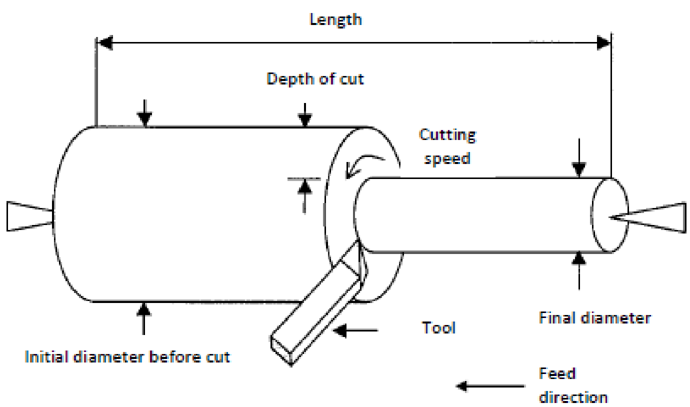
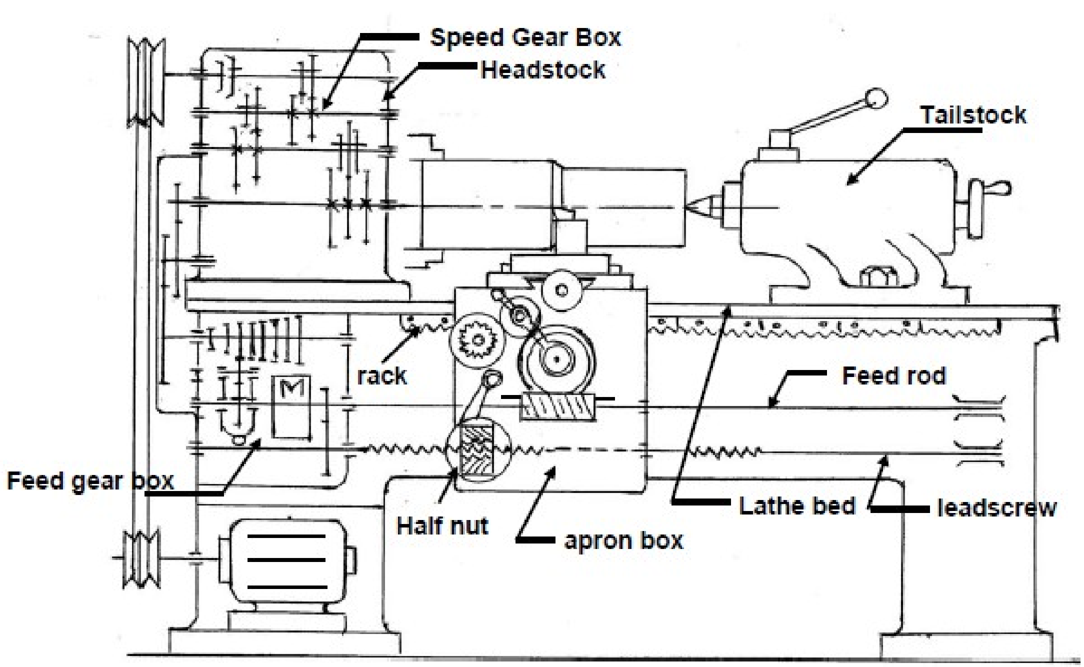
Turning operation

Lathe is the father of all machine tools. Lathe removes unwanted material from apiece of work to give it the required shape and size. The workpiece is rotated at the desired speed and the tool removes the metal in the form of chips.



The cutting tool may be fed in any direction relative to the work. If the tool moves parallel to the axis of rotation of the work a cylindrical surface is produced. And if the tool moves in a direction



perpendicular to the axis of the lathe a flat surface is produced. Conical and curved surfaces can be produced on a lathe too.

Lathe operations:

Before studying the various operations, we must study the cutting speed, feed and depth of cut:

CUTTING CONDITIONS IN TURNING

The rotational speed in turning is related to the desired cutting speed at the surface of the cylindrical workpiece by the equation

$$N = \frac{V}{\pi D_o}$$

Where N = rotational speed, rev/min; v = cutting speed, m/min (ft/min); and D_o = original diameter of the part, m.

The turning operation reduces the diameter of the work from its original diameter Do to a final diameter Df, as determined by the depth of cut d:

$$Df = D_o - 2d$$

The feed in turning is generally expressed in mm/rev. This feed can be converted to a linear travel rate in mm/min by the formula

$$f_r = N f$$

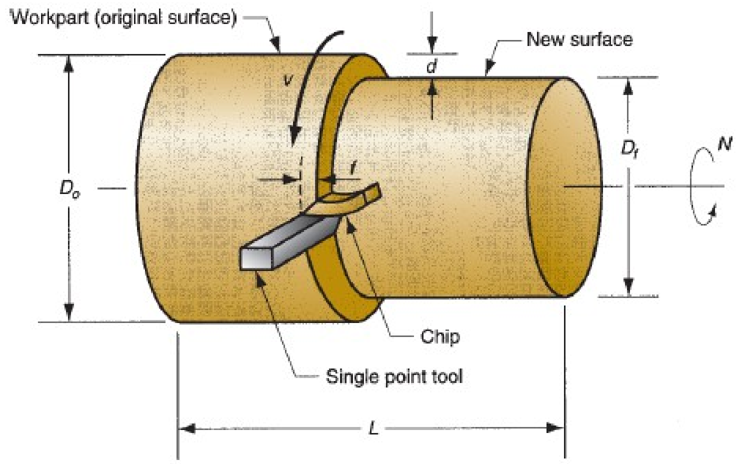
Where f_r = feed rate, mm/min; and f = feed, mm/rev.

There are three types of feed:

1- Longitudinal feed. Tool moves parallel to the axis of lathe.

2- Cross feed. Tool moves normal to the lathe axis.

3- Angular feed. Tool moves at an angle to the lathe axis.



The time to machine from one end of a cylindrical work part to the other is given by

$$T_m = \frac{L}{f_r}$$

Where *Tm* = machining time, min; and *L* = length of the cylindrical work part, mm. A more direct computation of the machining time is provided by the following equation:

$$T_m = \frac{\pi D_\circ L}{fv}$$

Where D_o = work diameter, mm ; *L* =work part length, mm ; *f* = feed, mm/rev ; and *v* = cutting speed, mm/min . As a practical matter, a small distance is usually added to the work part length at the beginning and end of the piece to allow for approach and overtravel of the tool. Thus, the duration of the feed motion past the work will be longer than T_m.

The volumetric rate of material removal can be most conveniently determined by the following equation:

$$MRR = v\,f\,d$$

Where *MRR* = material removal rate, mm3/min . In using this equation, the units for *f* are expressed simply as mm, in effect neglecting the rotational character of turning. Also, care must be exercised to ensure that the units for speed are consistent with those for *f* and *d*.

Example: A turning operation is performed on a cylindrical work part whose diameter = 120 mm and length = 450 mm. Cutting speed = 2.0 m/s, feed =0.25 mm/rev, and depth of cut =2.2 mm. Determine (a) cutting time and (b) material removal rate.

Solution: (a) For consistency of units, cutting speed *v* _ 2000 mm/s.

a) $$T_m = \frac{\pi D_\circ L}{fV} = \frac{\pi(120)(450)}{(0.25)(2000)} = 5.65 \text{ min}$$

b) $$MRR = v\,f\,d = 2000(0.25)\,(2.2) = 1100 \text{ mm}^3/\text{s}$$

Example: A cylinder of 155 mm diameter is to be reduced to 150mm diameter in one turning cut with a feed of 0.15mm/rev and a cutting speed of 150m/min.Find the spindle speed, feed rate and metal removal rate.

$$D_{av} = \frac{155+150}{2} = 152.5\text{mm}$$

The cutting speed, Vis obtained as

$$V = \frac{\pi\, D_{av}\, N}{1000} \quad m/\min$$

Its gives spindle speed, N as

$$N = \frac{150*1000}{\pi*152.5} = \mathbf{313\ rpm}$$

The feed rate, f_m is obtained as

$f_m = f_r * N$

$$= \frac{0.15*313}{60} = \mathbf{0.7825\ mm/s}$$

The depth of cut, d is expressed as

$$d = \frac{155-150}{2} = 2.5\ \text{mm}$$

The metal removal rate can be obtained as

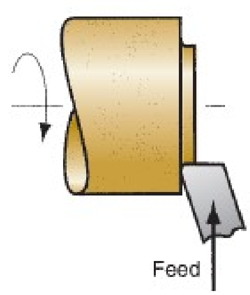
$$= \frac{\pi * f_r * N * D_{av} * d}{60}\ \text{mm}^3/\text{s}$$

$$= \frac{\pi * 0.15*313*152.5*2.5}{60} = \mathbf{937.22\ mm^3/s}$$

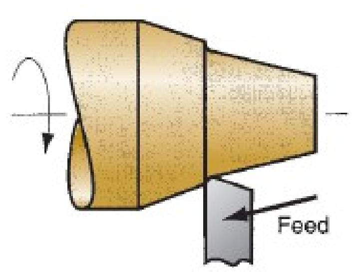
OPERATIONS RELATED TO TURNING

A variety of other machining operations can be performed on a lathe in addition to turning; these include the following, illustrated in Figure :

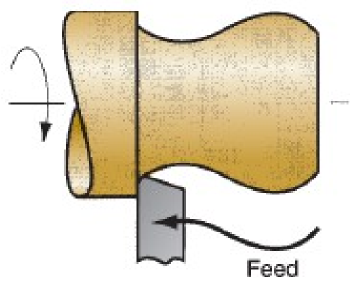
(a) ***Facing***. The tool is fed radially into the rotating work on one end to create a fl at surface on the end.



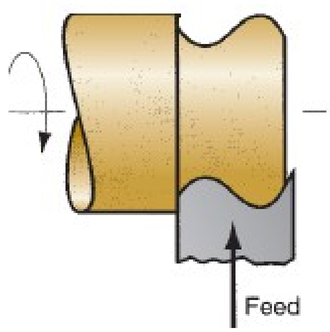
(b) ***Taper turning***. Instead of feeding the tool parallel to the axis of rotation of the work, the tool is fed at an angle, thus creating a tapered cylinder or conical shape.



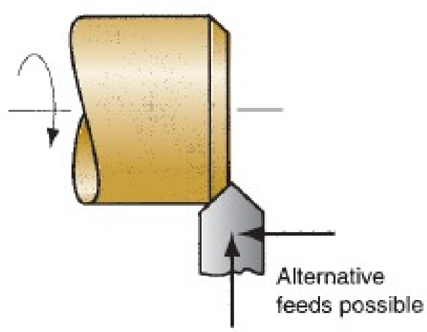
(c) ***Contour turning***. Instead of feeding the tool along a straight line parallel to the axis of rotation as in turning, the tool follows a contour that is other than straight, thus creating a contoured form in the turned part.



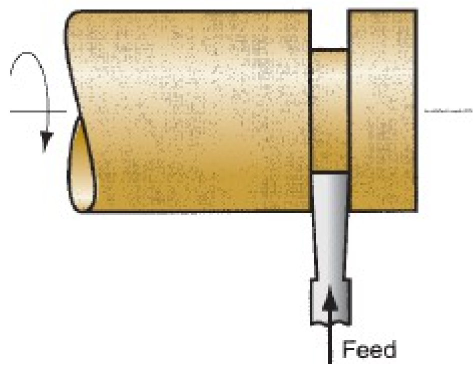
(d) ***Form turning***. In this operation, sometimes called ***forming***, the tool has a shape that is imparted to the work by plunging the tool radially into the work.



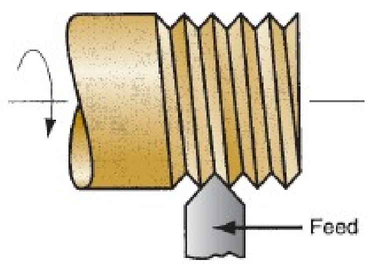
(e) ***Chamfering***. The cutting edge of the tool is used to cut an angle on the corner of the cylinder, forming a "chamfer."



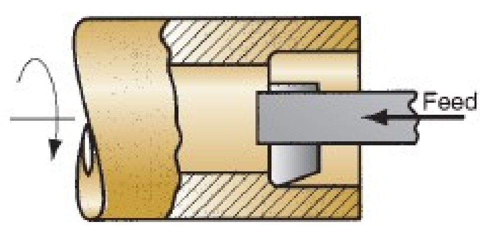
(f) ***Cutoff***. The tool is fed radially into the rotating work at some location along its length to cut off the end of the part. This operation is sometimes referred to as ***parting***.



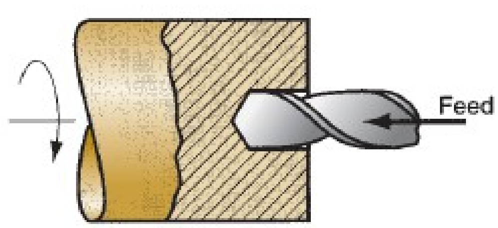
(g) ***Threading***. A pointed tool is fed linearly across the outside surface of the rotating work part in a direction parallel to the axis of rotation at a large effective feed rate, thus creating threads in the cylinder.



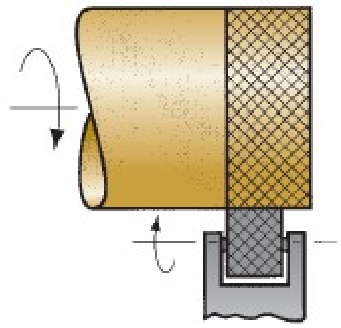
(h) ***Boring***. A single-point tool is fed linearly, parallel to the axis of rotation, on the inside diameter of an existing hole in the part.



(i) ***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.



(j) ***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.



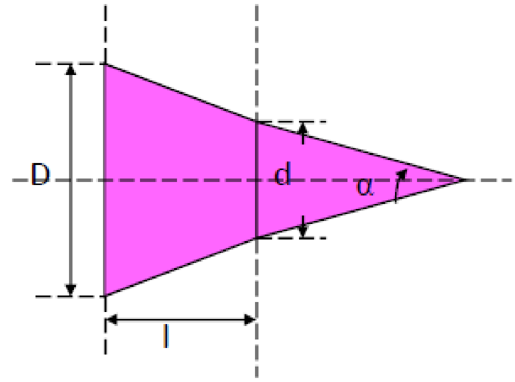
Taper Turning

- Taper - Uniform change in diameter along the length of work piece
- Taper turning - Operation of producing conical surface on cylindrical work piece
- Taper specified by conicity (K) – ratio of difference in diameters of taper to its length:

$$K = \frac{D - d}{L}$$

Taper Turning - Methods

- Form tool method
- Tail stock method
- Compound rest method
- Taper turning attachment method



$$K = \frac{D-d}{L}$$

Conicity

D – Large diameter of taper

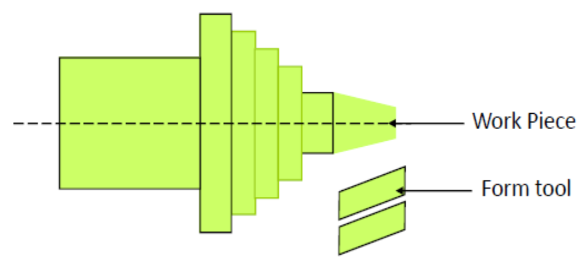
d – Small diameter of taper

L – Length of taper

α - Half taper angle

Form Tool Method

- Short taper
- Form tool ground to required angle
- Tool fed perpendicular to lathe axis
- Operation done at slow speed

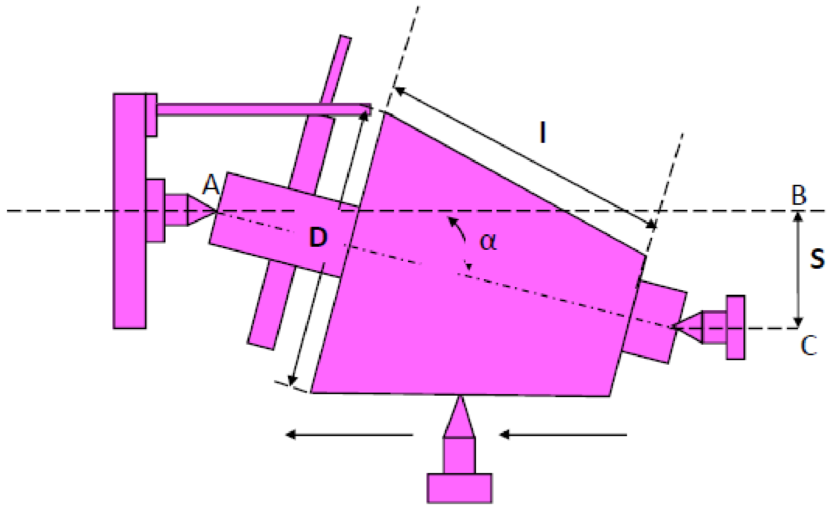


Tail Stock Set Over Method

- Small tapers (> 8º)on long work pieces
- Work piece - b/w centers
- Line centre i.e. tail stock is off-set to a distance set over
- Axis of work piece turned to an angle from lathe axis
- Tool fed over rotating work piece parallel to lathe axis

•Then taper is made on work piece.

Tail Stock Set over Method



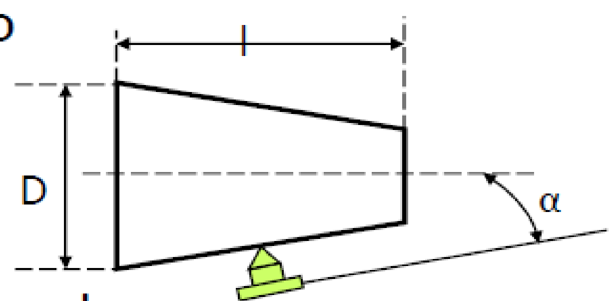
Set over h = $\frac{D - d}{2l}$ x L = L tan α

If the job is turned to its full length, l = L

Set over h = $\frac{D - d}{2}$

Compound Rest Method

- Work piece held in chuck – rotated
- Compound rest – swiveled to required angle – clamped
- Angle tan α = $\frac{D - d}{2l}$
- Tool fed by compound rest hand wheel



Taper Turning Attachment Method

• Arrangement

– Taper turning operation

– Attached - rear end of bed using bottom plate or bracket

– Swinging guide bar set to required angle – swiveled to a max of 100

– Guide block moves on guide bar & connects rear end of the cross slide

– Cross slide made to move along the guide block by removing the binder screw

Taper Turning Attachment Method

• Operation

– Work piece held b/w centers or in a chuck

– Guide bar turned to a required angle

– Longitudinal feed - tool

– Tool moves in angular way

– Depth of cut given by turning the hand wheel of compound rest

Taper Turning Attachment Method