Turning Operations

Chapter 5

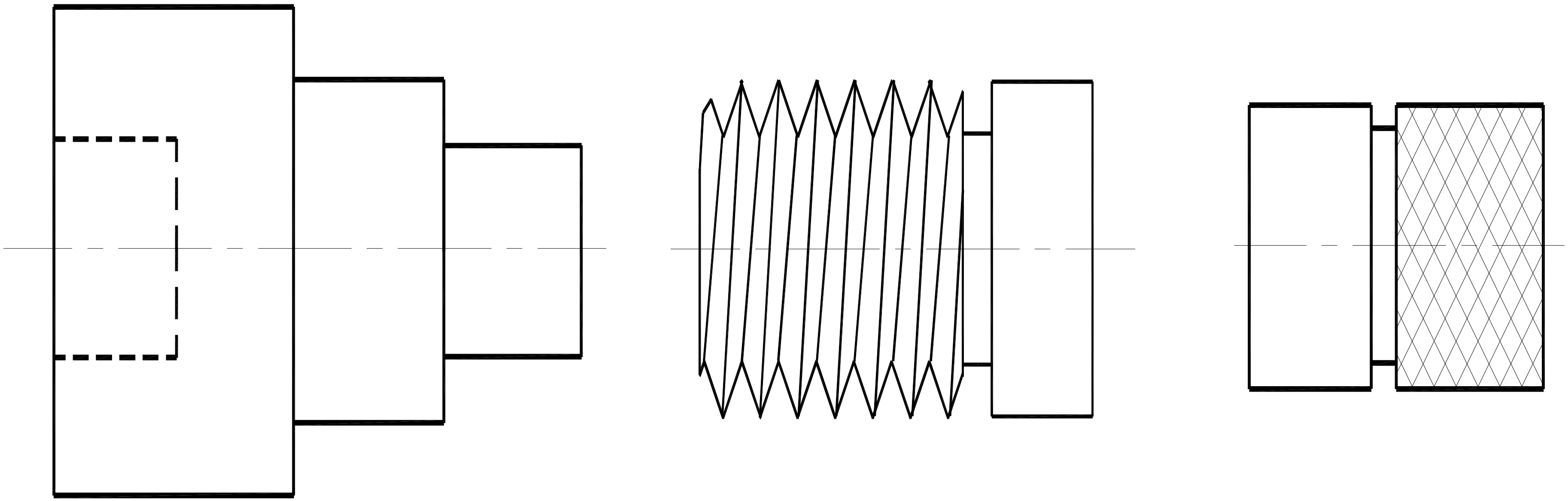
L a t h e

Turning Operations

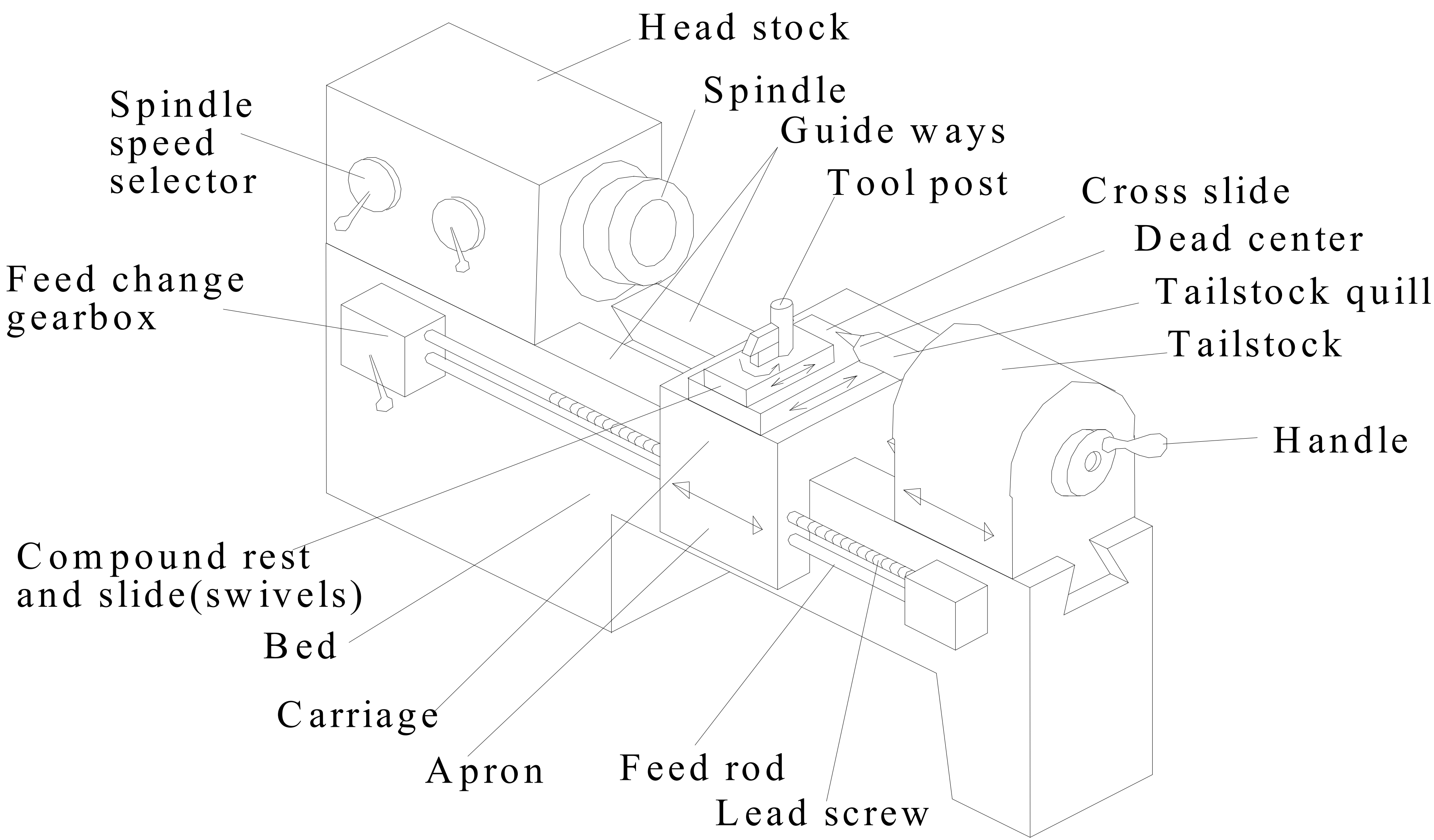
- Machine Tool – LATHE
- Job (workpiece) – rotary motion
- Tool – linear motions
  - "*Mother of Machine Tools* "
  - Cylindrical and flat surfaces

Some Typical Lathe Jobs

Turning/Drilling/Grooving/
Threading/Knurling/Facing...

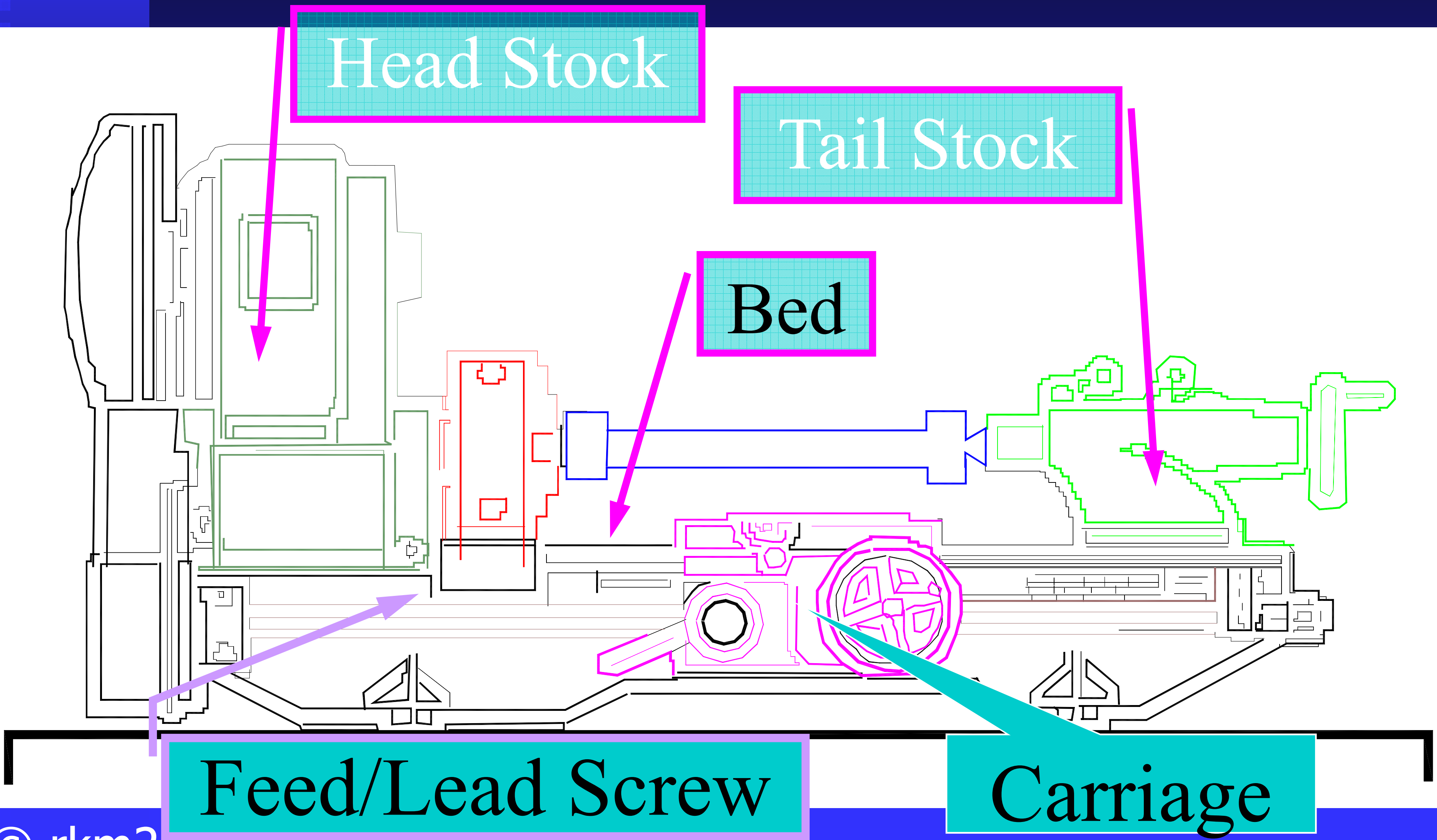


The Lathe



Head stock
Spindle
Guide ways
Tool post
Cross slide
Dead center
Tailstock quill
Tailstock
Handle
Spindle speed selector
Feed change gearbox
Compound rest and slide(swivels)
Bed
Carriage
Apron
Feed rod
Lead screw

The Lathe



Types of Lathes

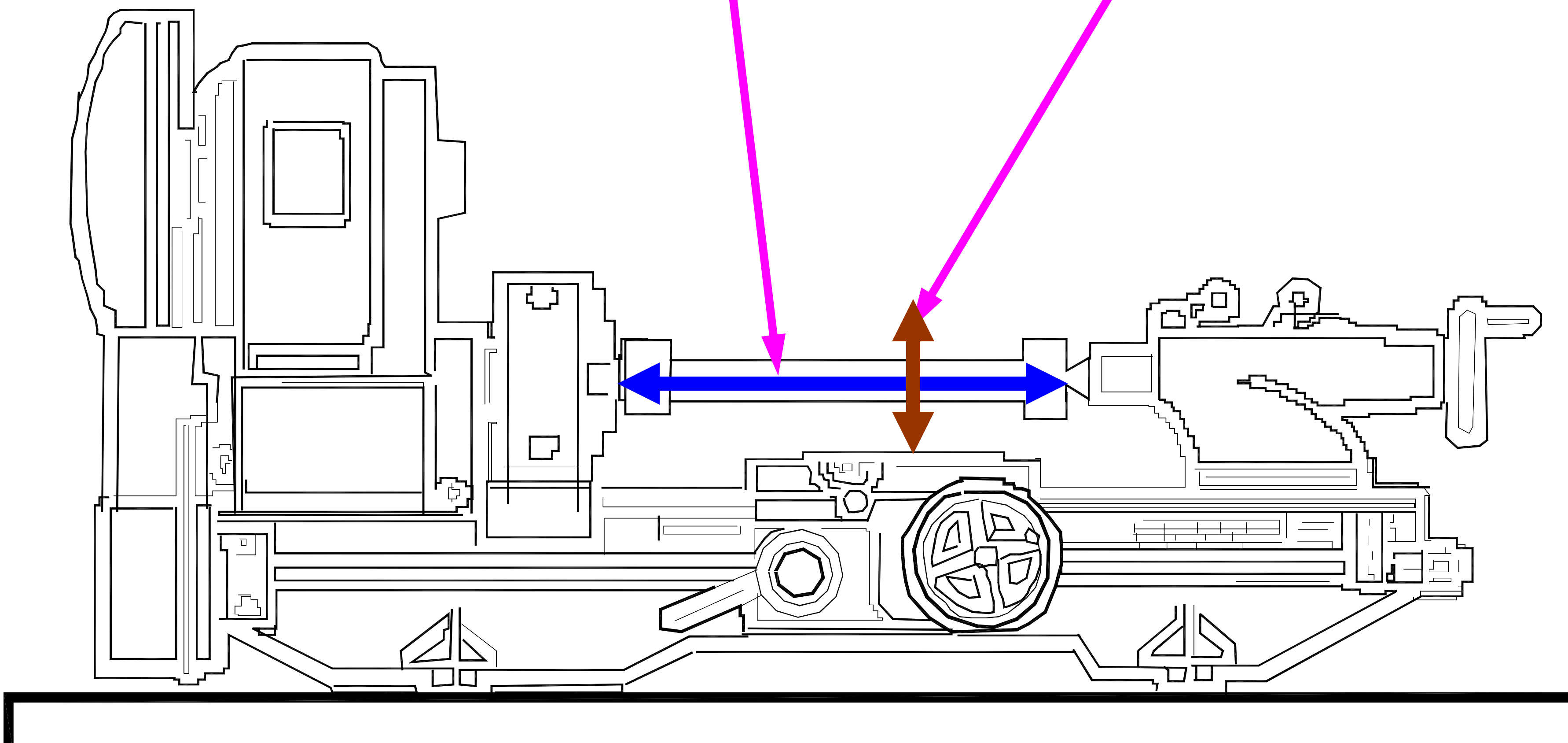
- Engine Lathe
- Speed Lathe
- Bench Lathe
- Tool Room Lathe
- Special Purpose Lathe
- Gap Bed Lathe

...

Size of Lathe

Workpiece Length

Swing



Size of Lathe ..

Example: 300 - 1500 Lathe

- Maximum Diameter of Workpiece that can be machined

  = SWING (= 300 mm)

- Maximum Length of Workpiece that can be held between Centers (=1500 mm)

Workholding Devices

- Equipment used to hold
  - Workpiece – **fixtures**
  - Tool - **jigs**

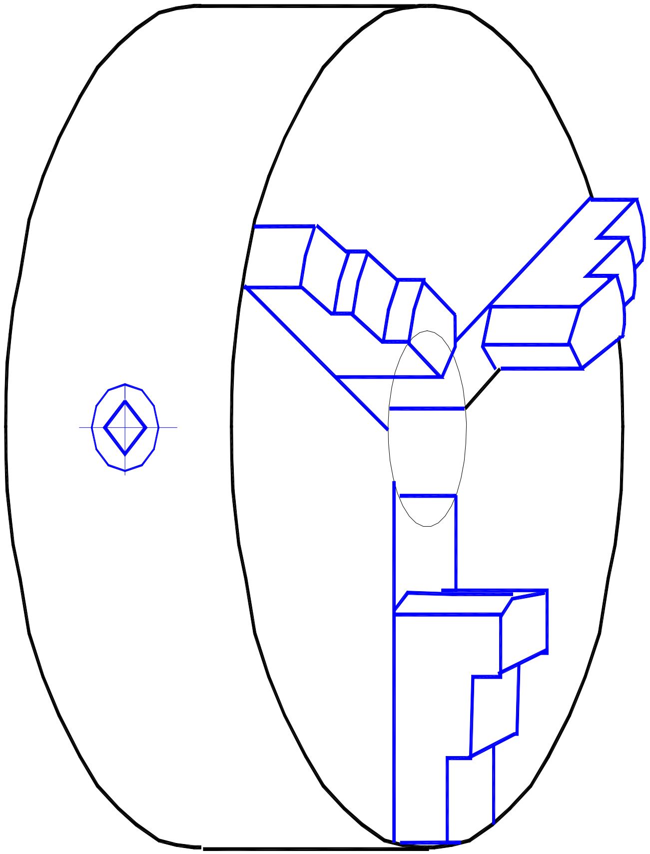
Securely HOLD or Support while machining

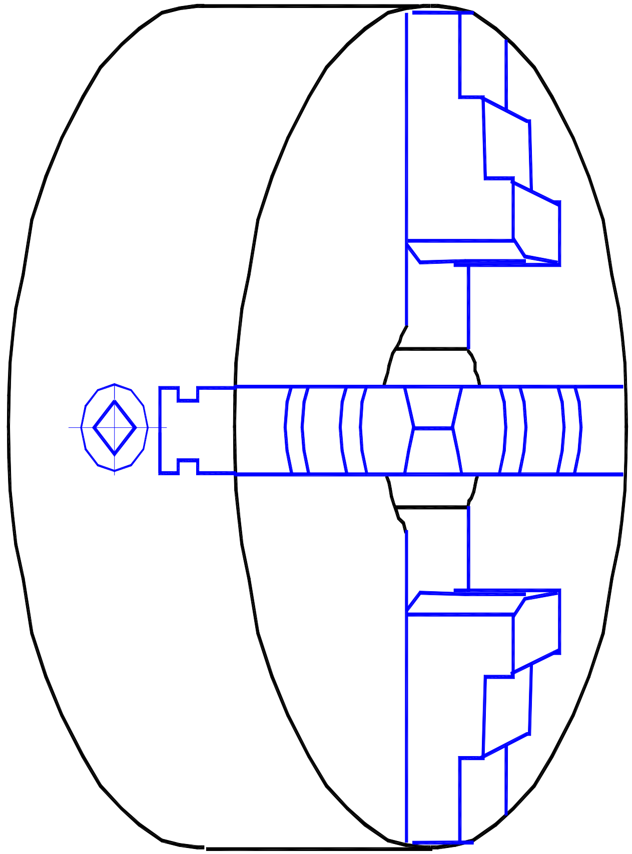
Chucks

Workholding Devices ..

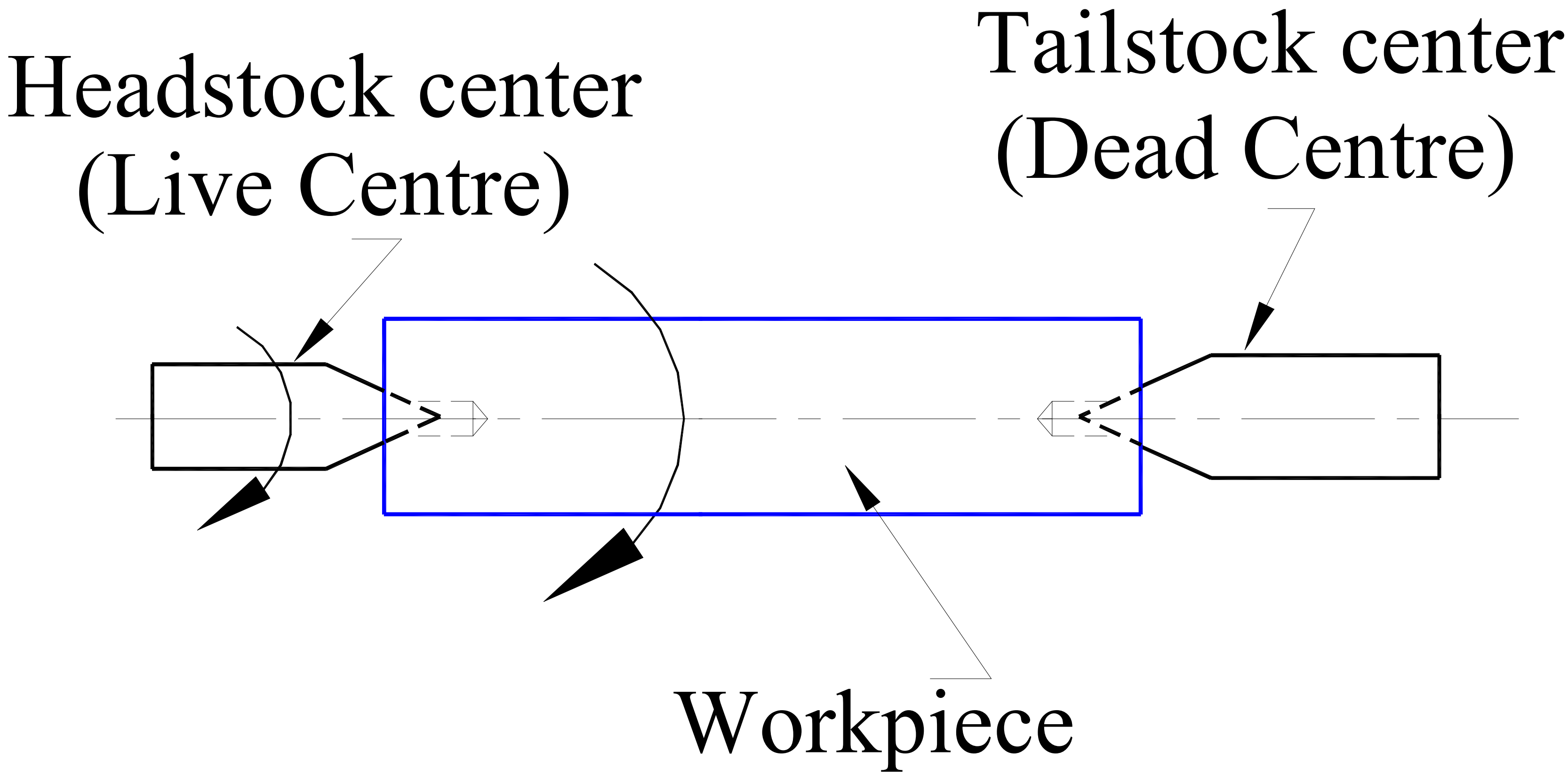
Three jaw

Four Jaw

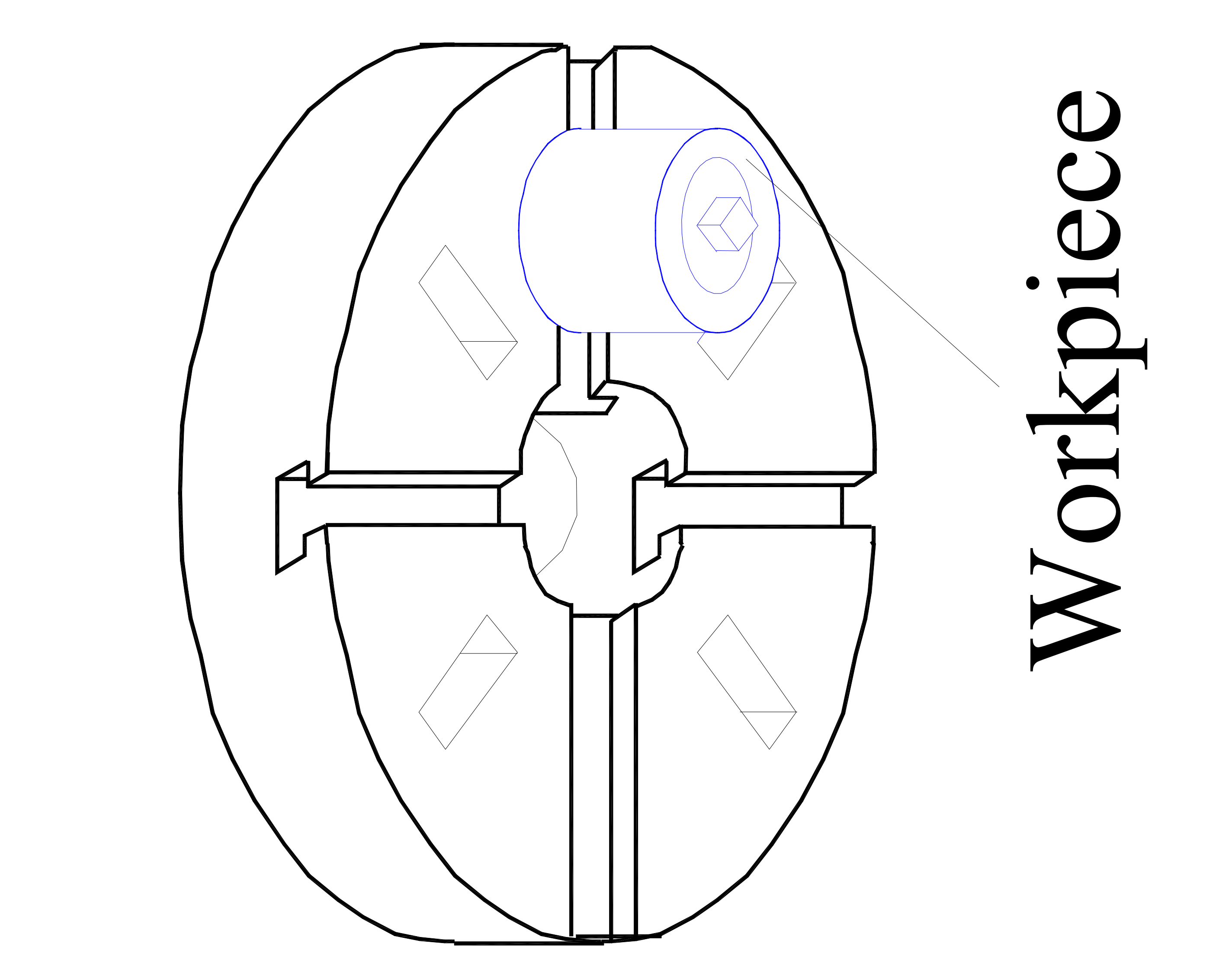




Centers

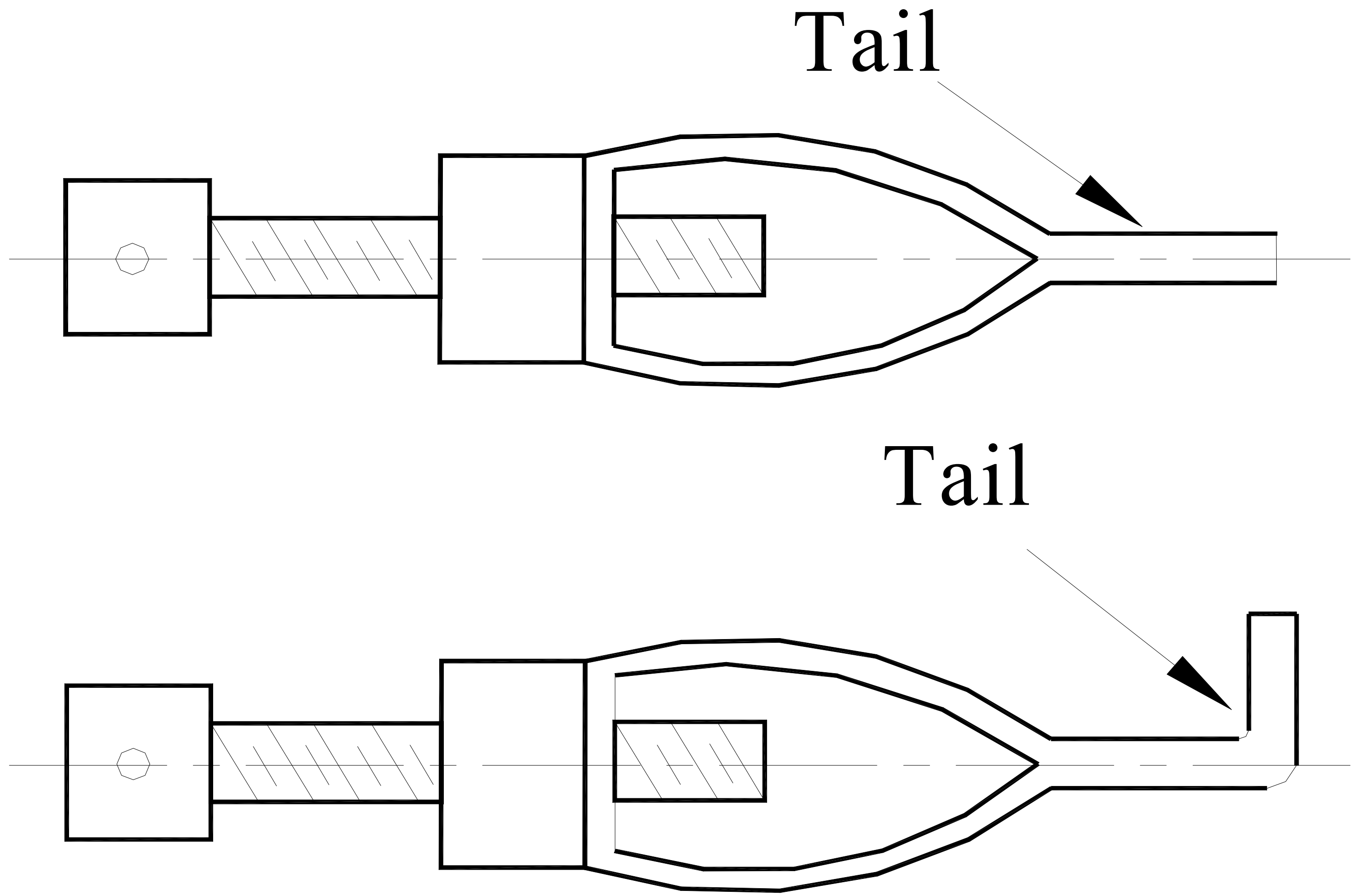

Headstock center
(Live Centre)
Tailstock center
(Dead Centre)
Workpiece

Faceplates



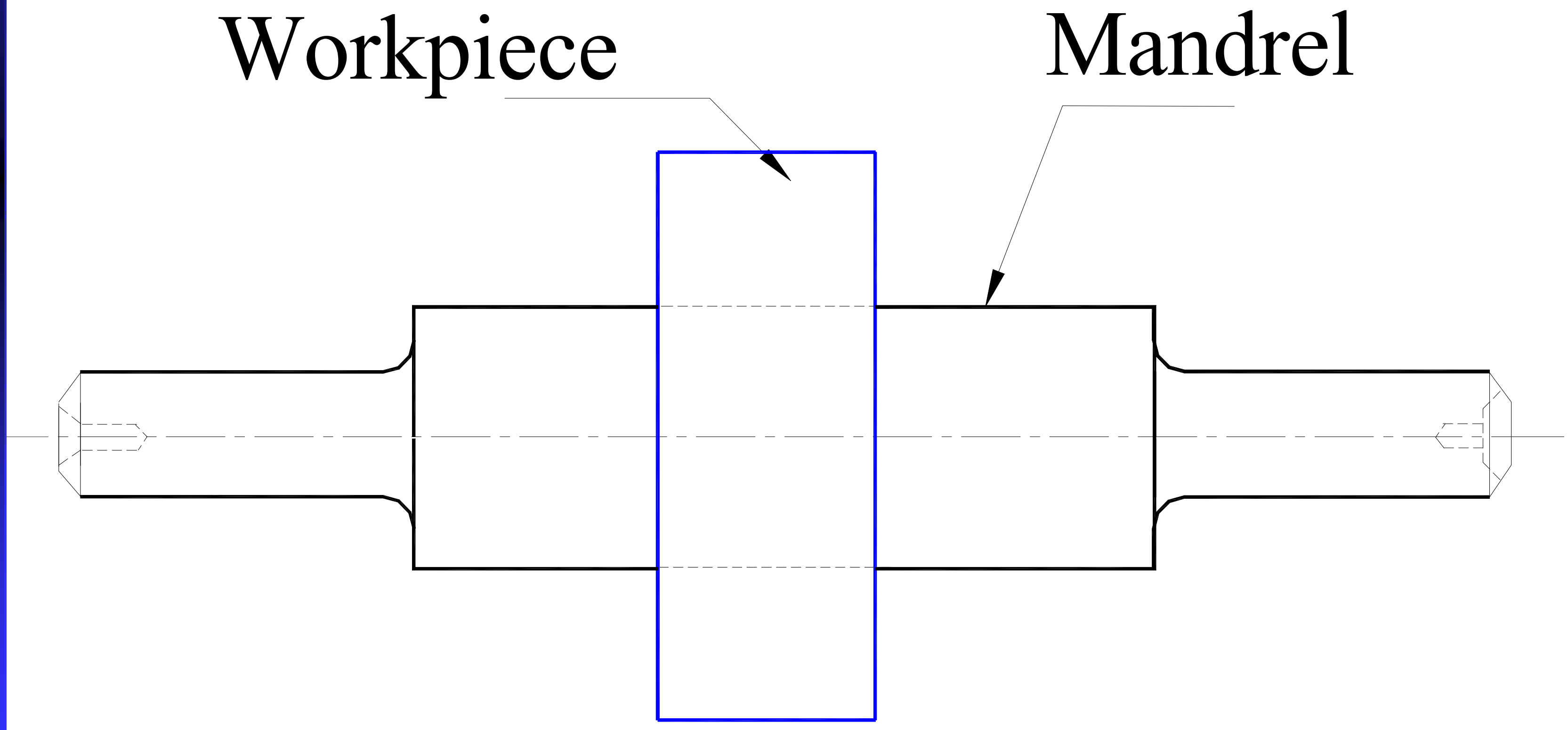
Workholding Devices ..

Dogs



Mandrels

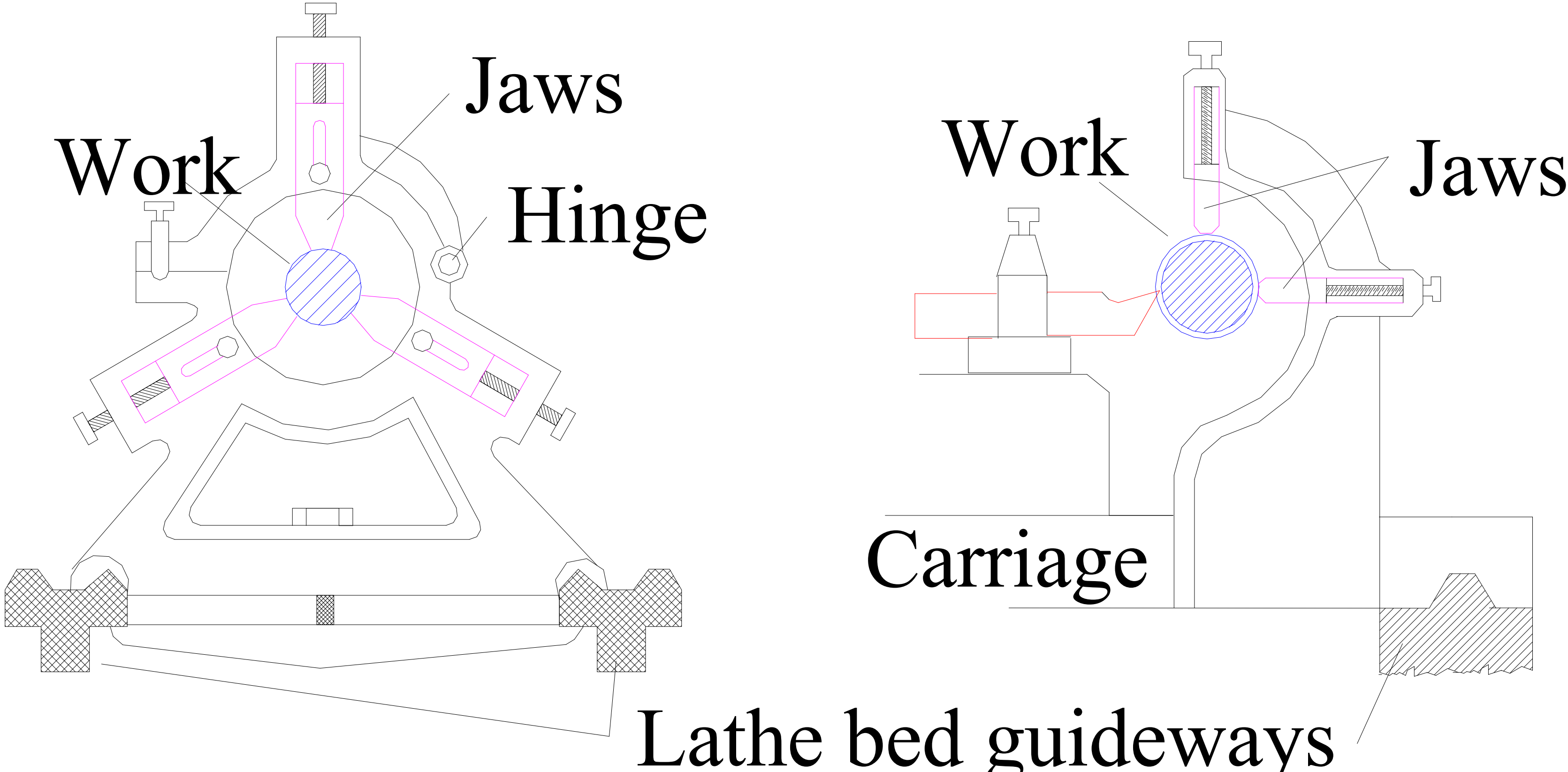
Workpiece (job) with a hole



Rests

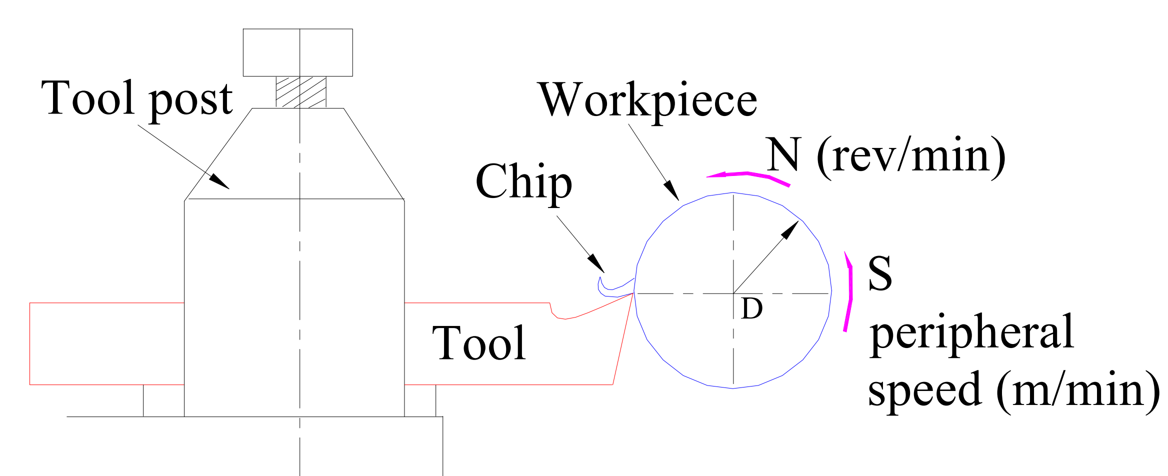
Steady Rest

Follower Rest

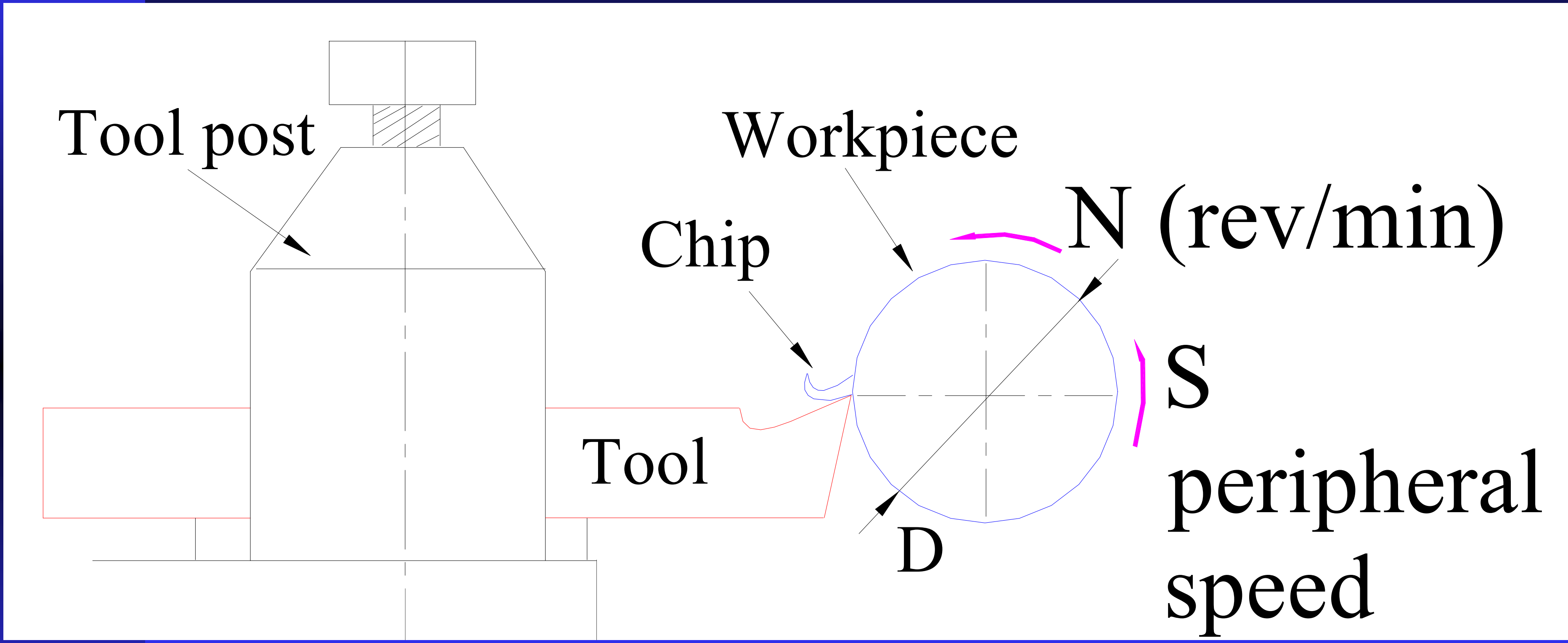


Operating/Cutting Conditions

1. Cutting Speed ***v***
2. Feed ***f***
3. Depth of Cut ***d***



Operating Conditions



relative tool travel in 1 rotation $= \pi D$

$$peripheral\ speed = S = \pi D N$$

Cutting Speed

D – Diameter (mm)

N – Revolutions per Minute (rpm)

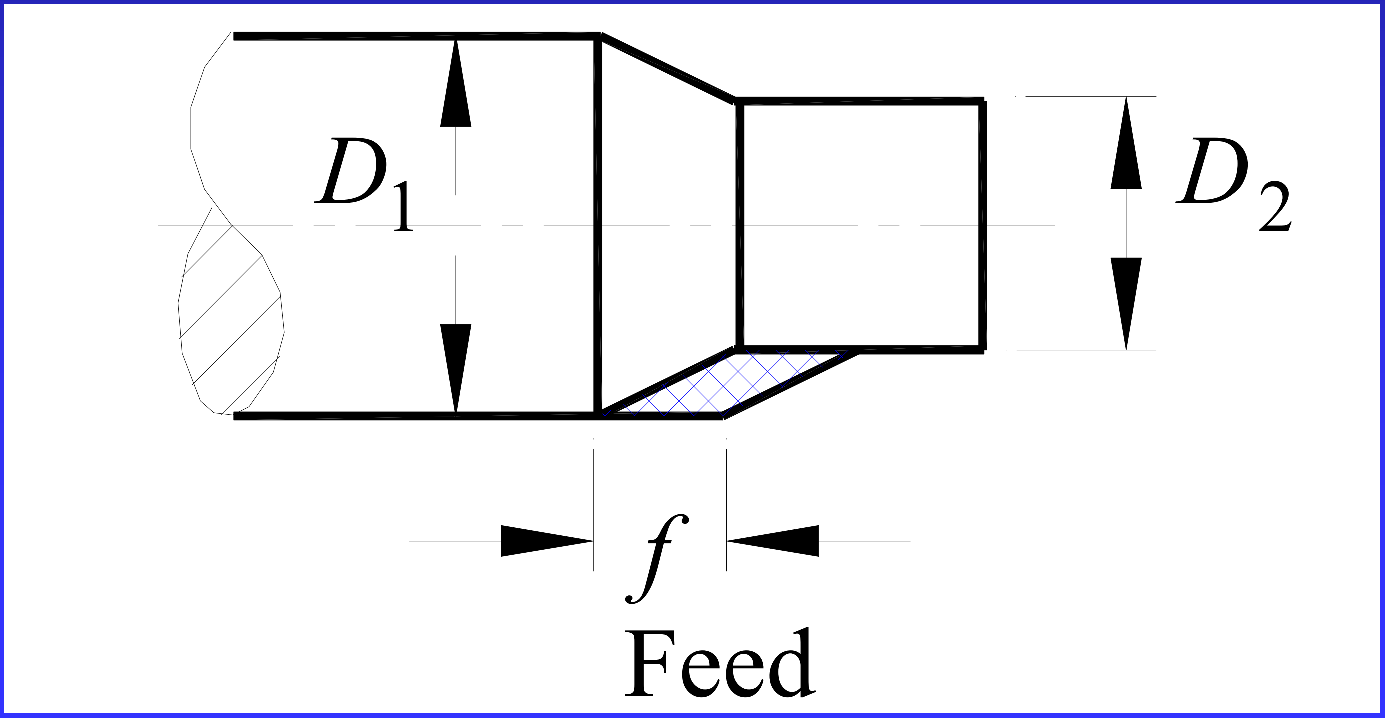
$$v = \frac{\pi D N}{1000} \quad \text{m/min}$$

The **Peripheral Speed** of Workpiece past the Cutting Tool

=**Cutting Speed**

Feed

f – the distance the tool advances for every rotation of workpiece (mm/rev)

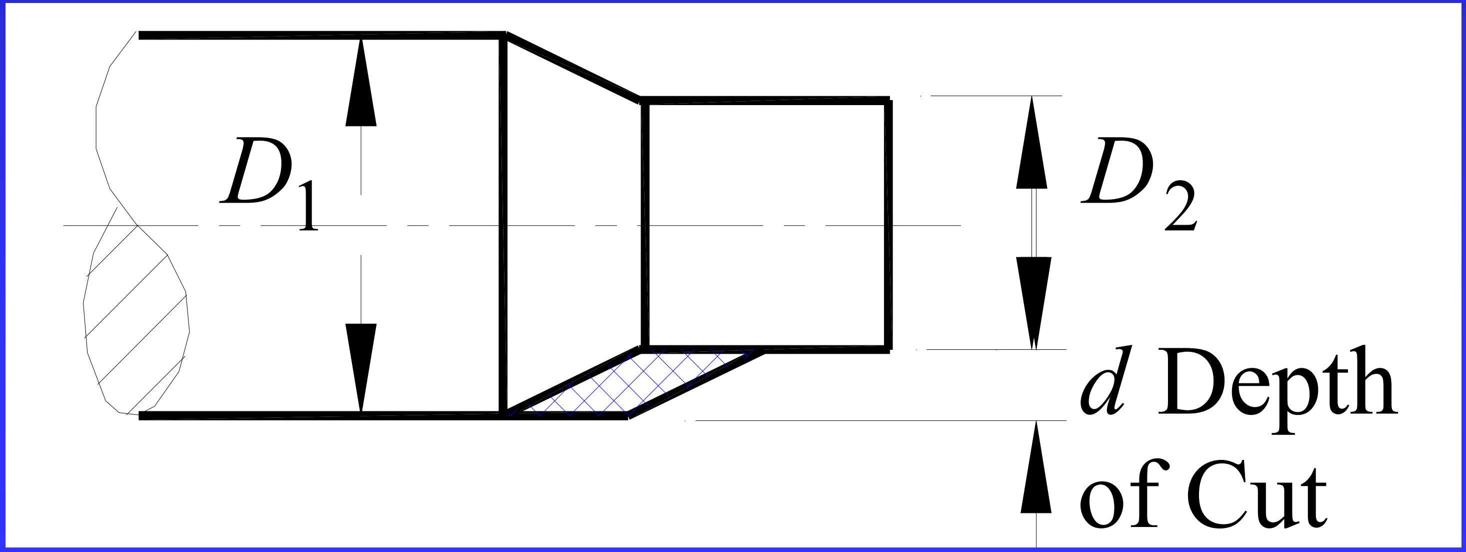


Operating Conditions..

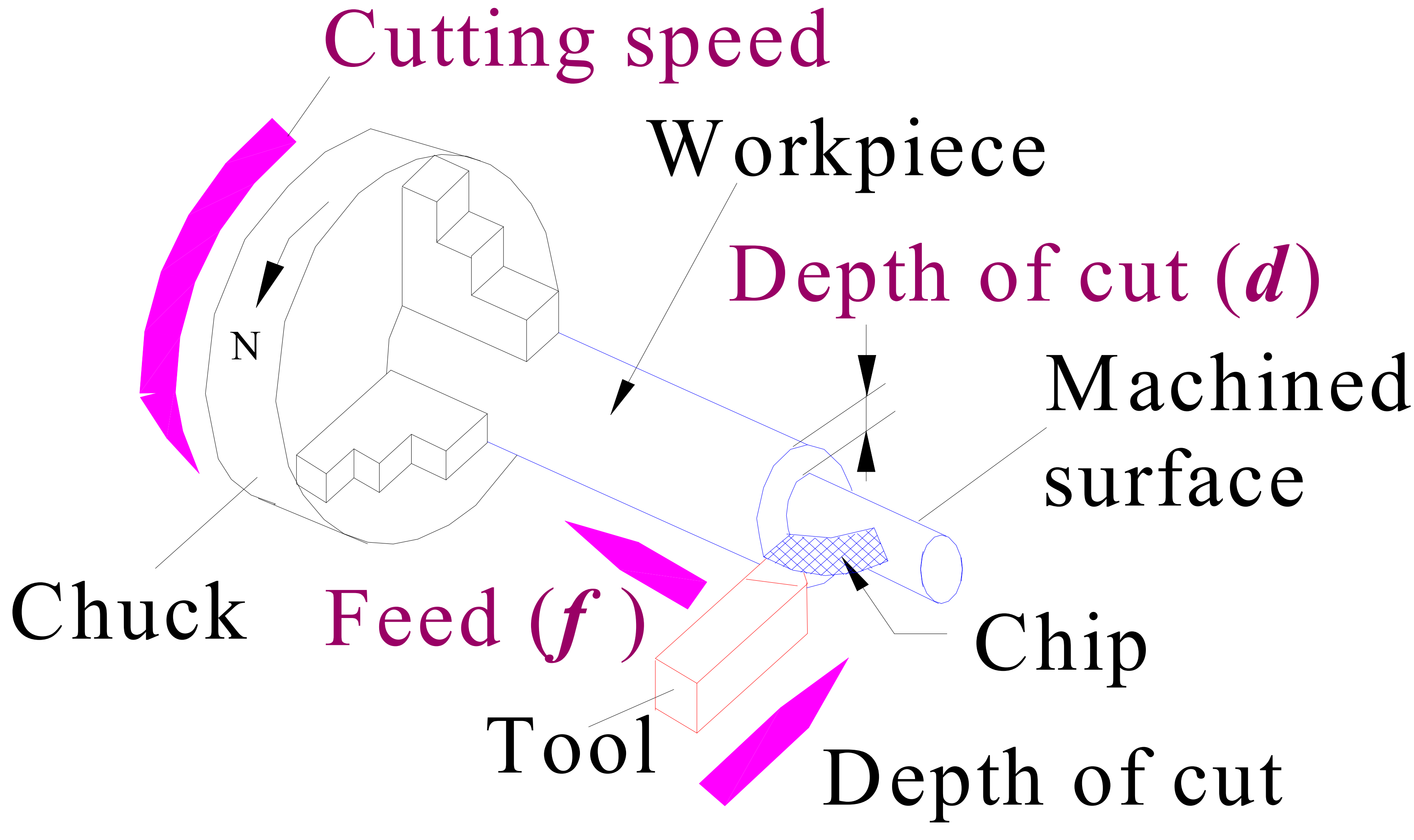
Depth of Cut

perpendicular distance between machined surface and uncut surface of the Workpiece

$\boldsymbol{d} = (D_1 - D_2)/2$ (mm)



3 Operating Conditions



Selection of ..

- Workpiece Material
- Tool Material
- Tool signature
- Surface Finish
- Accuracy
- Capability of Machine Tool

Material Removal Rate

MRR

Volume of material removed in one revolution $MRR = \pi D d f$ mm^3

- Job makes N revolutions/min

$$\mathbf{MRR} = \pi D d f N \ (\text{mm}^3/\text{min})$$

- In terms of ***v*** MRR is given by

$$\mathbf{MRR} = 1000\, v d f \ (\text{mm}^3/\text{min})$$

MRR

dimensional consistency by substituting the units

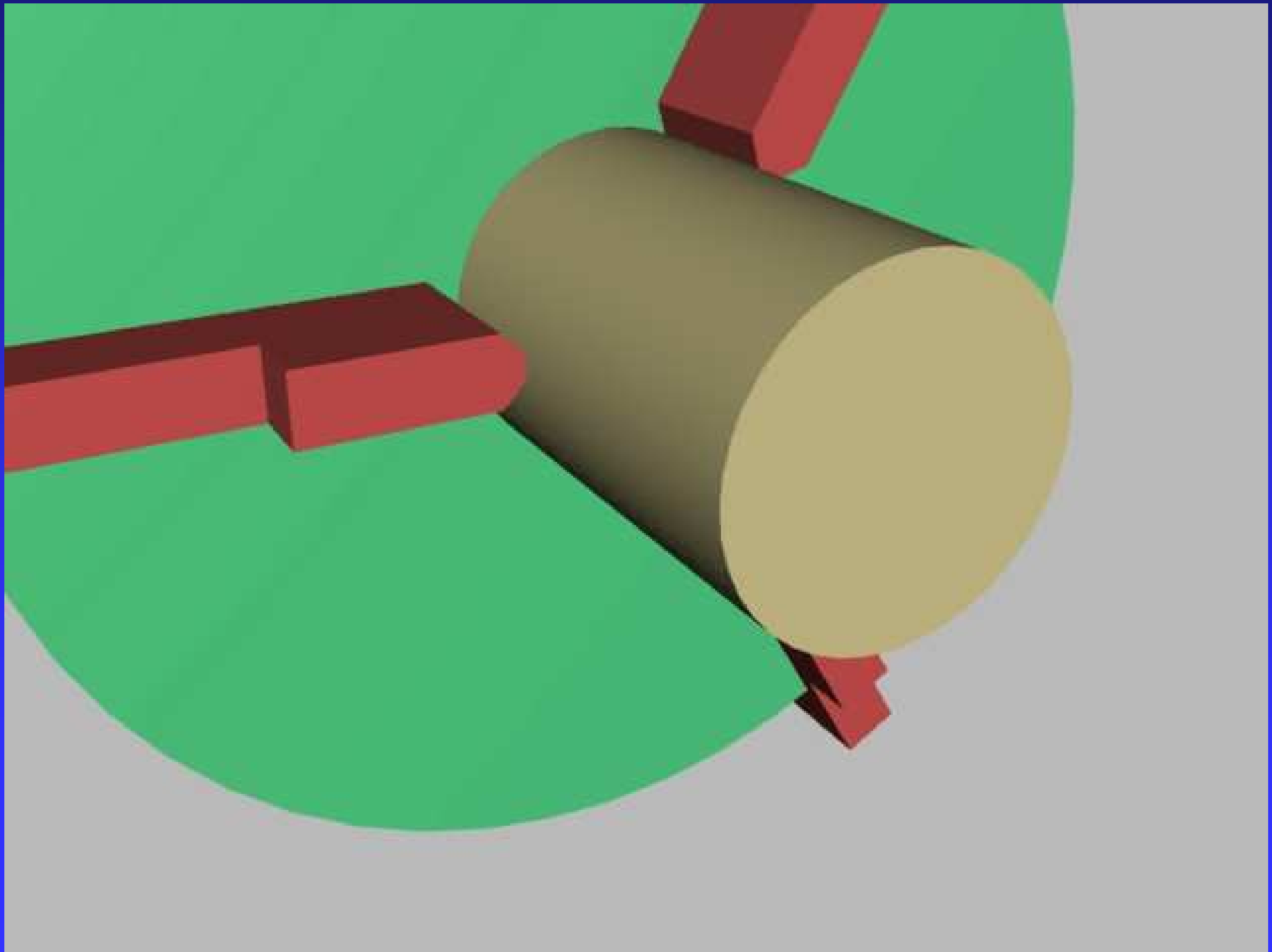
MRR: *D d f N* ⇨ (mm)(mm)(mm/rev)(rev/min) = mm^3/min

Operations on Lathe

- Turning
- Facing
- knurling
- Grooving
- Parting
- Chamfering
- Taper turning
- Drilling
- Threading

Turning

Cylindrical job

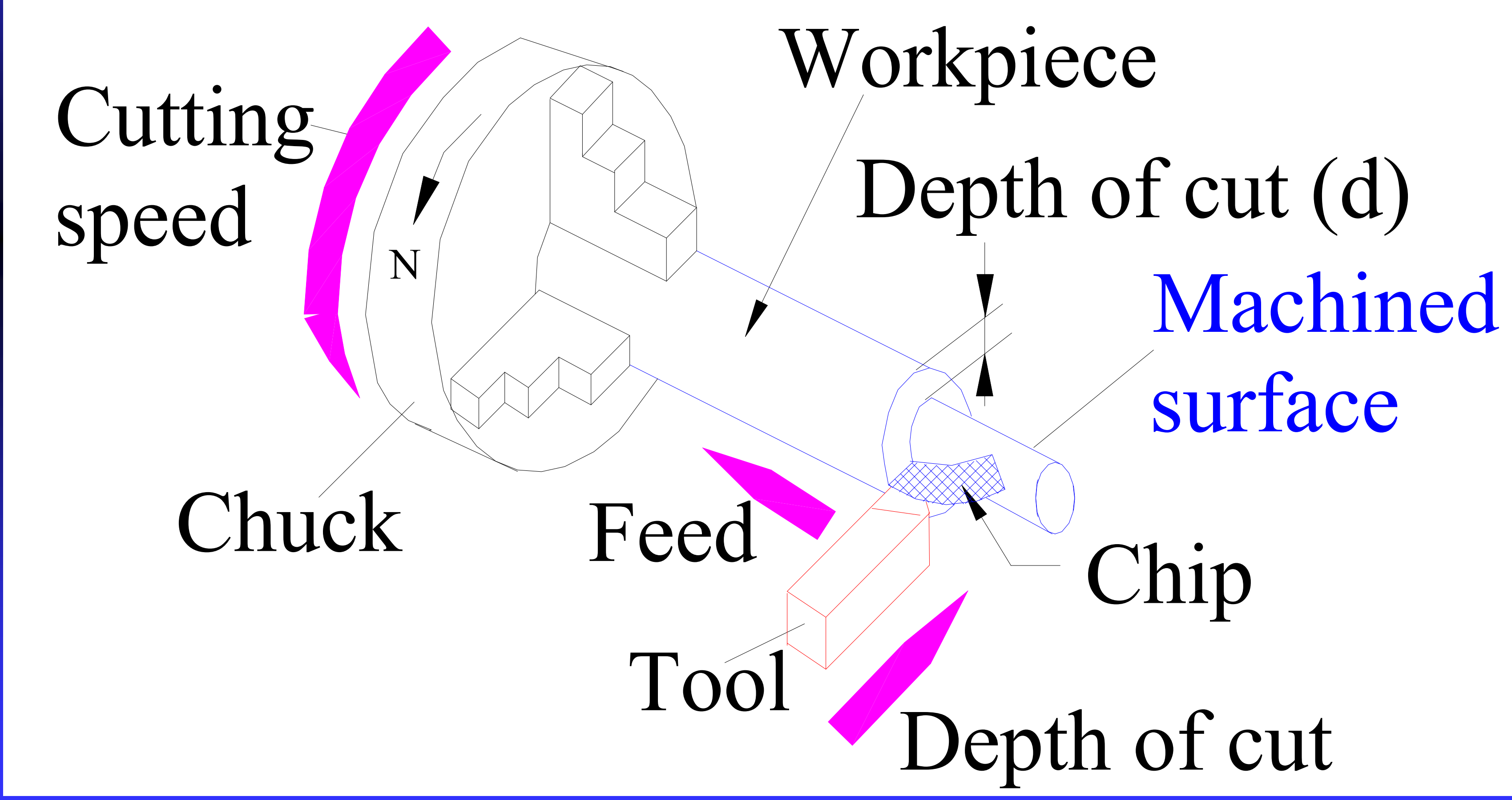


Operations on Lathe :

Operations on Lathe ..

Turning ..

Cylindrical job



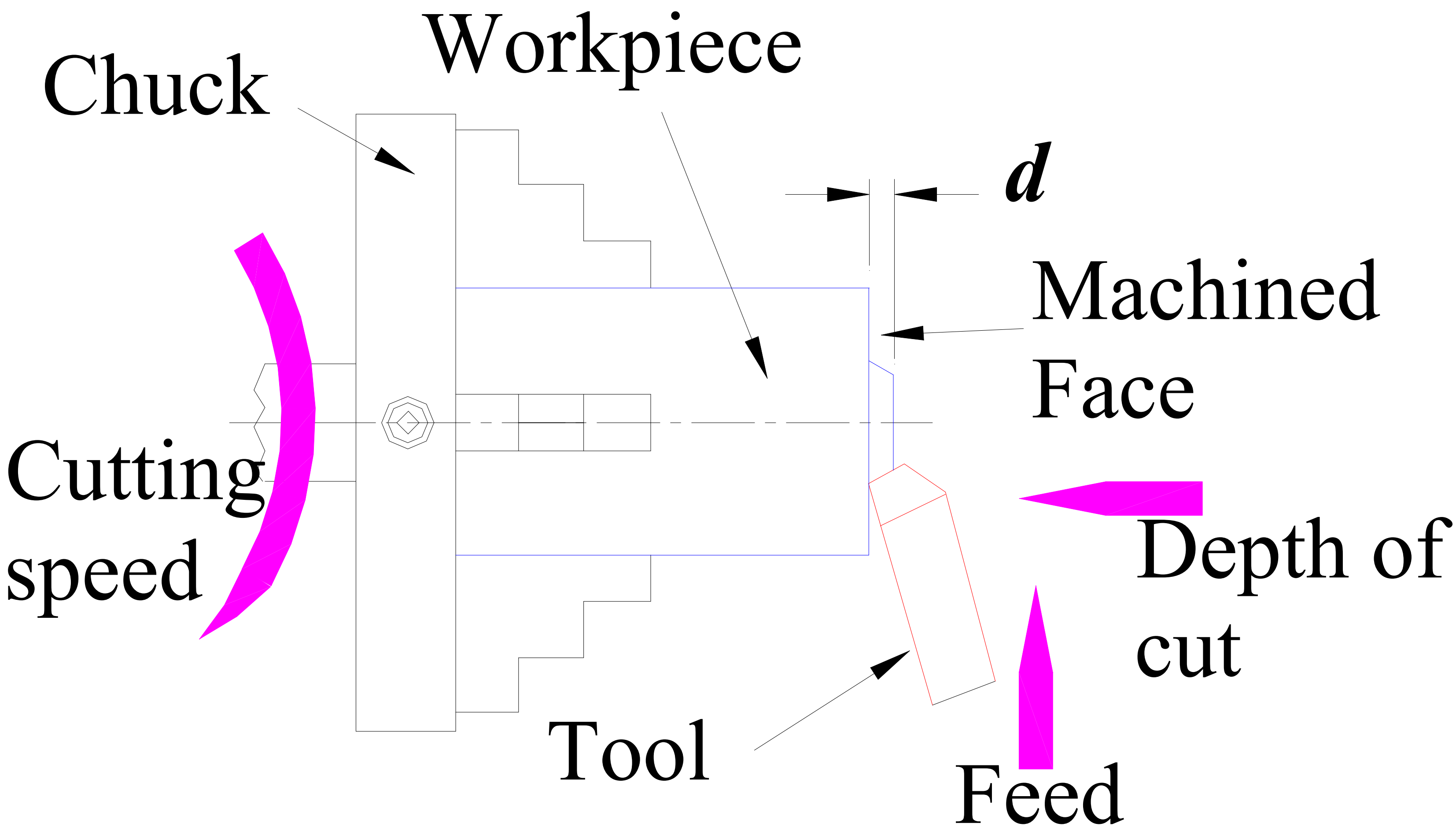
Turning ..

- Excess Material is removed to reduce Diameter
- Cutting Tool: *Turning Tool*

✓a *depth of cut* of 1 mm will reduce diameter by 2 mm

Facing

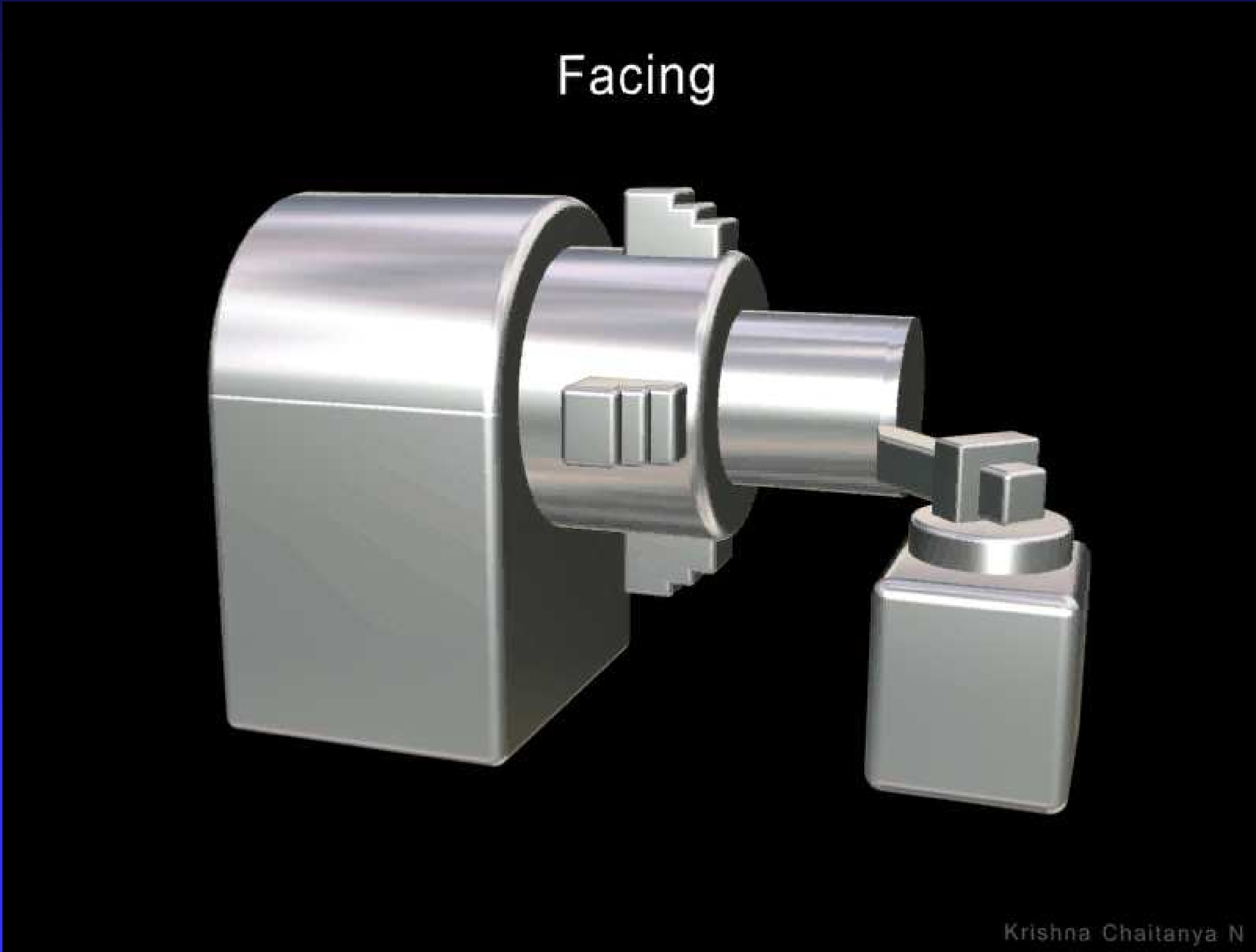
Flat Surface/Reduce length



Facing ..

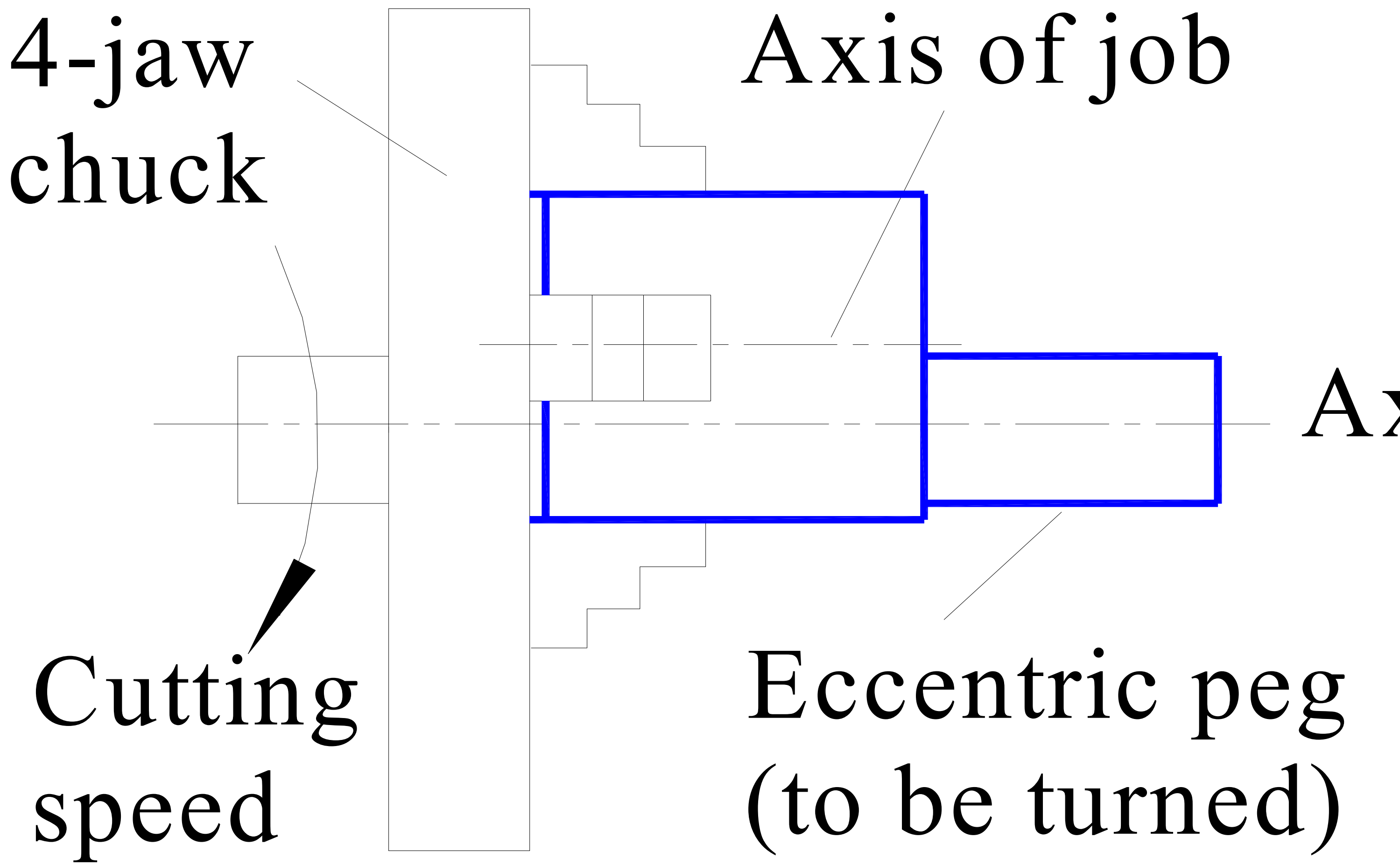
- machine end of job ⇨ Flat surface or to Reduce Length of Job
- Turning Tool
- Feed: in direction perpendicular to workpiece axis
  - Length of Tool Travel = radius of workpiece
- Depth of Cut: in direction parallel to workpiece axis

Facing ..



Operations on Lathe ..

Eccentric Turning

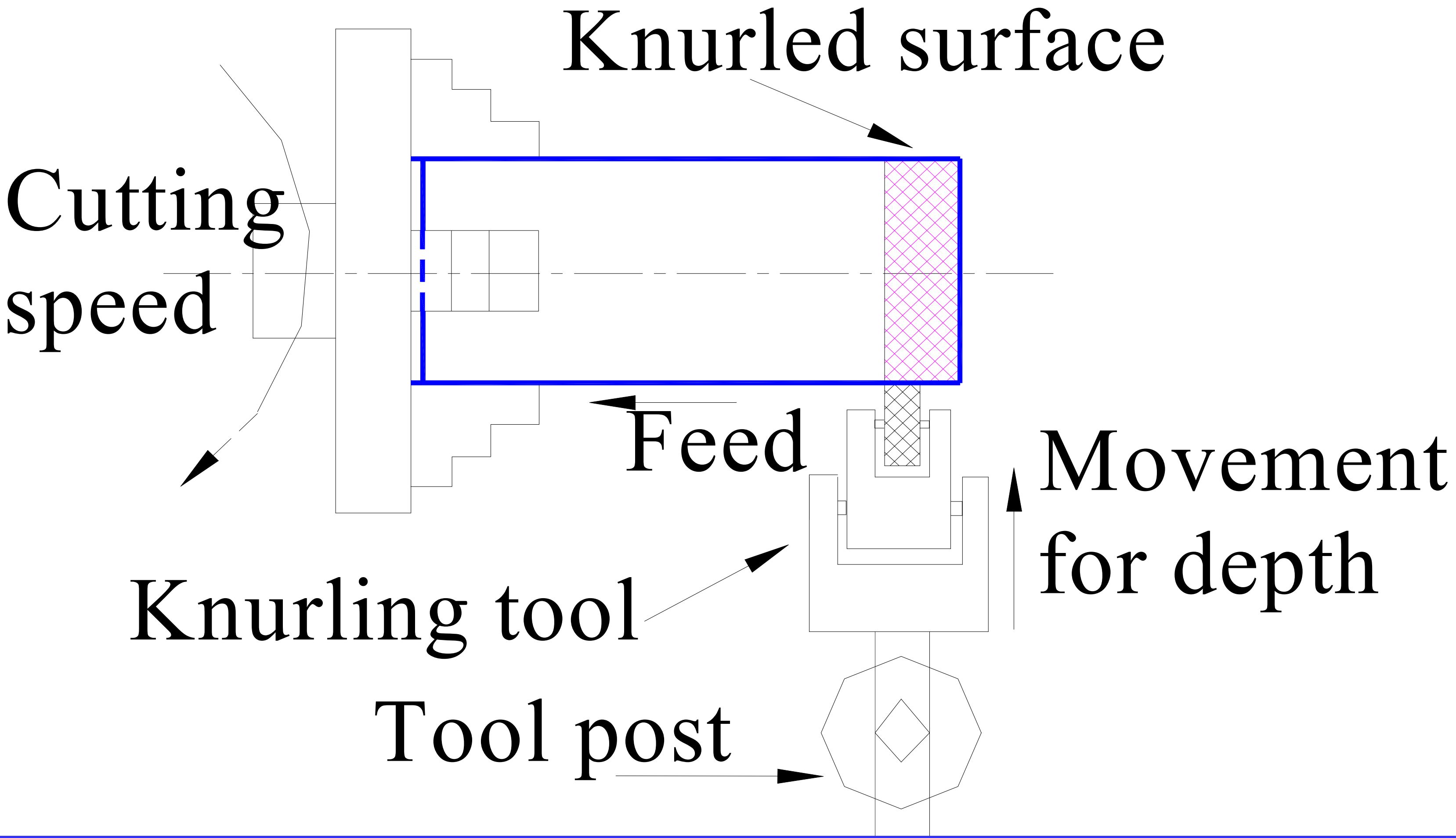


Knurling

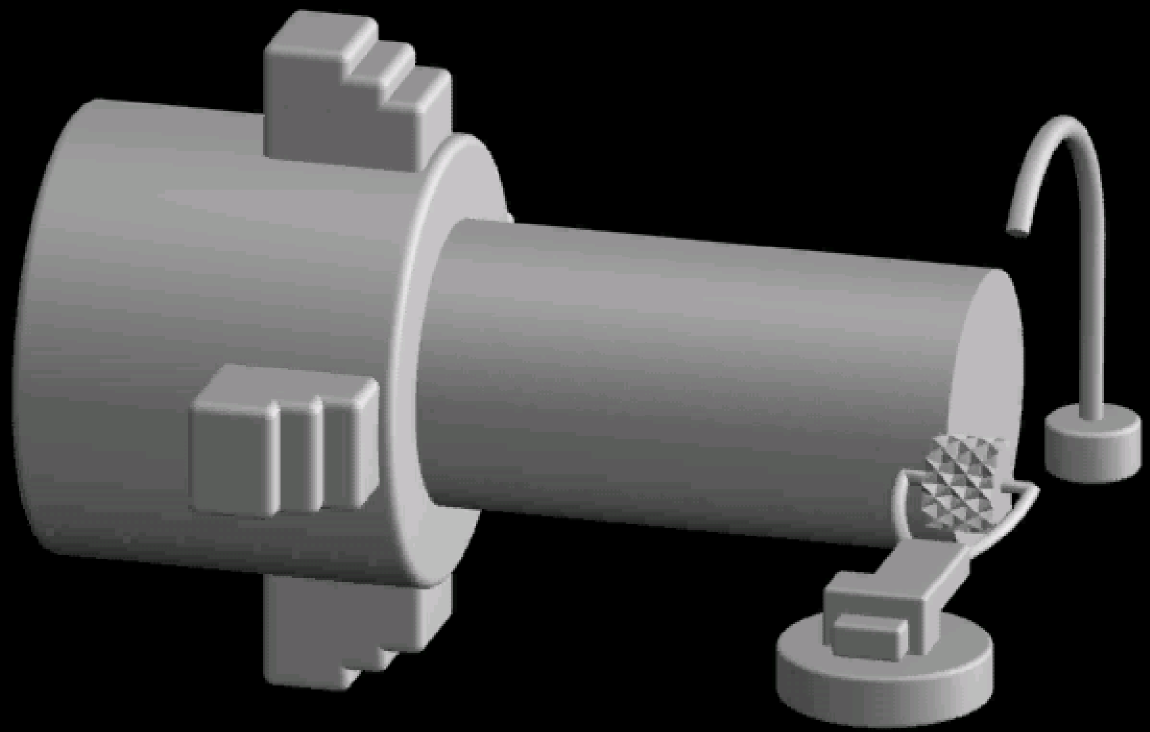
- Produce rough textured surface
  - For Decorative and/or Functional Purpose
- *Knurling Tool*

- A *Forming* Process
- MRR~0

Knurling


Knurled surface
Cutting
speed
Feed
Movement
for depth
Knurling tool
Tool post

Knurling ..



Knurling

It is used to produce regular patterned rough surface. Knurling tool containing a set of hardened steel rollers with teeth cut on them is used. The metal is squeezed against the multiple edges. The speed should be low and plenty of lubricant should be used.

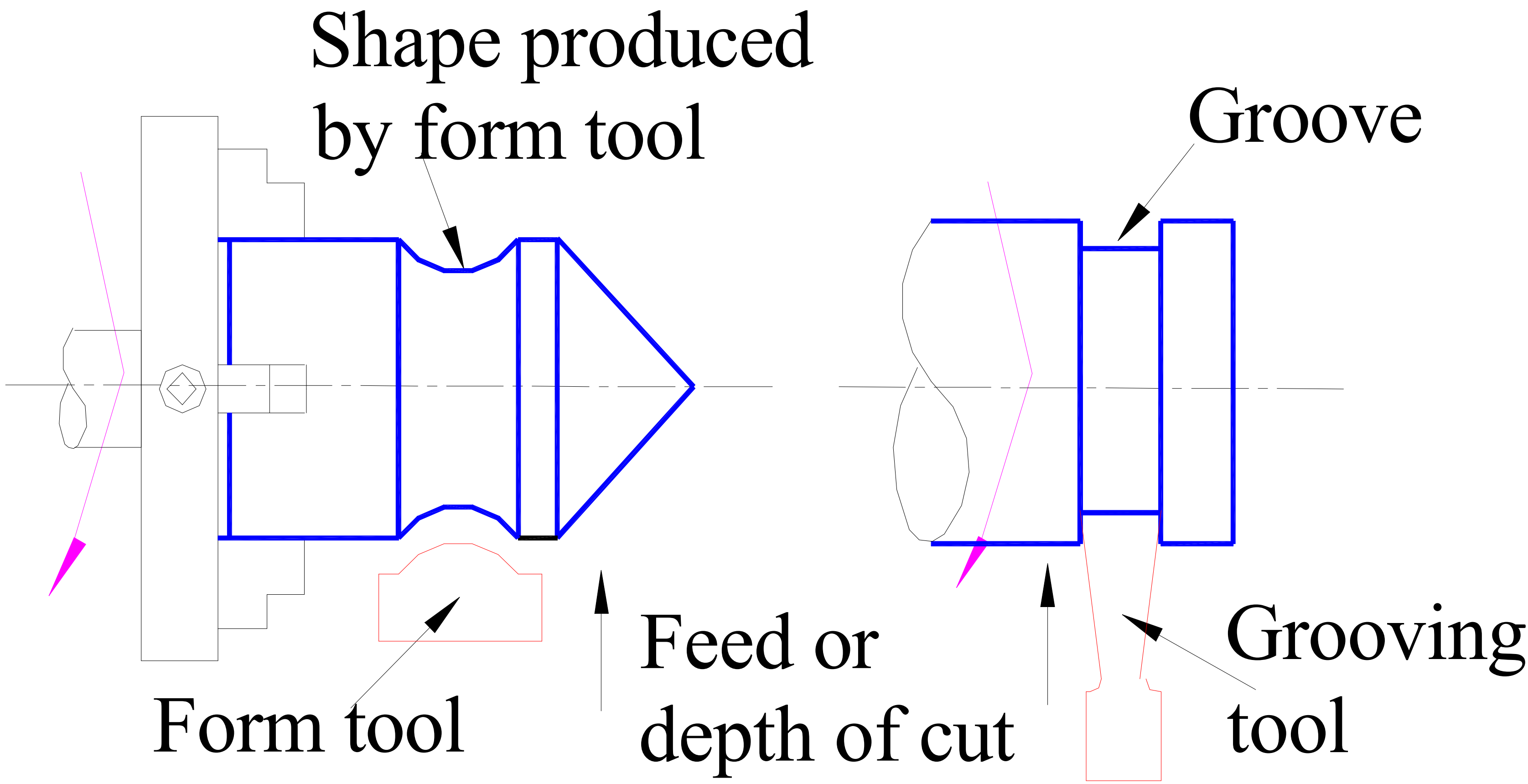
Krishna Chaitanya N

knurling

Grooving

- Produces a Groove on workpiece
- Shape of tool ⇨ shape of groove
- Carried out using Grooving Tool ⇨ A form tool
- Also called Form Turning

Grooving ..

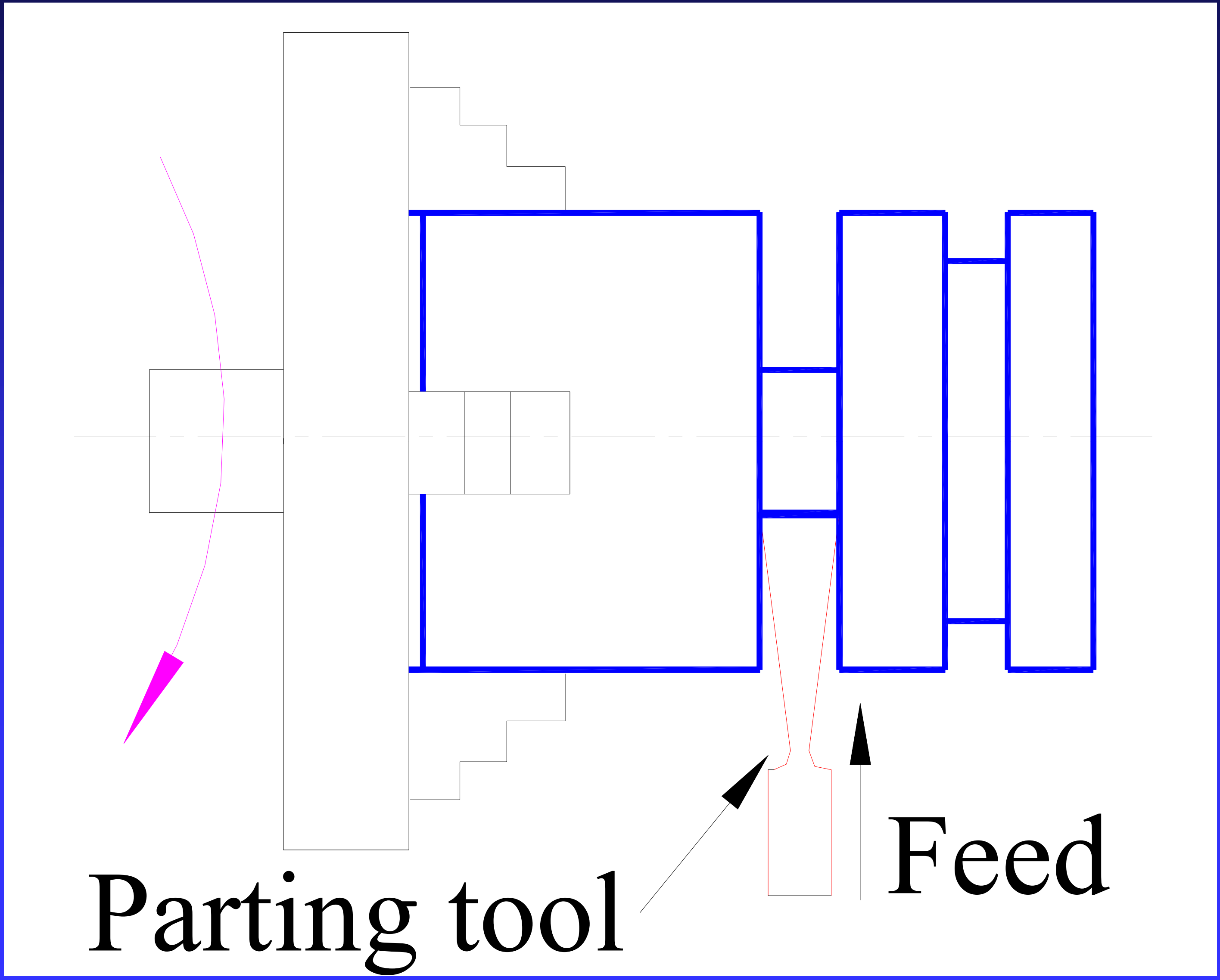

Shape produced
by form tool
Groove
Feed or
depth of cut
Form tool
Grooving
tool

Parting

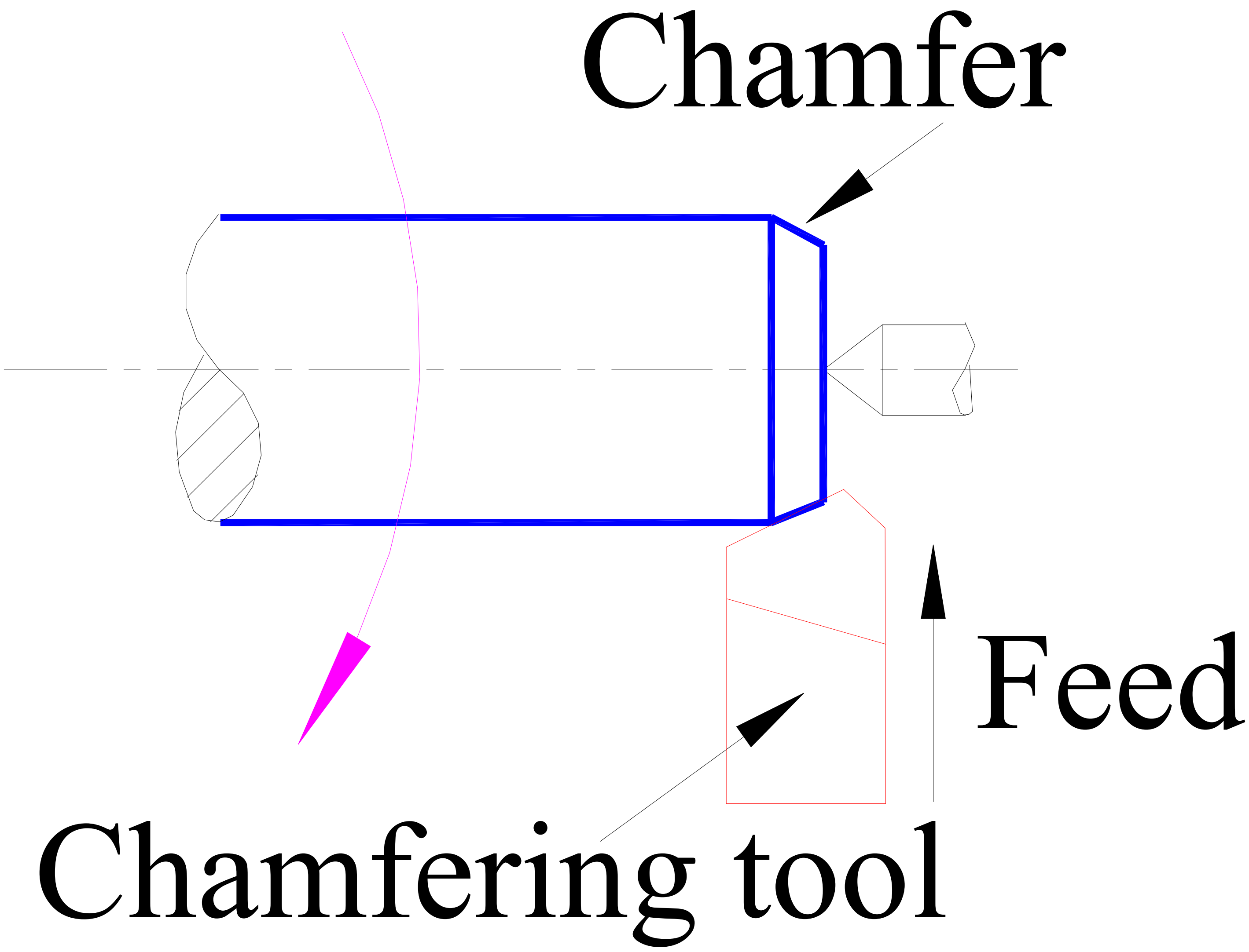
- Cutting workpiece into **Two**
- Similar to grooving
- ***Parting Tool***
- *Hogging* – tool rides over – at slow feed
- Coolant use

Parting ..

Operations on Lathe ..



Chamfering

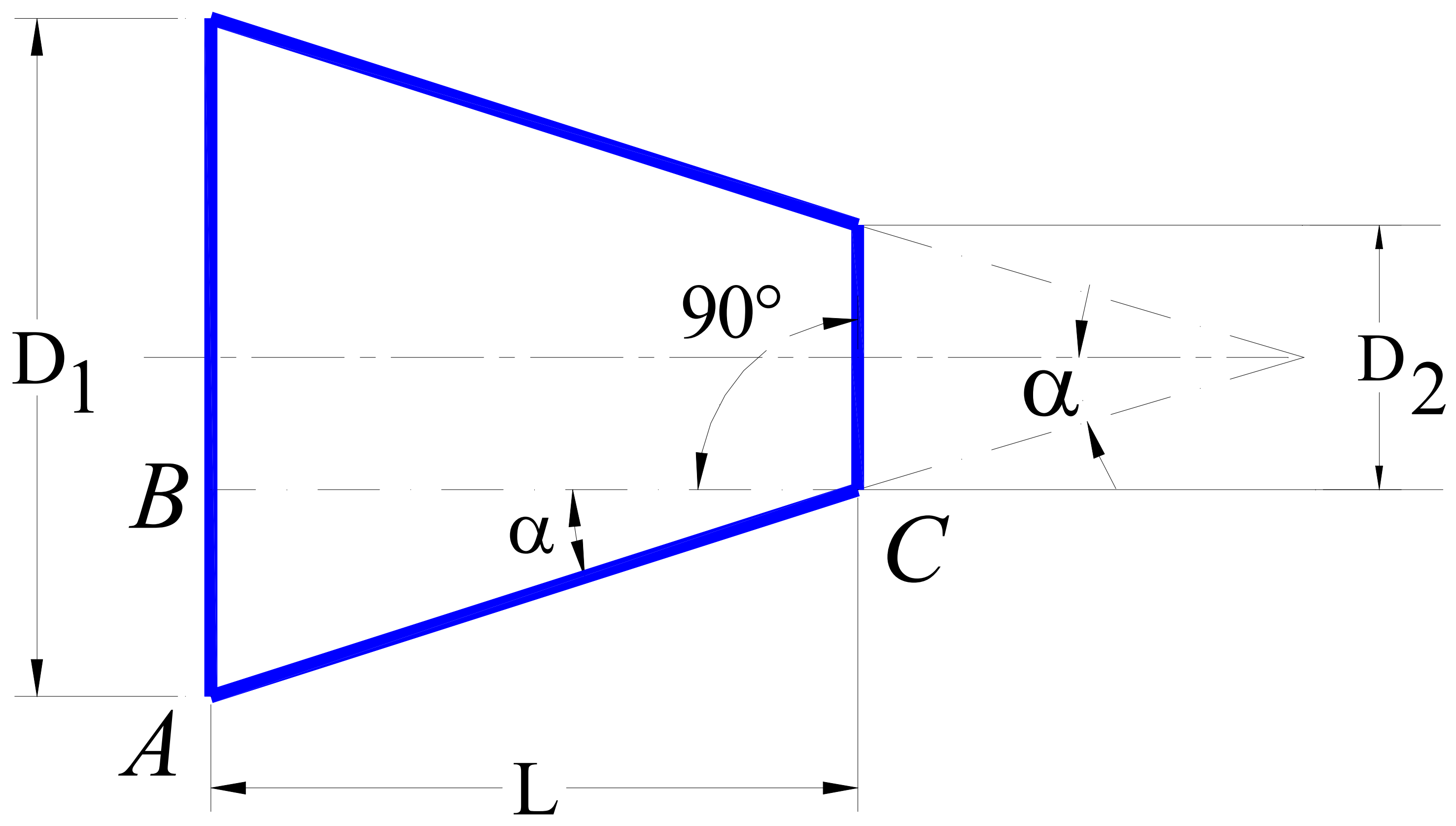


Chamfering

- Beveling sharp machined edges
- Similar to form turning
- Chamfering tool – 45°
- To
  - Avoid Sharp Edges
  - Make Assembly Easier
  - Improve Aesthetics

Taper Turning

- Taper: $$\tan\alpha = \frac{D_1 - D_2}{2L}$$



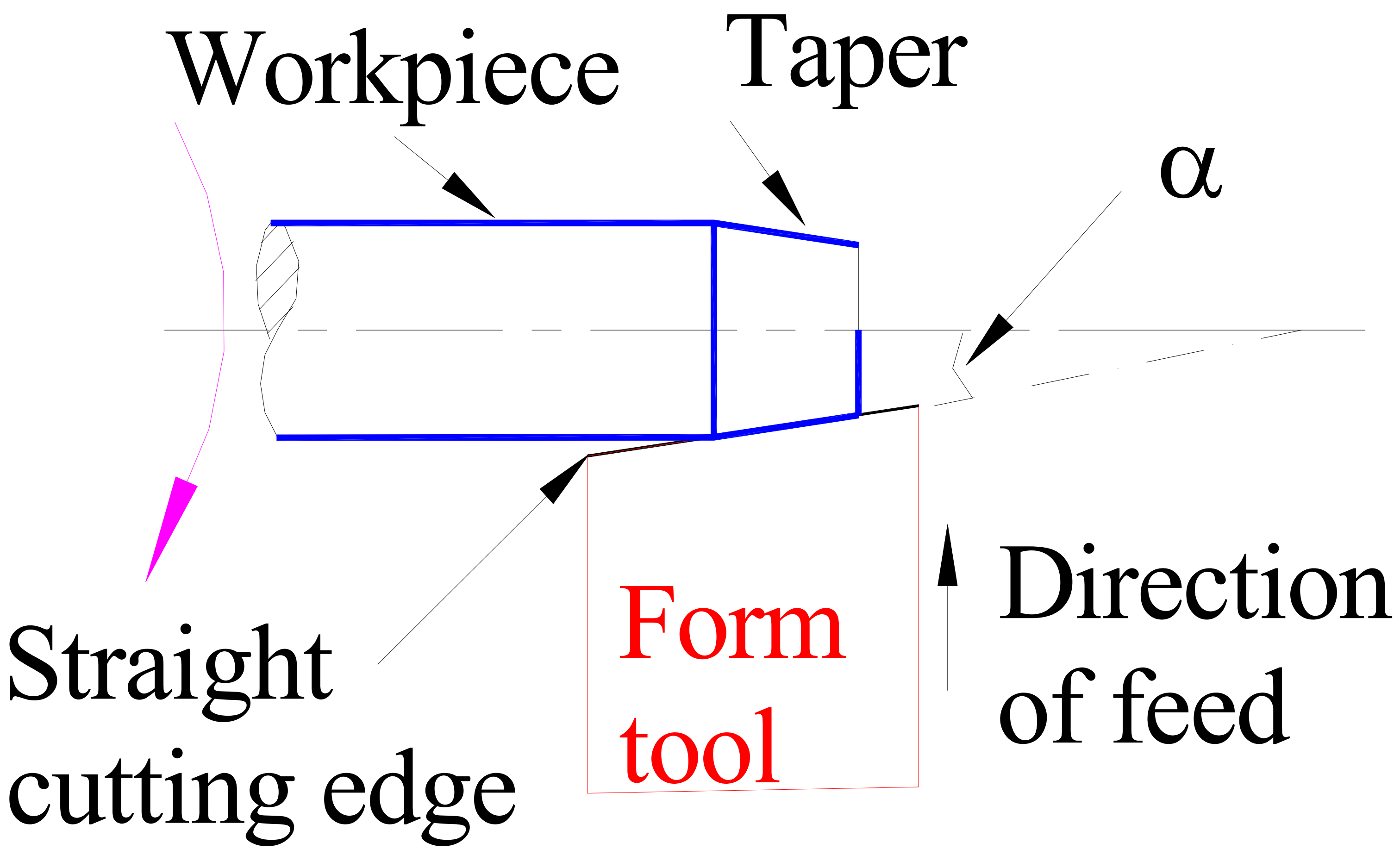
Taper Turning..

Conicity $$K = \frac{D_1 - D_2}{L}$$

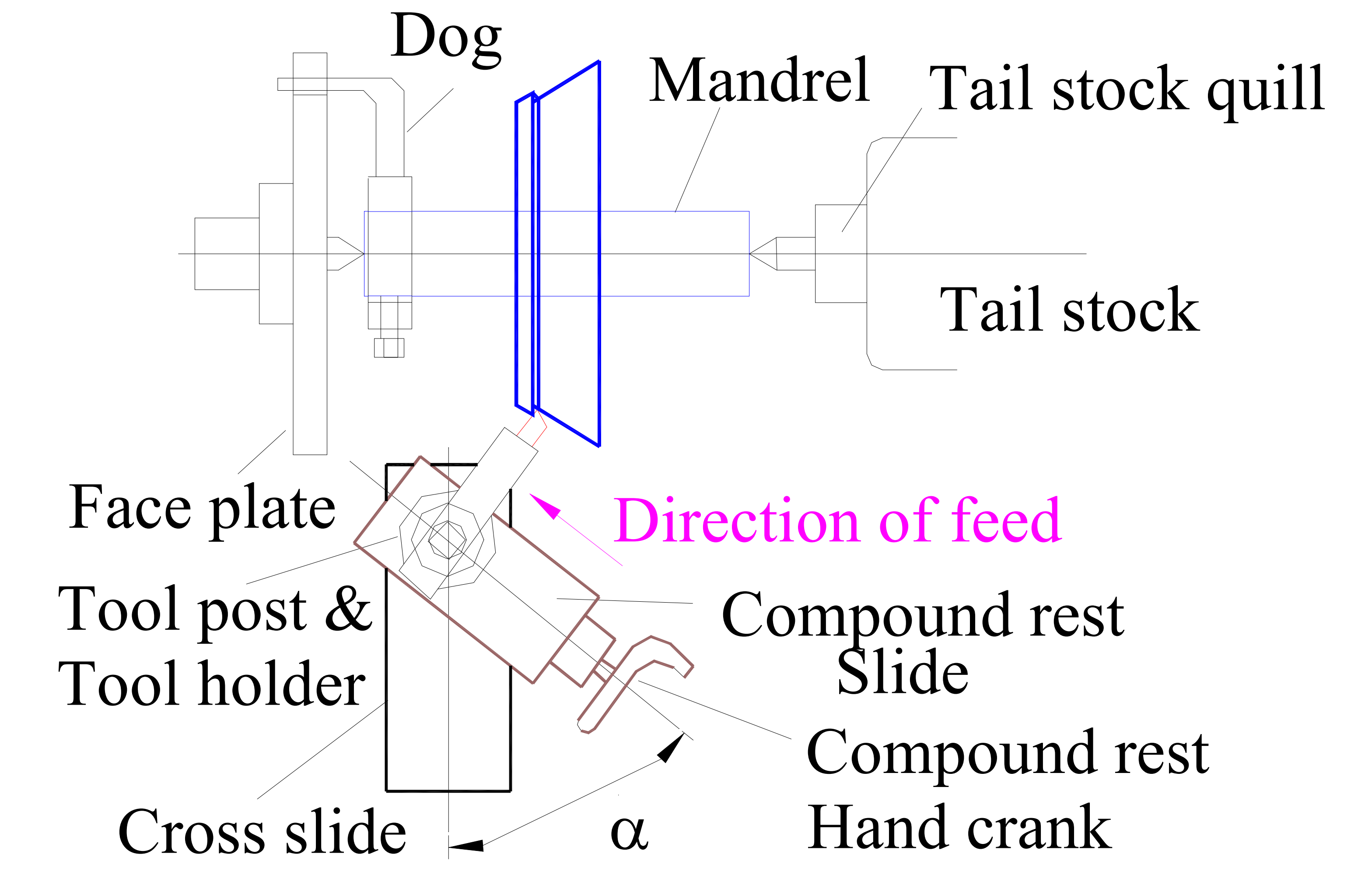
Methods

- Form Tool
- Swiveling Compound Rest
- Taper Turning Attachment
- Simultaneous Longitudinal and Cross Feeds

Taper Turning ..
By Form Tool

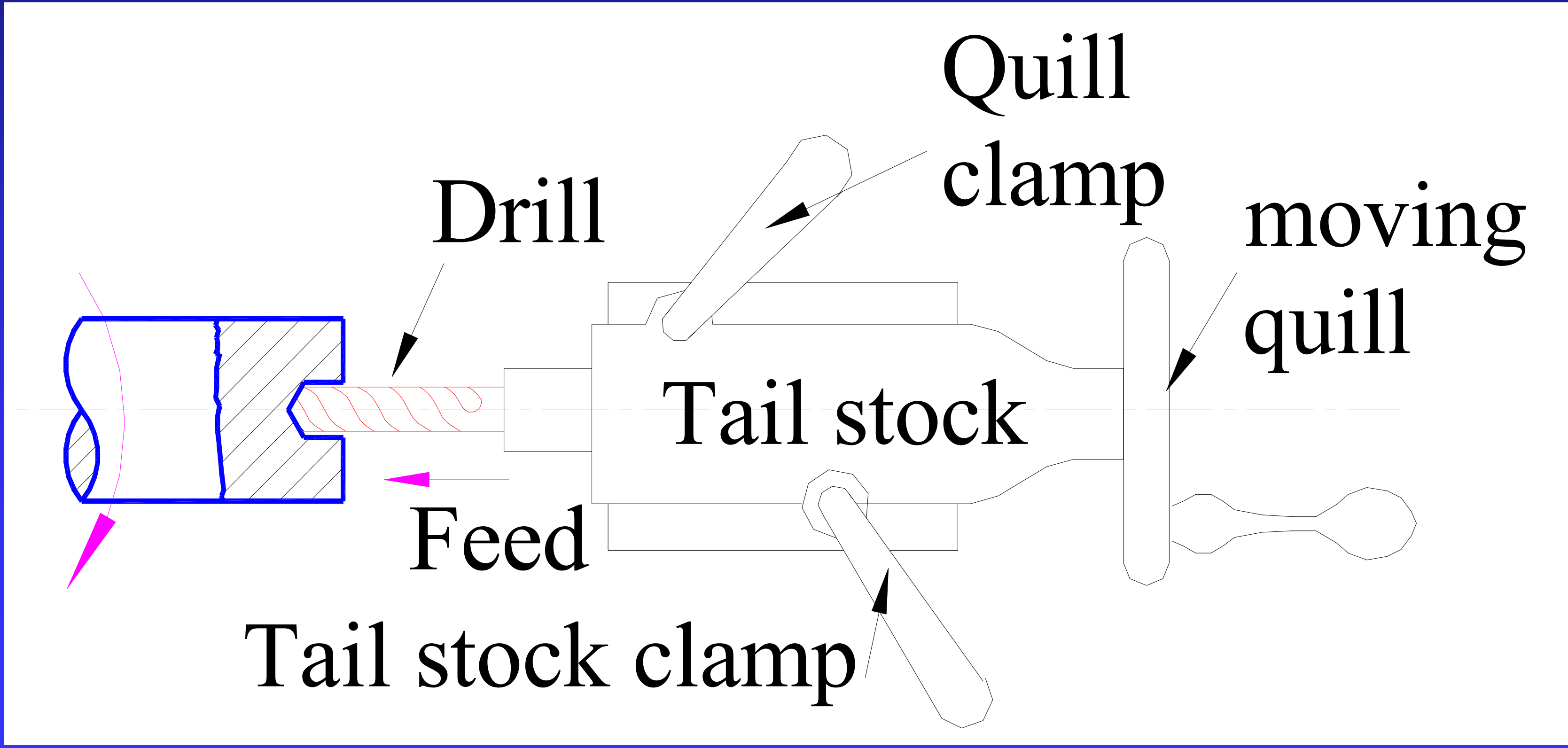


Taper Turning ,,
By Compound Rest



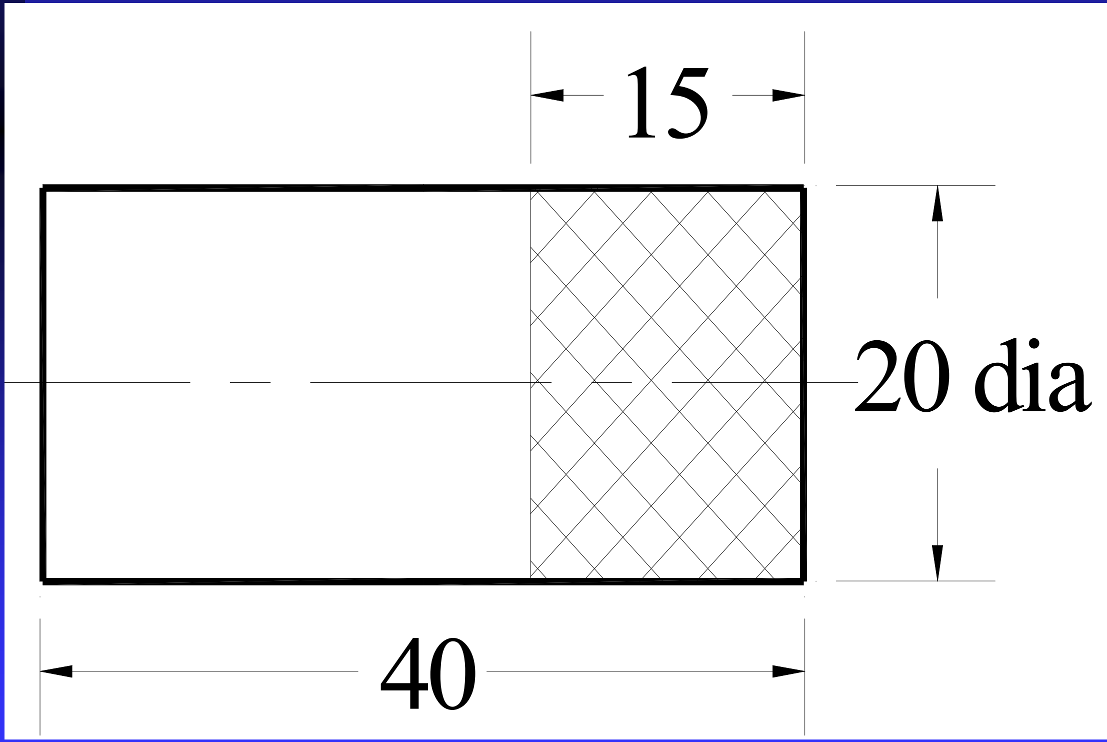
Drilling

Drill – cutting tool – held in TS – feed from TS



Process Sequence

- How to make job from raw material 45 long x 30 dia.?



Steps:
- Operations
- Sequence
- Tools
- Process

Process Sequence ..

Possible Sequences

- TURNING - FACING - KNURLING
- TURNING - KNURLING - FACING X
- FACING - TURNING - KNURLING
- FACING - KNURLING - TURNING X
- KNURLING - FACING - TURNING X
- KNURLING - TURNING – FACING X

What is an Optimal Sequence?

Machining Time

Turning Time

- Job length L_j mm
- Feed f mm/rev
- Job speed N rpm
- $f\,N$ mm/min

$$t = \frac{L_j}{f\,N} \text{ min}$$

Manufacturing Time

Manufacturing Time

= Machining Time

+ Setup Time

+ Moving Time

+ Waiting Time

Example

A mild steel rod having 50 mm diameter and 500 mm length is to be turned on a lathe. Determine the machining time to reduce the rod to 45 mm in one pass when cutting speed is 30 m/min and a feed of 0.7 mm/rev is used.

Example

Given data: $D = 50$ mm, $L_j = 500$ mm
$v = 30$ m/min, $f = 0.7$ mm/rev

Substituting the values of v and D in

$$v = \frac{\pi D N}{1000} \quad \text{m/min}$$

calculate the required spindle speed as: N = 191 rpm

Example

Can a machine has speed of 191 rpm?

Machining time:

$$t = \frac{L_j}{f\,N} \text{ min}$$

- $t = 500 / (0.7 \times 191)$
- $= 3.74$ minutes

Example

- Determine the angle at which the compound rest would be swiveled for cutting a taper on a workpiece having a length of 150 mm and outside diameter 80 mm. The smallest diameter on the tapered end of the rod should be 50 mm and the required length of the tapered portion is 80 mm.

Example

- Given data: $D1$ = 80 mm, $D2$ = 50 mm, Lj = 80 mm (with usual notations)

  tan α = (80-50) / 2×80
- or α = 10.620
- The compound rest should be swiveled at 10.62°

Example

- A 150 mm long 12 mm diameter stainless steel rod is to be reduced in diameter to 10 mm by turning on a lathe in one pass. The spindle rotates at 500 rpm, and the tool is traveling at an axial speed of 200 mm/min. Calculate the cutting speed, material removal rate and the time required for machining the steel rod.

Example

- Given data: Lj = 150 mm, $D1$ = 12 mm, $D2$ = 10 mm, N = 500 rpm
- Using Equation (1)
- $v = \pi \times 12 \times 500 / 1000$
- $= 18.85$ m/min.
- depth of cut = d = (12 – 10)/2 = 1 mm

Example

- feed rate = 200 mm/min, we get the feed *f* in mm/rev by dividing feed rate by spindle rpm. That is
- $f = 200/500 = 0.4$ mm/rev
- From Equation (4),
- $MRR = 3.142 \times 12 \times 0.4 \times 1 \times 500 =$ 7538.4 mm3/min
- from Equation (8),
- $t = 150/(0.4 \times 500) = 0.75$ min.

Example

- Calculate the time required to machine a workpiece 170 mm long, 60 mm diameter to 165 mm long 50 mm diameter. The workpiece rotates at 440 rpm, feed is 0.3 mm/rev and maximum depth of cut is 2 mm. Assume total approach and overtravel distance as 5 mm for turning operation.

Example

- Given data: Lj = 170 mm, $D1$ = 60 mm, $D2$ = 50 mm, N = 440 rpm, f = 0.3 mm/rev, d= 2 mm,
- How to calculate the machining time when there is more than one operation?

Example

- <u>Time for Turning:</u>
- Total length of tool travel = job length + length of approach and overtravel
- L = 170 + 5 = 175 mm
- Required depth to be cut = (60 – 50)/2 = 5 mm
- Since maximum depth of cut is 2 mm, 5 mm cannot be cut in one pass. Therefore, we calculate number of cuts or passes required.
- Number of cuts required = 5/2 = 2.5 or 3 (since cuts cannot be a fraction)
- Machining time for one cut = $L / (f \times N)$
- Total turning time = $[L / (f \times N)] \times$ Number of

Example

- <u>Time for facing:</u>
- Now, the diameter of the job is reduced to 50 mm. Recall that in case of facing operations, length of tool travel is equal to half the diameter of the job. That is, $l = 25$ mm. Substituting in equation 8, we get
- $t = 25/(0.3 \times 440)$
- $= 0.18$ min.

Example

- Total time:
- Total time for machining = Time for Turning + Time for Facing
- = 3.97 + 0.18
- = 4.15 min.
- The reader should find out the total machining time if first facing is done.

Example

- From a raw material of 100 mm length and 10 mm diameter, a component having length 100 mm and diameter 8 mm is to be produced using a cutting speed of 31.41 m/min and a feed rate of 0.7 mm/revolution. How many times we have to resharpen or regrind, if 1000 work-pieces are to be produced. In the taylor's expression use constants as $n = 1.2$ and $C =$ 180

Example

- Given $D = 10$ mm , $N = 1000$ rpm, $v = 31.41$ m/minute
- From Taylor's tool life expression, we have $vT^n = C$
- Substituting the values we get,
- $(31.40)(T)^{1.2} = 180$
- or $T = 4.28$ min

Example

- Machining time/piece = $L / (f \times N)$
- = 100 / (0.7×1000)
- = 0.142 minute.
- Machining time for 1000 work-pieces = 1000 × 0.142 = 142.86 min
- Number of resharpenings = 142.86/ 4.28
- = 33.37 or 33 resharpenings

Example

- ***6:*** While turning a carbon steel cylinder bar of length 3 m and diameter 0.2 m at a feed rate of 0.5 mm/revolution with an HSS tool, one of the two available cutting speeds is to be selected. These two cutting speeds are 100 m/min and 57 m/min. The tool life corresponding to the speed of 100 m/min is known to be 16 minutes with n=0.5. The cost of machining time, setup time and unproductive time together is Rs.1/sec. The cost of one tool re-sharpening is Rs.20.

Example

- Given $T1$ = 16 minute, $v1$ = 100 m/minute, $v2$ = 57 m/minute, D = 200mm, l = 300 mm, f = 0.5 mm/rev
- <u>Consider Speed of 100 m/minute</u>
- $N1 = (1000 \times v) / (\pi \times D) = (1000 \times 100) / (\pi \times 200) = 159.2$ rpm
- $t1 = l / (f \times N) = 3000 / (0.5 \times 159.2) = 37.7$ minute
- Tool life corresponding to speed of 100 m/minute is 16 minute.
- Number of resharpening required = 37.7 / 16 = 2.35
-

Example

- Total cost =
- Machining cost + Cost of resharpening × Number of resharpening
- $= 37.7 \times 60 \times 1 + 20 \times 2$
- = Rs.2302

Example

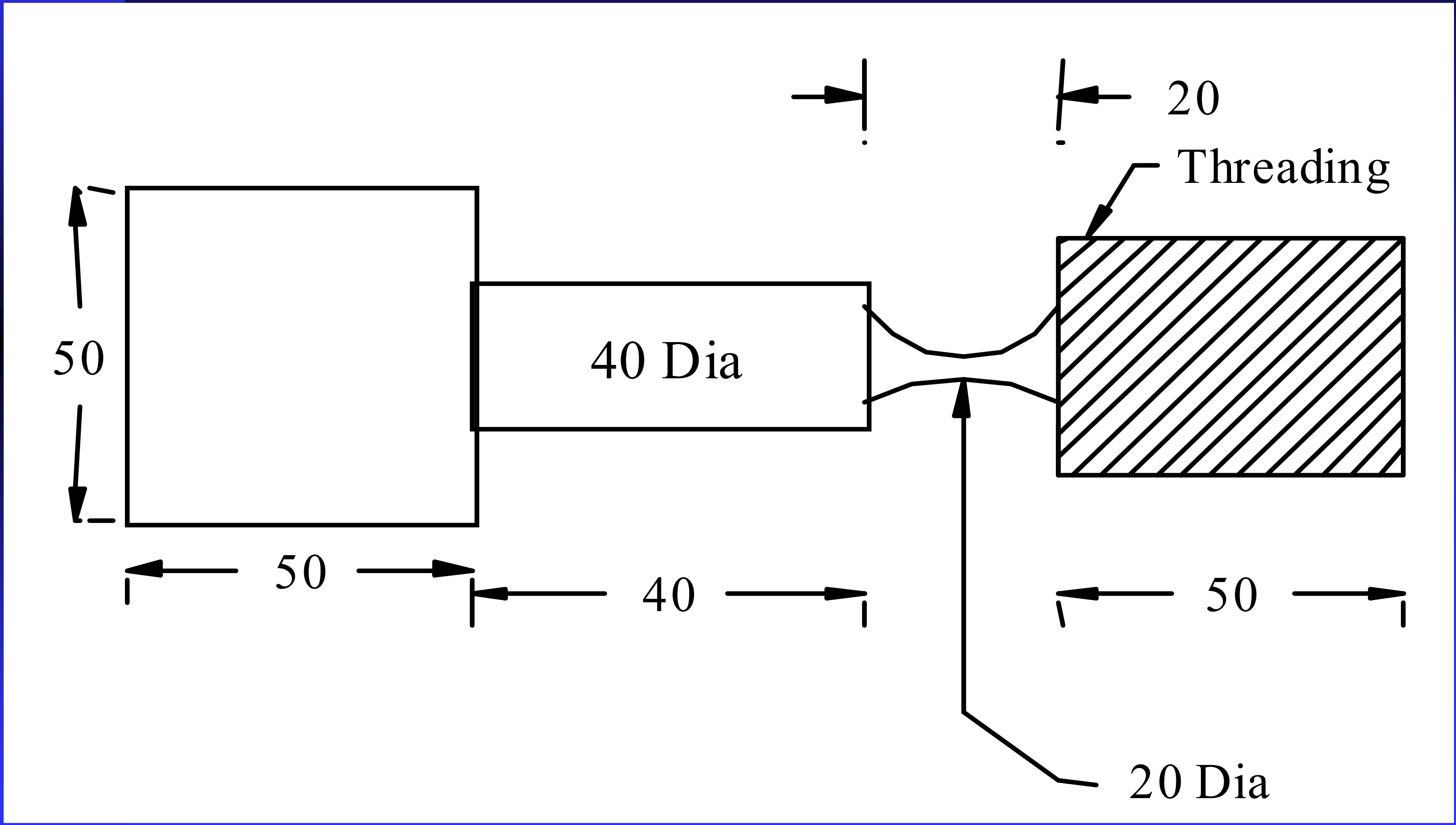
- Consider Speed of 57 m/minute
- Using Taylor's expression $T2 = T1 \times (v1 / v2)2$ with usual notations
- $= 16 \times (100/57)2 =$ 49 minute
- Repeating the same procedure we get $t2 = 66$ minute, number of reshparpening=1 and total cost = Rs. 3980.
-

Example

- Write the process sequence to be used for manufacturing the component

from raw material of 175 mm length and 60 mm diameter

Example



Example

- To write the process sequence, first list the operations to be performed. The raw material is having size of 175 mm length and 60 mm diameter. The component shown in Figure 5.23 is having major diameter of 50 mm, step diameter of 40 mm, groove of 20 mm and threading for a length of 50 mm. The total length of job is 160 mm. Hence, the list of operations to be carried out on the job are turning,

Example

- A possible sequence for producing the component would be:
- Turning (reducing completely to 50 mm)
- Facing (to reduce the length to 160 mm)
- Step turning (reducing from 50 mm to 40 mm)
- Thread cutting.
- Grooving