Instead, it is a metal forming operation used to produce a regular cross-hatched pattern in the work surface.



TURNING PARAMETERS



CUTTING SPEED (v)

- Cutting speed may be defined as the rate (or speed) that the material/job moves past the cutting edge of the tool.

Material	Rough Cut m/min	Finish Cut m/min
Cast iron	18	24
Bronze	27	30
Aluminum	61	93

CUTTING SPEED (v) mm/min

$$\boxed{v \quad = \quad \pi D_o N} \qquad (1)$$

v	*cutting speed*	**mm/min**
N	*rotational speed*	**rev/min**
D_o	*original dia of the part*	**mm**

Feed (*f*) *mm/rev or mm/stroke*

- **Feed** *f*, may be defined as the small relative movement per cycle (per revolution or per stroke) of the cutting tool in a direction usually normal to the cutting speed direction.

Feed Rate (f_r) *mm/min*

- **Feed** (f) mm/rev is the distance cutting tool advances along length of work for every revolution of the spindle.
- This feed can be converted to a linear travel rate (**Feed Rate**) (f_r) in mm/min by the formula

$$\boxed{f_r = N f} \qquad (2)$$

DEPTH OF CUT (d) mm

- It is defined as the depth of penetration of the tool into the work piece during machining.
- In other words, it is the perpendicular distance measured from the machined surface to the unmachined surface of the work piece.
- It is usually expressed in millimeters.

DEPTH OF CUT (d) mm

- The thickness of material removed by one pass of the cutting tool is called Depth of Cut.

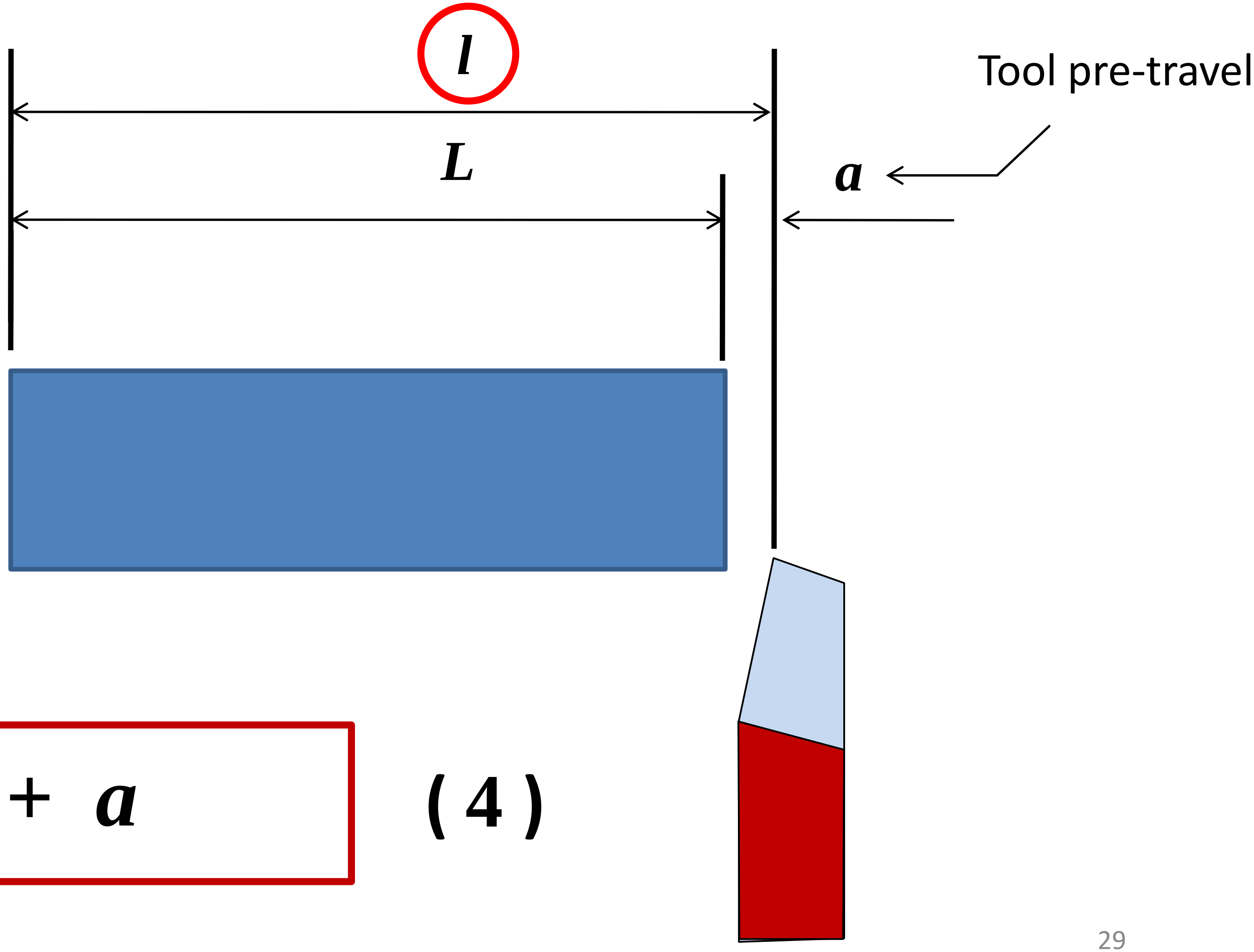
$$d = \frac{D_o - D_f}{2} \qquad (3)$$

d — *depth of cut* **mm**

D_o — *original dia of the part* **mm**

D_f — *final dia of the part* **mm**

MACHINING LENGTH (l) mm



$$\boxed{l = L + a} \quad (4)$$

MACHINING TIME (T_M) min

- The time required to machine a workpiece length "l" is given by:

$$T_M = \frac{l}{Feed\ rate} = \frac{l}{f_r}$$

$$\boxed{T_M = \frac{l}{f\,N} = \frac{\pi D_o l}{f\,v}} \qquad (5)$$

MATERIAL REMOVAL RATE (R_{MR}) mm^3/min

- It is the volume of material removed per unit time.

$$R_{MR} = vfd \qquad (6)$$

MATERIAL REMOVAL RATE (R_{MR}) mm^3/min

- It is the volume of material removed per unit time.

- $$R_{MR} = \frac{volume}{time} = \frac{\pi\,[\,(D_o)^2 - (D_f)^2\,]\,l}{4\,T_M}$$

- $$R_{MR} = \frac{\pi\,[\,(D_o)^2 - (D_f)^2\,]\,l\,(fN)}{4\,l}$$

MATERIAL REMOVAL RATE (R_{MR}) mm^3/min

$$R_{MR} = \frac{\pi \left[\underbrace{(D_o - D_f)}_{(2)} \underbrace{(D_o + D_f)}_{(2)} \right] \cancel{l} \, (fN)}{\cancel{l}}$$

$$R_{MR} = \pi \, d \, D_{avg} \, f \, N$$

$$R_{MR} = v \, f \, d \qquad \text{because} \left(\pi \, D_{avg} N = v \right)$$

NO. OF PASSES (n)

$$\text{No. of Passes } (n) = \frac{D_o - D_f}{2\,(d)}$$

where, d is DOC per pass

$$\boxed{\text{Total machining time} = n\,T_M}$$

TURNING NUMERICAL 1

- A cylindrical workpart ***125 mm in diameter*** and ***900 mm long*** is to be turned in an engine lathe. Cutting speed = ***2.50 m/s***, feed = ***0.3 mm/rev***, and depth of cut = ***2 mm***. Determine (a) cutting time, and (b) metal removal rate.

TURNING NUMERICAL 1

D_o = *125 mm*

l = *900 mm*

v = *2.50 m/s = 2500 mm/s*

f= *0.3 mm/rev*

d =*2 mm*

Formula Used

(1)

(2)

(5)

MRR = $vdf\ mm^3/s$

TURNING NUMERICAL 1

$$N = (2500)/125\pi = 6.366 \text{ rev/s} \qquad (1)$$

$$f_r = 6.366(.3) = 1.91 \text{ mm/s} \qquad (2)$$

$$T_M = 900/1.91 = 471.2 \text{ s} = 7.85 \text{ min} \qquad (5)$$

TURNING NUMERICAL 1

$$MRR = vfd \qquad (6)$$

$$= (2500)(.3)(2.0)$$

$$= 1500\ mm^3/s$$

TURNING NUMERICAL 2

- In a production turning operation, the foreman has decided that the single pass must be completed on the cylindrical workpiece in ***5.0 min***. The piece is ***400 mm long*** and ***150 mm in diameter***. Using a ***feed = 0.30 mm/rev*** and a ***depth of cut = 4.0*** mm, what cutting speed must be used to meet this machining time requirement?

TURNING NUMERICAL 2

$T_{M}=$ ***5.0 min***

l = ***400 mm***

D_o = ***150 mm***

f= ***0.3 mm/rev***

d =***4 mm***

Extra Info

Formula Used

(5)

Ans:-125.7 m/min