Tishk International University
Mechatronics Engineering Department
Manufacturing Technology Week 2025

Forging &Rolling Process

Instructor: Sara Serwer Youns
Email:sara.sarwer@tiu.edu.iq

Introduction to Forging

- Definition: Forging is deforming metals/alloys into shapes by repeated hammer blows, usually hot forging.
- Raw Material: Piece slightly larger than final component, allowing for scaling and machining allowance.
- Usage: Forged parts used as-is or machined for precise dimension

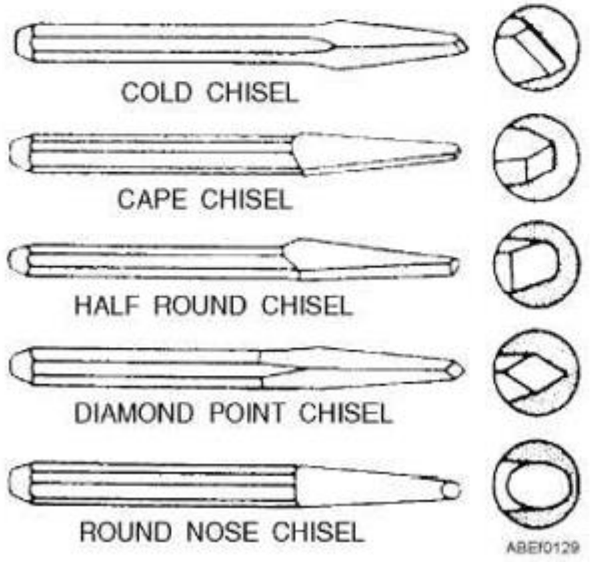
Classification of Forging

- Hand Forging: Manual hammering by blacksmith on anvil, suitable for small parts and quantities. Hand forging, or blacksmithing, is a traditional metal shaping method that involves heating metal in a forge and then using a hammer and anvil to shape it.

- Power Hammer Forging: Powered by electricity, steam, or compressed air for larger parts. Power hammer forging uses a mechanically powered hammer to strike hot metal, allowing for more efficient and powerful shaping than manual hammering. It involves placing heated metal on an anvil and using a foot pedal or lever to control the hammer's strike force and speed

- Hydraulic Press Forging: Uses squeezing action of press, produces superior quality forgings.

- Machine Forging: Special machines for mass production of bolts and nuts.



Hand Forging Operations

- Upsetting: Increase cross-section, decrease length.
- Drawing Down: Increase length, reduce cross-section.
- Cutting: Remove extra metal by hot chisels.
- Bending: Heated and upset area to allow bending without cross-section reduction.
- Punching & Drifting: Creating rough holes and improving finish of holes.
- Setting Down & Finishing: Removing rounded corners, smoothing surfaces.
- Forge Welding: Joining two heated and cleaned metal pieces by hammering with flux.

Power Hammers Overview

- Spring Hammer: Obsolete electric motor powered hammer with a laminated spring.
- Pneumatic Hammer: Uses compressed air to power piston for blows; regulated blow intensity.
- Steam Hammer: Uses steam pressure for stronger blows than pneumatic.

Types of Die Forging

- Open Die Forging: Material not fully enclosed; uses flat or V dies.
- Impression Die Forging: Dies have carved impressions; flash formed and trimmed.
- Closed Die Forging: Precise material amount; no flash; suitable for mass production.

Important Considerations for Quality Forgings

- Correct heating and soaking time for thickness.
- Good forging practice: 40% cross-section reduction.
- Use minimal heats to finish.
- Stop forging at recommended low temperature to avoid grain growth.
- Avoid forging cold material to prevent cracks.

Forging Defects

- Laps, cracks, incomplete forging, mismatched dies, scale pits.
- Overheating and internal cracks.
- Fiber flow disruption due to rapid plastic flow.

Heat Treatment of Forgings

- Purpose: Improve strength, remove stresses, improve machinability.
- Common treatment: Normalising.

Cold Forging

- Limited to low-medium carbon steel, wire, thin rods.
- Mechanical press used.
- Products: Nails, rivets, pins, brass bolts.

Rolling Process

- In this process, metals and alloys are plastically deformed into semifinished or finished products by being pressed between two rolls which are rotating. The metal is initially pushed into the space between two rolls, thereafter once the roll takes a “bite’’ into the edge of the material, the material gets pulled in by the friction between the surfaces of the rolls and the material. The material is subjected to high compressive force as it is squeezed (and pulled along) by the rolls. This is a process to deal with material in bulk in which the cross-section of material is reduced and its length increased. The final cross-section is determined by the impression cut in the roll surface through which the material passes and into which it is compressed. The essentials of the rolling process can be understood from the Fig. 3.1

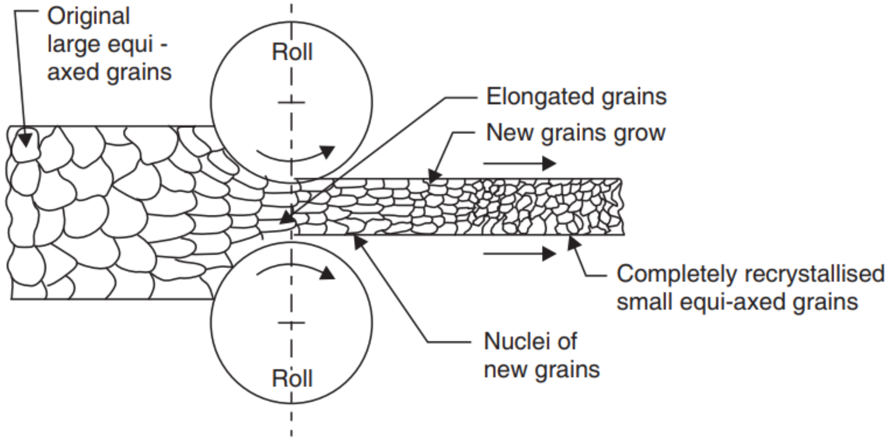


Fig. 3.1 Rolling Process

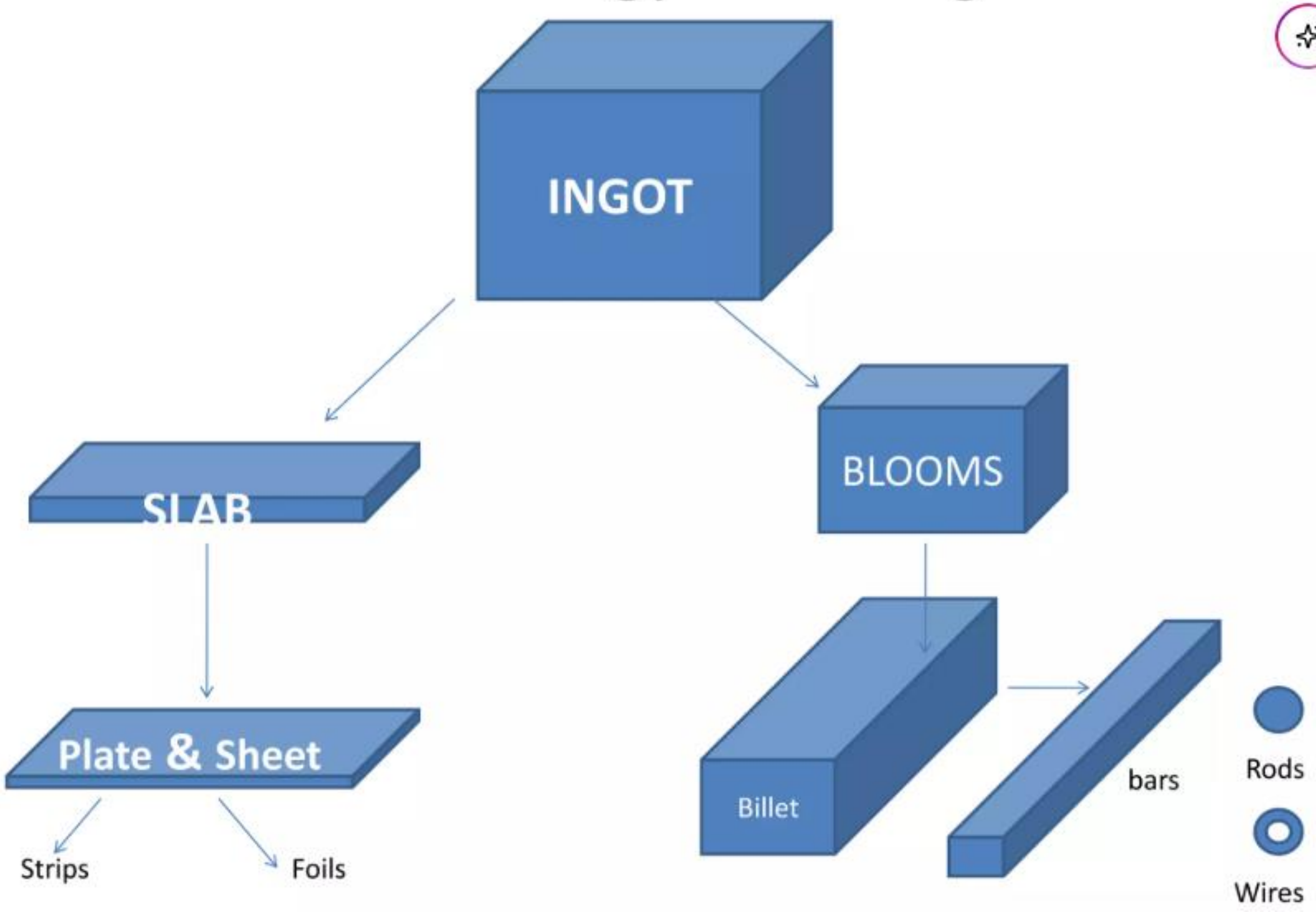
Hot Rolling

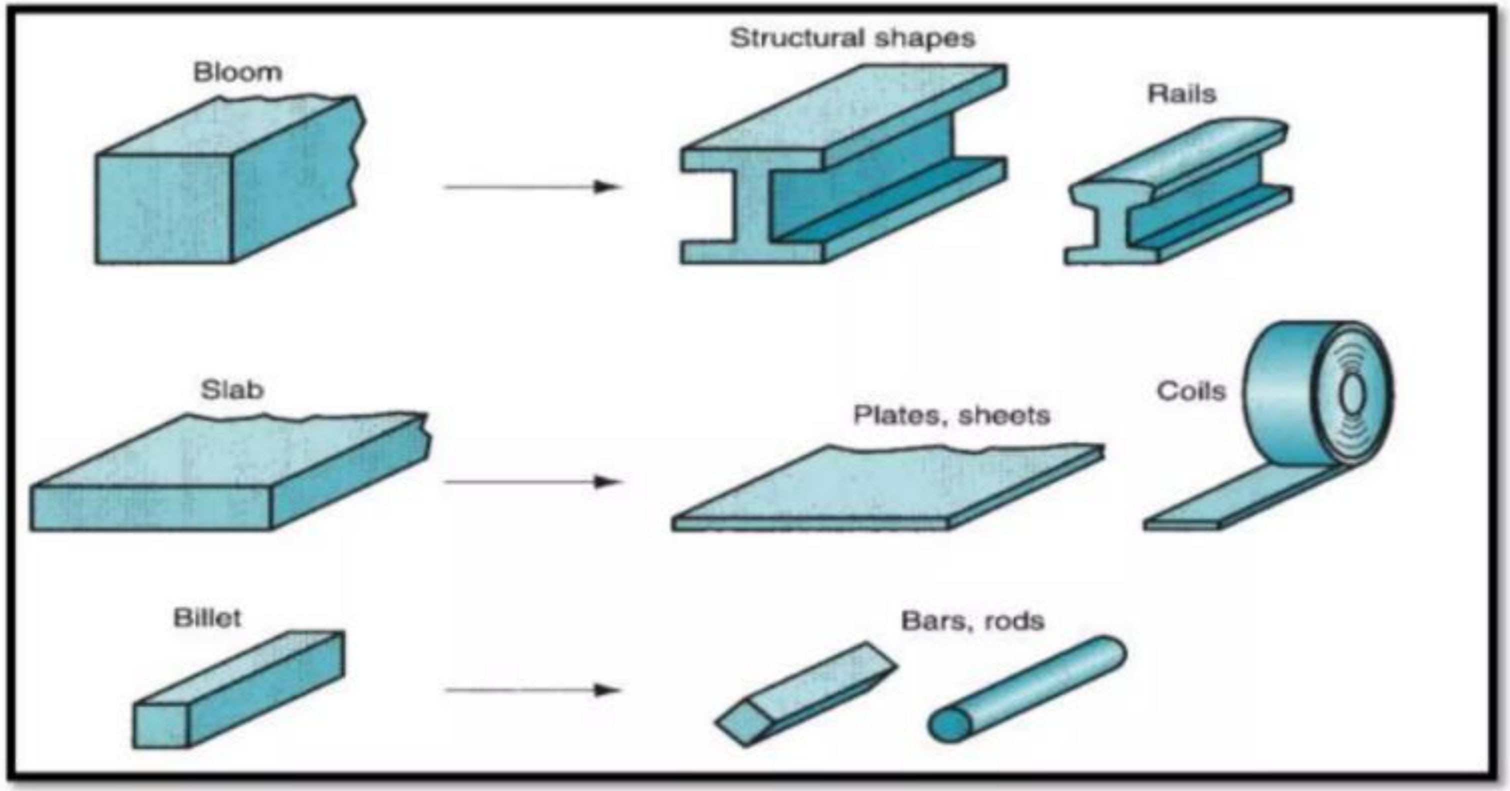
- Hot rolling is carried out above the metal’s recrystallization temperature.
- At this temperature, the material is soft and ductile, so deformation requires lower forces and large reductions are possible in a single pass.
- Grains are usually coarse, dimensional accuracy is moderate, and there are almost no residual stresses in the product.

Cold Rolling

- Cold rolling is done below the recrystallization temperature, often at room temperature.
- Higher rolling loads are needed, but the process gives better dimensional accuracy and surface finish.
- The material work-hardens, so strength and hardness increase, but residual stresses are introduced and ductility decreases.

Terminology of Rolling



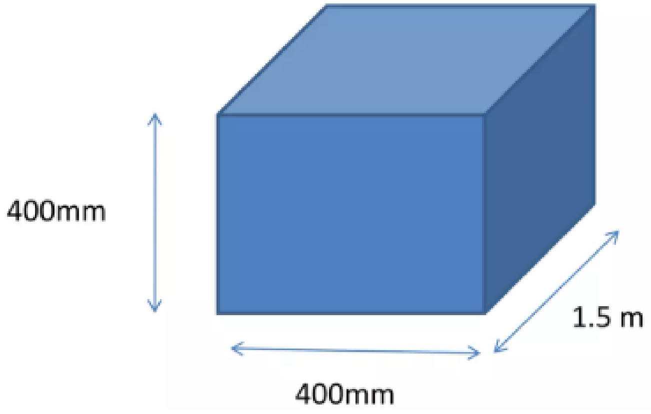

Bloom
Structural shapes
Rails
Slab
Plates, sheets
Coils
Billet
Bars, rods

Basic Definitions

- **<u>Ingot</u>** : The metal in a square shape obtained from casting process is known as ingot.

  Area range : 300 to 500 mm^2

  Length is between 1.5 to 2m



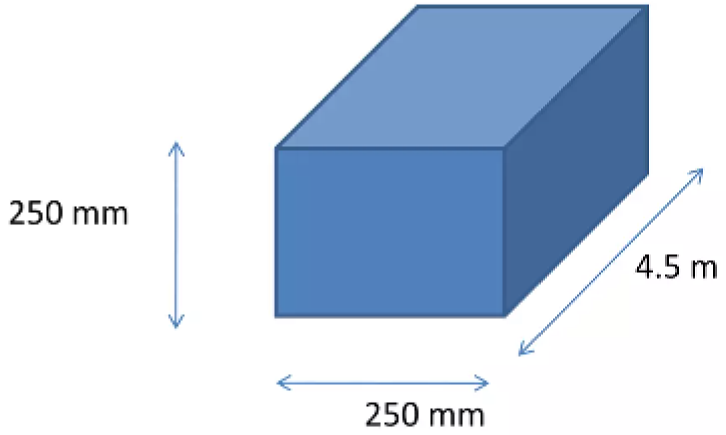
Basic Definitions

- **Bloom**: Metal piece smaller than ingot.

  Area range : 150X150 mm^2 (Square)

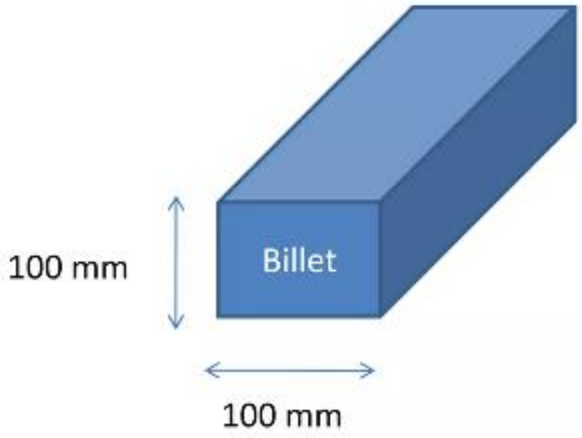
  200 to 300 mm^2 (Rectangle)

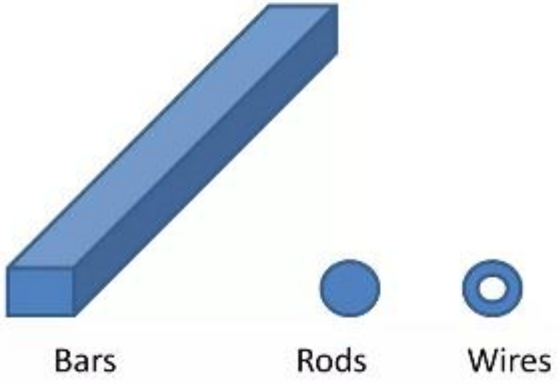
  Length is between 3.5 to 5.5 m



Basic Definitions

- **Billet :** Metal piece produced from bloom is known as Billet. Further billet is rolled into bars. (40X40 – 125X125 mm^2)
- **Bar/Rod:** Long, straight and symmetrical piece of round or square cross sections. (>10 mm^2)

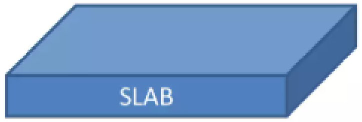




- **Slab**: The rectangular cross section type metal obtained from rolling of bloom or billet is known as slab.

  Thickness: 50 to 150 mm

  Width : 0.5 to 1.5 m

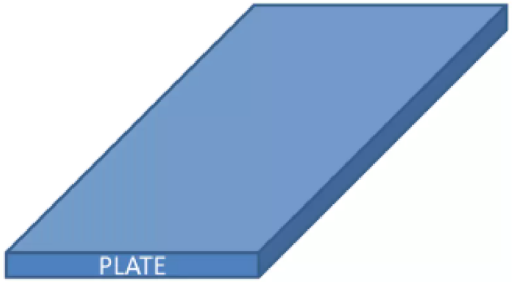


- **Plate** : Further rolling slabs, we get plates.

  Width : 750 to 1200 mm

  Thickness: 2.7 to 7mm

  Length: 1.5m to 3m



- **Sheet** : Rolling of Slab will result into sheets.

  Thickness: 0.21 to 2.64mm

  Width and length same as plate.

Classification of Rolling

1 By temperature of rolling:

- Hot rolling: Rolling above recrystallization temperature.
- Cold rolling: Rolling below recrystallization temperature.
- (Sometimes warm rolling is also listed between hot and cold.)

2 By product geometry:

- Flat rolling: Produces plates, sheets, strips, and foils.
- Shape (section) rolling: Produces I-beams, channels, rails, bars, rings, etc.

3 By type of product or stage:

- Semi-finished rolling: Produces blooms, billets, and slabs.
- Finishing rolling: Produces saleable products like plates, sheets, strips, bars, wire, and structural sections.

4 By mill arrangement / operation:

- Two-high, three-high, four-high, cluster (Sendzimir) mills.
- Reversing mills, continuous/tandem mills

Different types of rolling processes

There are different types of rolling processes as listed below;

- *Continuous rolling*
- *Transverse rolling*
- *Shaped rolling or section rolling*
- *Ring rolling*
- *Powder rolling*
- *Continuous casting and hot rolling*
- *Thread rolling*
- *Tube rolling*

Types of Rolling

- Continuous rolling is a metalworking process that involves passing a workpiece through a series of rollers to continuously reduce its thickness, and it can be used in both hot and cold rolling operations.

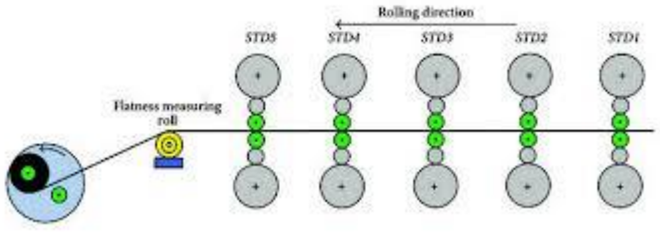
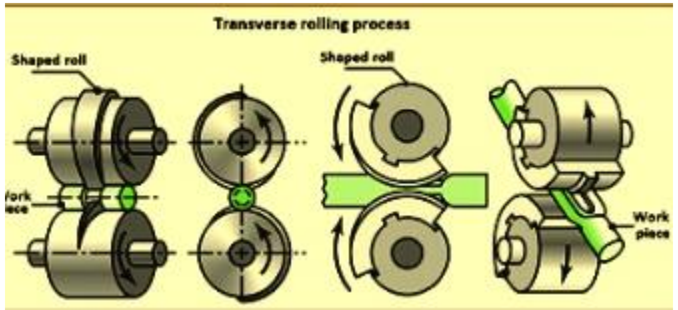


Fig Continuous Rolling

Transverse rolling

A short, thick workpiece is rotated between rolls whose axes are parallel to each other, so deformation spreads mainly sideways rather than along the length. It is commonly used for forming stepped shafts, wheels, or discs.



Transverse Rolling

Types of Rolling

Shaped or section rolling

- Grooved rolls with specific contours are used so the metal emerges as an I-beam, channel, angle, rail, or other structural section. The bar is passed through multiple roll passes, each gradually bringing it closer to the final profile.

Ring rolling

- A thick ring is placed between a driven roll and an decreases, diameter increases. This produces se flanges, and gears with good strength.

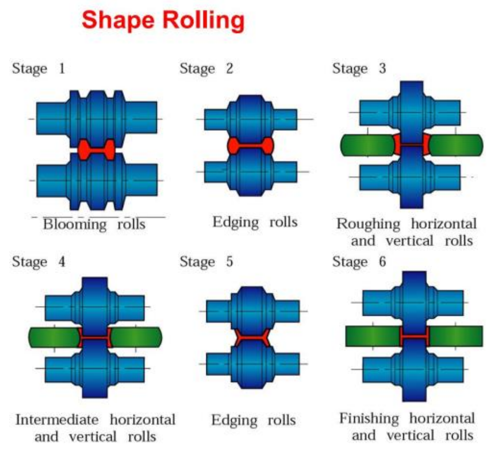


Fig Shaped Rolling

Powder Rolling

- Powder rolling is a metal forming process in which loose metal powder (instead of a solid slab) is fed between rotating rolls, compacted into a thin “green” strip, and then sintered to become a solid sheet or strip.
- In the roll gap, the powder particles are mechanically pressed together under high pressure so they stick and form a continuous porous strip.
- After rolling, this green strip is passed through a furnace for sintering, which bonds the particles metallurgically, increases density and strength, and can be followed by additional rolling to reach the final thickness and properties.
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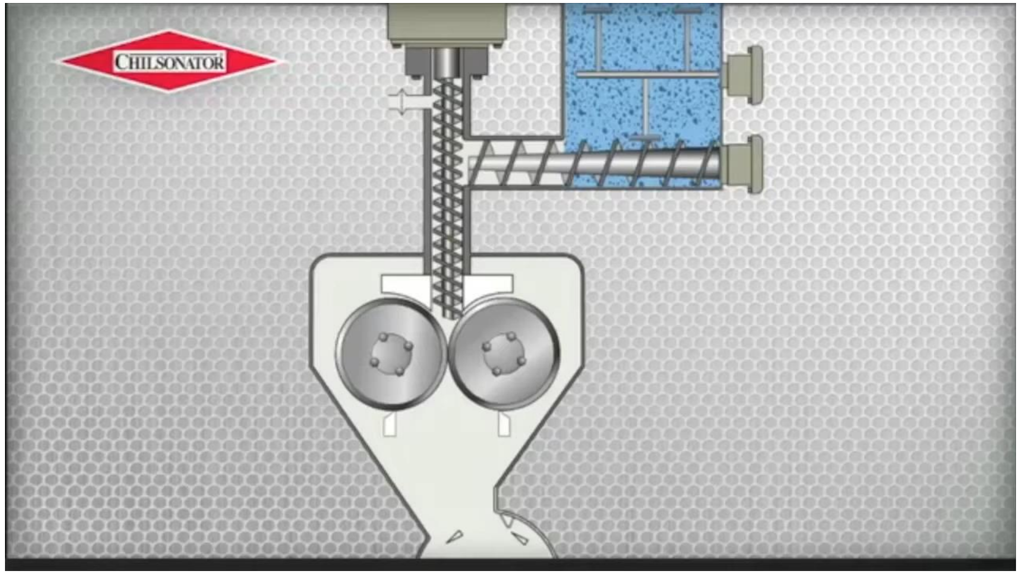


https://www.youtube.com/watch?v=C1Z-Vp4rUl4

continuous casting and hot rolling

- Continuous casting and hot rolling is an integrated steelmaking route in which molten steel is solidified into semifinished shapes and then immediately rolled while still hot.

Continuous casting

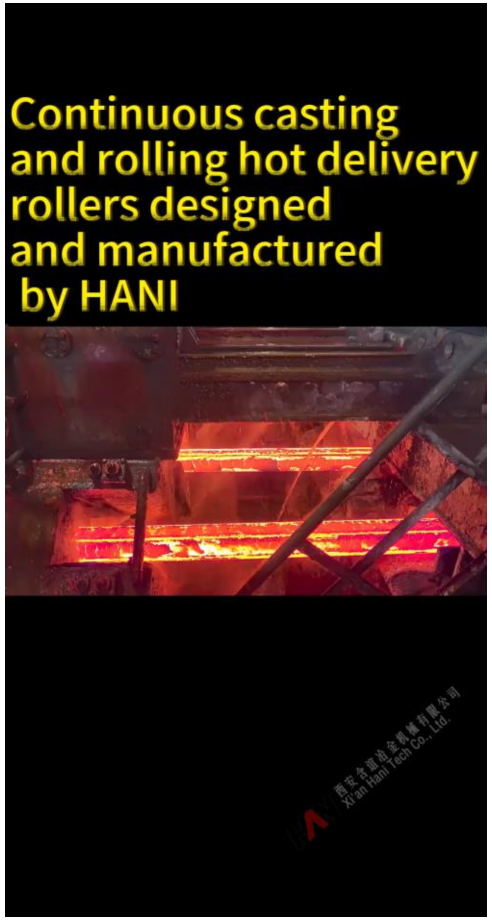
- Molten steel from the ladle flows through a tundish into a water-cooled copper mould, where it solidifies at the surface and forms a continuous strand (slab, bloom, or billet).

- This red-hot strand is continuously withdrawn by rollers, fully solidified by secondary water spray cooling, straightened, and cut to length; these products are the feedstock for rolling mills.

- Hot rolling after casting
- Instead of cooling and reheating, the still-hot slabs/billets from the caster are sent directly (or via a short reheating step) to a hot-rolling mill.

- In the hot mill they pass through a series of stands to reduce thickness and shape the steel into plate, strip, bar, or other sections, saving energy and improving productivity and surface quality.

Video on continuous casting and hot Rolling



Types of ROLLING

- Thread rolling: Rod rolled between threaded dies to form external threads without cutting.
- Tube rolling: Rolls and mandrel used to form or size hollow tubes with controlled wall thickness

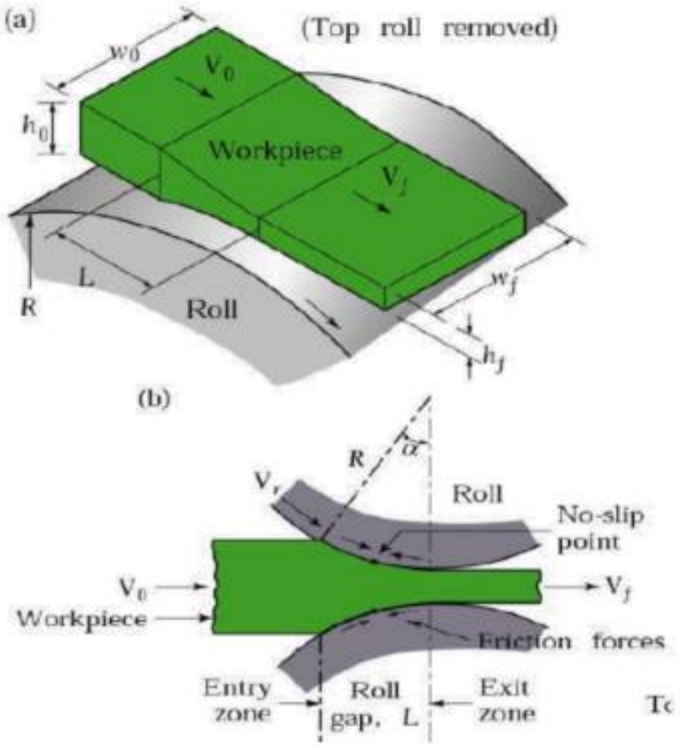
.Flat Rolling Analysis:

Flat rolling is the rolling process where a thick, flat slab or plate is passed between rotating rolls to reduce its thickness and increase its length and width, producing plate, sheet, or strip. The contact area between rolls and workpiece is approximately rectangular, and the final product has a uniform, flat cross-section

the volume of metal exiting the rolls equals the volume entering.

$$h_{\circ} w_{\circ} L_{\circ} = h_f w_f L_f$$

w_o and w_f are the *width* before and after work, mm



To keep constant the volume rate of the material, the velocity of the strip must increase as it moves through the roll gap

$$V_f = V_0\left(\frac{h_0}{h_f}\right)$$

NEUTRAL POINT: point in the arc of contact where the roll velocity and the strip velocity are the same

$$\text{Forward slip} = \frac{V_f - V_r}{V_r}$$

Draft thickness (d)

$d = h_\circ - h_f = 2R\,(1\text{-}\cos\alpha)$

h_o= starting thickness, mm (in); and

h_f= final thickness, mm (in).

R = roll radius in mm

(α) = bite angle in degree.

The maximum draft (dmax)

$d_{max} = \mu^2 R$

coefficient of friction, μ

The power

$$\text{Power (in Kw)} = \frac{2\pi FLN}{60000}$$

F is in newtons,

L is in meters, and

N is the revolutions per minute (rpm)

Reduction (r)

$$r = \frac{d}{h_\circ}$$

Contact length (L)

$$L = \sqrt[2]{R(h_\circ - h_f)}$$

True strain (ε)

$$\varepsilon = \ln\frac{h_\circ}{h_f}$$

Average flow stress (Yf)

$$\bar{Y}_f = \frac{K\varepsilon^n}{1+n}$$

K and n: (strength and strain hardening)

Roll force in flat rolling:

$$F = \bar{Y}_f \; w \; L$$

The torque in rolling

$$T = 0.5FL$$

Example

Ex: A 300-mm-wide strip 25-mm thick is fed through a rolling mill with two powered rolls each of radius = 250 mm. The work thickness is to be reduced to 22 mm in one pass at a roll speed of 50 rev/min. The work material has a flow curve defined by K = 275 MPa and n = 0.15, and the coefficient of friction between the rolls and the work is assumed to be 0.12. Determine if the friction is sufficient to permit the rolling operation to be accomplished. If so, calculate the roll force, torque, and power.

Solution:

The draft attempted in this rolling operation is

$$d = h_\circ - h_f$$

d = 25 - 22 = 3mm

Maximum draft

$$d_{max} = \mu^2 R$$

d_{max} = $(0.12)^2(250)$ = 3.6mm

The contact length

L= $\sqrt[2]{R(h_\circ - h_f)}$ L= $\sqrt[2]{250(25-22)}$ =27.4 mm

$$\varepsilon = \ln\frac{h_\circ}{h_f}$$

$$\varepsilon = \ln\frac{25}{22} = 0.128$$

$$\bar{Y_f} = \frac{275X0.128^{0.15}}{1+0.15} = 175.7 \text{ MPa}$$

Rolling force is determined

$F = \bar{Y_f}\ w\ L$ F =175.7(300) (27.4) =1,444,254 N

Torque required to drive each roll

T=0.5FL T = 0.5(1,444,254) (27.4) (10^{-3}) = 19.786 N-m

Power:

$$\text{Power (in Kw)} = \frac{\mathbf{2\pi FLN}}{\mathbf{60000}}$$

$$\text{Power (in Kw)} = \frac{2\pi X1.444.786X0.274X50}{60000} = 207.284 \text{ Kw}$$

Conventional Machining:

- Conventional 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 conventional machining involves shear deformation of w.p. to form chip; as chip is removed a new surface is produced as shown in figure (4-22).

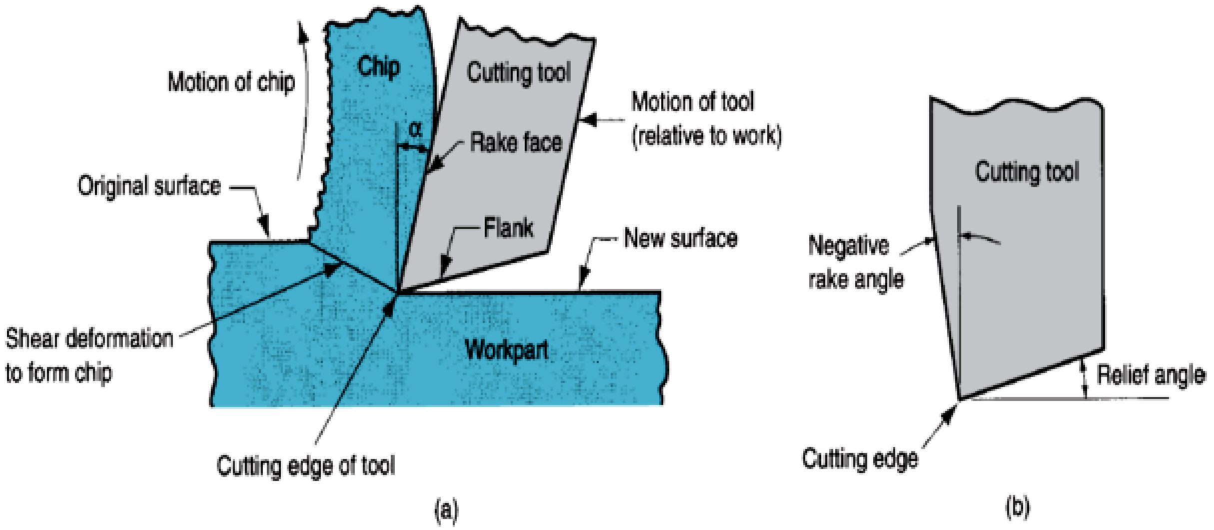


Figure (4-22) (a) a cross-sectional view of the machining process (b) tool with negative rake angle compare with positive rake angle in (a).

- Conventional machining is generally performed after other manufacturing processes such as casting or bulk deformation (e.g., forging, bar drawing).
- The other processes create the general shape of the starting w.p. and conventional machining provides the final geometry, dimensions and finish.

Advantages of Conventional Machining:

- Variety of work materials can be machined like all solid metals, plastics, plastic composites. Ceramics can be machined by abrasive machining.
- Variety of part shapes and geometric features can be produced by conventional machining. Regular geometries (flat planes, round holes, cylinders) and irregular geometries (screw threads, T-slots) can be manufactured by CM.
- Dimensional accuracy to very close tolerances. Some of machining operations can achieve tolerances of ±0.025mm.
- Good surface finish. Roughness values less than 0.4 microns can be achieved by CM processes.

Disadvantages of Conventional Machining:

- Wasteful of material. Although the generated chip can usually be recycled but still CM considered a wasteful processes.
- Time consuming. CM takes more time to shape part than alternative shaping processes such as casting or forging.

Overview of Conventional Machining Technology:

- To carry out CM and form the chip, a relative motion is required between cutting tool and w.p.
- This relative motion is achieved by means of a primary motion (cutting speed) and a secondary motion (feed).
- The shape of cutting tool and its penetration into w.p., combined with these motions, produces the desired geometry of w.p.

Convensional Machining Operation

- **Turning:** in which a cutting tool with a single cutting edge is used to remove material from a rotating w.p. to generate a cylindrical shape.
- The primary motion is provided by rotating w.p. and the feed motion is achieved by the cutting tool moving slowly in a direction parallel to axis of rotation of w.p.

- **Drilling:** is used to create a round hole. It is accomplished by a rotating cutting tool that typically has two cutting edges.
- The cutting tool is fed in a direction parallel to its axis of rotation into the w.p.

- **Milling:** in which a rotating cutting tool with multiple cutting edges is fed slowly across the w.p. to generate a plane or straight surface.
- The direction of feed motion (by w.p.) is perpendicular to the cutting tool's axis of rotation.

The Cutting Tool:

- A cutting tool has one or more sharp cutting edges and is made of a material that is harder than w.p.
- The cutting edge serves to separate a chip from the parent w.p. as shown in figure (4-22).
- Connected to the cutting edge are two surfaces of the tool: the rake face and flank.
- **The rake face:** it directs the flow of generated chip and is oriented at angle called "the rake angle".
- **The flank:** provides a clearance between the cutting tool and the new generated surface, thus protecting the surface from abrasion, which would degrade the finish. The flank is defined by angle called "the relief angle".
- There are two basic types of cutting tools: **(a) single-point tool (b) multiple-cutting-edge-tool**
- Figure (4-23) shows the cutting tool.

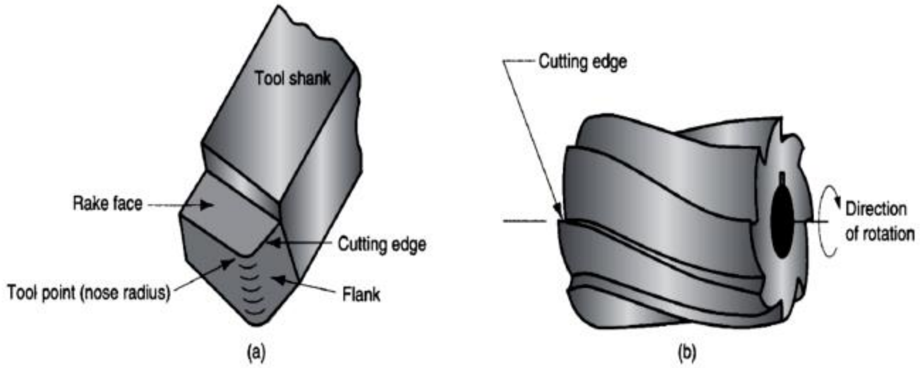


Figure (4-23) (a) a single-point tool, (b) a helical milling cutter (multiple cutting edge tool)

(a) Single-Point Tool

- It has one cutting edge and is used for operations such as turning.
- Also, there is one tool point, during machining, penetrates below the original w.p. surface.
- This point is usually rounded to a certain radius called "nose radius".

(b) Multiple-Cutting-Edge Tool

- It has more than one cutting edge and usually achieve its motion relative to w.p. by rotating.
- Drilling and milling use this type of tool.

Cutting Conditions:

- Cutting speed (*v*): primary relative motion between cutting tool and w.p. (mm/s, in/min, ft/min).
- Feed (*f*): secondary motion of the cutting tool laterally across the w.p. This is much slower motion. (mm, in, ft).
- Depth of cut (*d*): it is penetration of cutting tool below the original w.p. surface. (mm, in, ft).
- The above three terms are called the cutting conditions.
- They can be used to calculate the material removal rate (R_{MR}) for certain operations (e.g., most single-point tool operations).
- Figure (4-24) shows the cutting conditions for a turning operation.

- **Turning Operations:**

$$R_{MR} = vfd \quad \left(\frac{mm^3}{s}, \frac{in^3}{min}, \frac{ft^3}{min}\right)$$

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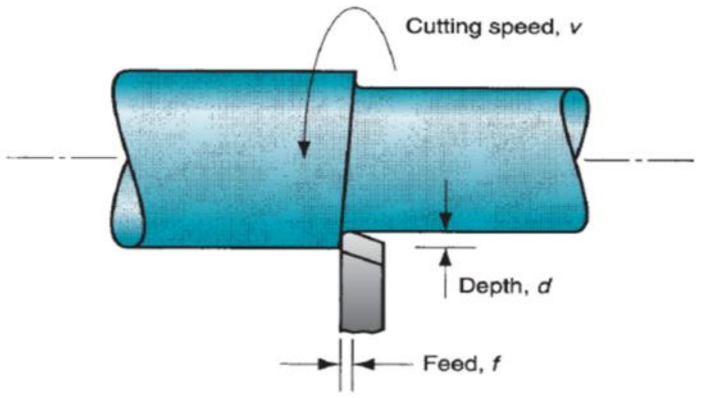


(a)

- Feed Rate: $f_r = Nf$

f_r: feed rate (mm/min), N: rotational speed (rpm), f: feed (mm/rev)

- Machining Time: $T_m = \frac{L}{f_r} = \frac{\pi D_o L}{f v}$, $N = \frac{v}{\pi D_o}$

T_m: machining time (min), L: w.p. length (mm), D_o: w.p. diameter (mm), v: cutting speed (m/min).

- **Drilling Operations:**

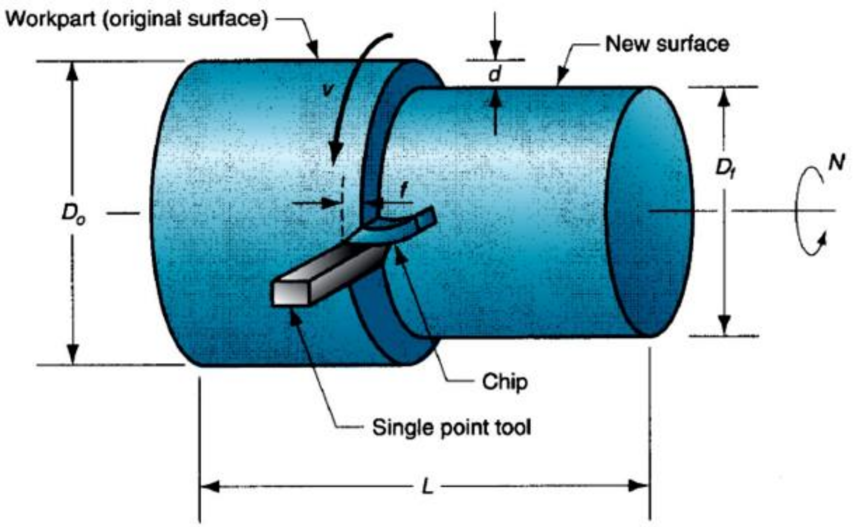
- **Material Removal Rate:** $R_{MR} = \frac{\pi D^2 f_r}{4}$ (mm^3/min)

D: drill diameter (mm), f_r: feed rate (mm/min)

- **Feed Rate:** $f_r = Nf$, $N = \frac{v}{\pi D}$

N: drill rotational speed (rpm), v: cutting speed (mm/min), f: feed (mm/rev)

Since there are (usually) two cutting edges at the drill point, the uncut chip thickness (chip load) taken by each cutting edge is half the feed.



(b)

Figure (4-24) cutting speed, feed and depth of cut for a turning operation; (a) two dimensions, (b) three dimensions

- **Machining Time:**

1. **Through Holes**: $T_m = \frac{t+A}{f_r}$, $A = 0.5D\tan\left(90 - \frac{\theta}{2}\right)$

t: w.p. thickness (mm), f_r: feed rate (mm/min), A: approach allowance (mm), θ: drill point angle

A: an approach allowance that accounts for the drill point angle, representing the distance the drill must feed into the work before reaching full diameter.

2. **Blind Holes**: $T_m = \frac{d+A}{f_r}$,

T_m: machining time (min), d: hole depth (mm),

Figure (4-25) shows cutting conditions of drilling operations.

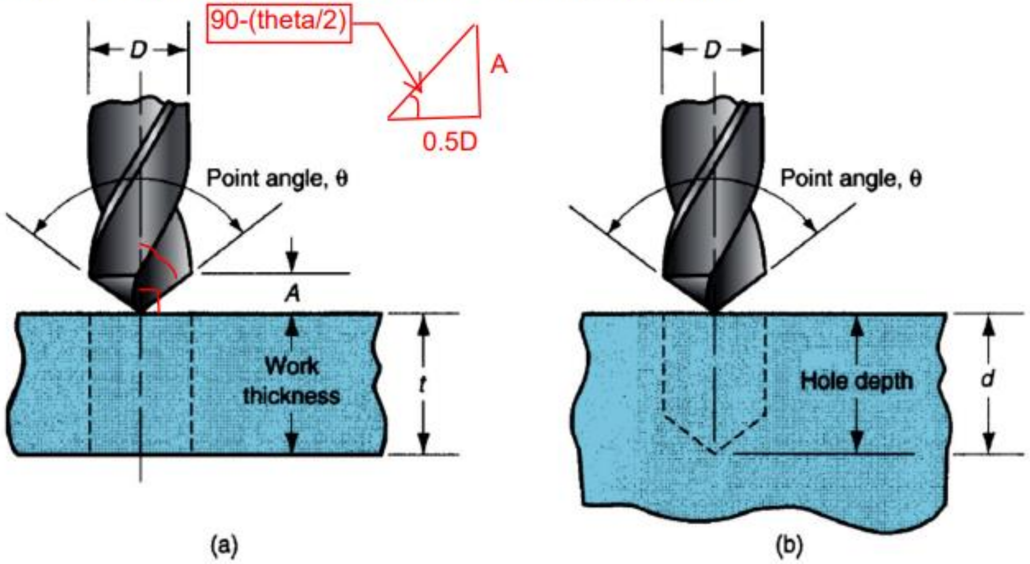


Figure (4-25) two hole types in drilling operation; (a) through hole, (b) blind hole

- **Milling Operations:**

- **Material Removal Rate:** $R_{MR} = wdf_r \quad (mm^3/min)$

w: w.p. width (mm), *d*: cut depth (mm), f_r: feed rate (mm/min)

MRR: it is determined using the product of the cross-sectional area of the cut and the feed rate.

- **Feed Rate:** $f_r = Nn_t f, \quad N = \frac{v}{\pi D}$

f_r: feed rate (mm/min), *N*: cutter rotational speed (rpm), n_t: number of teeth on the cutter, *f*: feed per cutter tooth (chip load) (mm/tooth), *v*: cutting speed (mm/min), *D*: cutter diameter (mm)

Chip Load: it represents the size of the chip formed by each cutting edge.

- **Machining Time:**

1. Slab Milling (Peripheral): $T_m = \frac{L+A}{f_r} \quad , \quad A = \sqrt{d(D-d)}$

T_m: machining time (min), *L*: w.p. length (mm), *d*: depth of cut (mm), *D*: cutter diameter (mm), *A*: approach distance

Approach Distance: the T_m required to mill a w.p. of length *L* must account for the approach distance (*A*) required to fully engage the cutter (to reach full cutter depth) as in Figure (4-26).

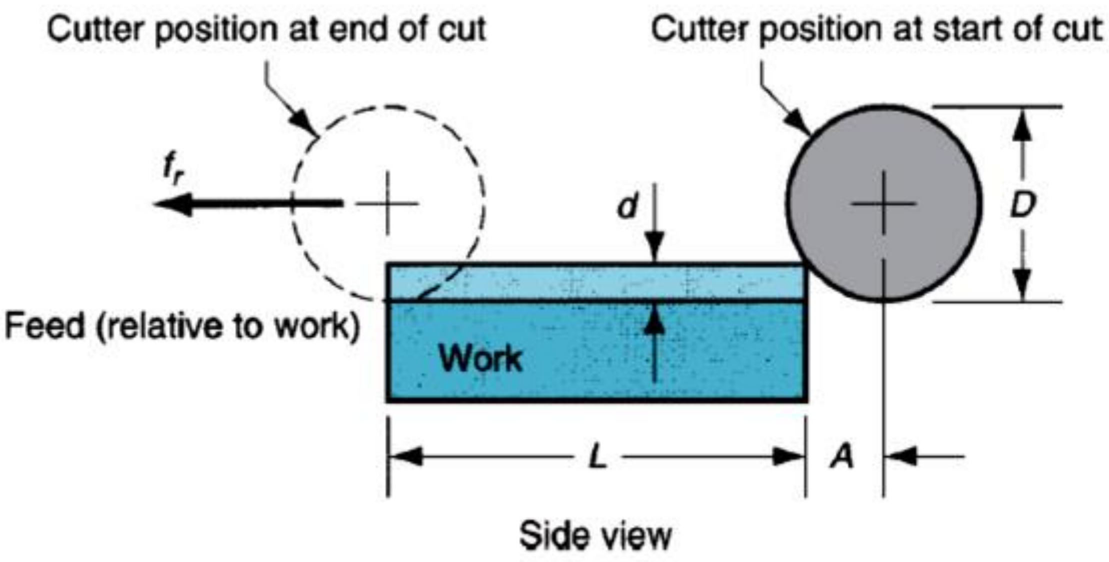


Figure (4-26) slab (peripheral) milling showing entry of cutter into w.p.

2. Face Milling: there are two cases as shown in figure (4-27).

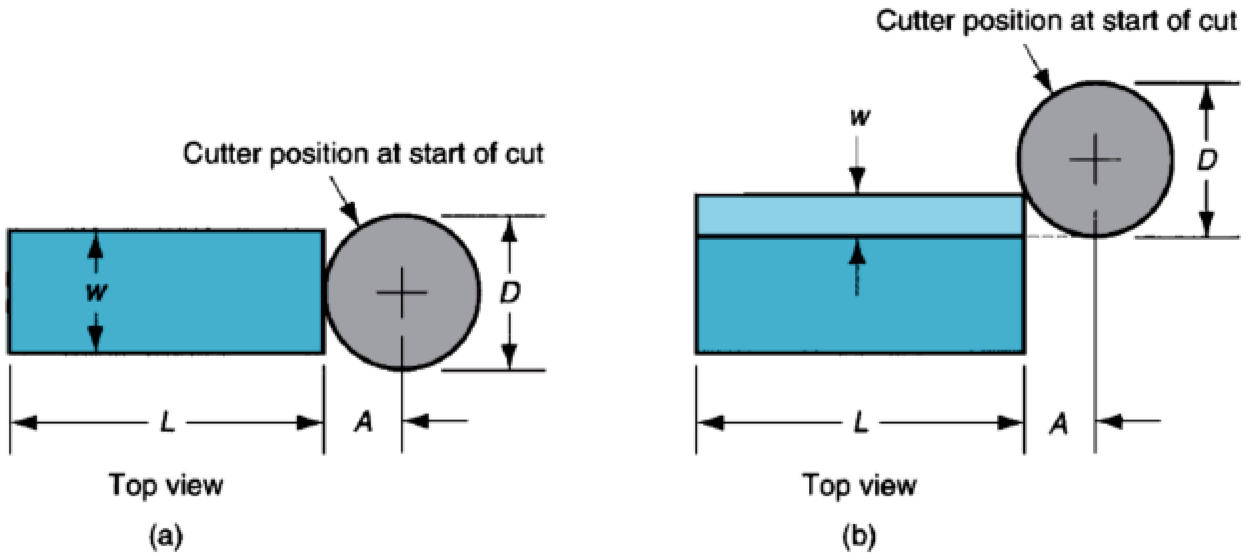


Figure (4-27) Face milling showing approach and overtravel distances for two cases.

(a) When cutter is centered over the w.p. The cutter feeds from right to left. In order for the cutter to reach the full width of w.p., it must travel an approach distance (A) which given by:

$$A = 0.5\left(D - \sqrt{D^2 - w^2}\right)$$

D: cutter diameter (mm), w: w.p. width (mm)

(b) When the cutter is offset to one side over the w.p. The approach distance is:

$$A = \sqrt{w(D - w)}$$

w: width of the cut (mm).

In both cases, the machining time is: $T_m = \frac{L+A}{f_r}$

Example (1):

A cylindrical w.p. 200 mm in diameter and 700 mm long is to be turned in an engine lathe. Cutting speed = 2.3 m/s, feed = 0.32 mm/rev, and depth of cut = 1.8 mm. Determine (a) feed rate, (b) cutting time (machining time), and (c) metal removal rate.

Solution:

(a) $f_r = Nf = \frac{v}{\pi D_o} f = \frac{2.3\,(10^3)}{\pi(200)}(0.32) = 1.17\,\frac{mm}{s} = 70.2\,\frac{mm}{min}$ Answer

(b) $T_m = \frac{L}{f_r} = \frac{700}{70.2} = 9.97\ min$ Answer

(c) $R_{MR} = vfd = 2.3(10^3)(60)(0.32)(1.8) = 79488\ mm^3/min$ Answer

Example (2):

A drilling operation is to be performed with a 12.7-mm diameter twist drill in a steel w.p. The hole is a blind hole at a depth of 60 mm and the point angle is 118º. The cutting speed is 25 m/min and the feed is 0.3 mm/rev. Determine (a) feed rate, (b) the cutting time to complete the drilling operation, and (c) metal removal rate during the operation, after the drill bit reaches full diameter.

Solution:

(a) $f_r = Nf = \frac{v}{\pi D} f = \frac{25\,(10^3)}{\pi(12.7)}(0.3) = 187.9\ \frac{mm}{min}$ Answer

(b) $T_m = \frac{d+A}{f_r}$

$$A = 0.5D \tan\left(90 - \frac{\theta}{2}\right) = 0.5(12.7) \tan\left(90 - \frac{118}{2}\right) = 3.815mm$$

$\therefore T_m = \frac{d+A}{f_r} = \frac{60+3.815}{187.9} = 0.339\ min = 20.34\ s$ Answer

(c) $R_{MR} = \frac{\pi D^2 f_r}{4} = \frac{\pi 12.7^2(187.9)}{4} = 23803\frac{mm^3}{min}$ Answer

Example (3):

A peripheral milling operation is performed on the top surface of a rectangular w.p. which is 400 mm long x 60 mm wide. The milling cutter, which is 80 mm in diameter and has five teeth, overhangs the width of the part on both sides.

Cutting speed = 70 m/min, chip load = 0.25 mm/tooth, and depth of cut = 5 mm. Determine (a) feed rate, (b) the actual machining time to make one pass across the surface and (c) the maximum material removal rate during the cut.

Solution:

Chip load = feed = 0.25 mm/tooth

(a) $f_r = Nn_t f = \frac{v}{\pi D} n_t f = \frac{70(10^3)}{\pi(80)}(5)(0.25) = 348.15 \frac{mm}{min}$ Answer

(b) $T_m = \frac{L+A}{f_r}$, $A = \sqrt{d(D-d)} = \sqrt{5(80-5) = 19.4\, mm}$

$\therefore T_m = \frac{L+A}{f_r} = \frac{400+19.4}{348.15} = 1.2\, min$ Answer

(c) $R_{MR} = wdf_r = 60(5)(348.15) = 104445\, mm^3/min$ Answer

Example (4):

A face milling operation is used to machine 6 mm from the top surface of a rectangular piece of aluminum 300 mm long by 125 mm wide in a single pass. The cutter follows a path that is centered over the w.p. It has four teeth and is 150 mm in diameter. Cutting speed = 2.8 m/s, and chip load = 0.27 mm/tooth. Determine (a) feed rate, (b) the actual machining time to make the pass across the surface and (c) the maximum metal removal rate during cutting.

Solution:

Chip load = feed = 0.27 mm/tooth

(a) $f_r = Nn_tf = \frac{v}{\pi D}n_tf = \frac{2.8(10^3)(60)}{\pi(150)}(4)(0.27) = 385\frac{mm}{min}$ Answer

(b) $T_m = \frac{L+A}{f_r}$,

$A = 0.5\left(D - \sqrt{D^2 - w^2}\right) = 0.5\left(150 - \sqrt{150^2 - 125^2}\right) = 33.5\ mm$

$\therefore T_m = \frac{L+A}{f_r} = \frac{300+33.5}{385} = 0.866\ min = 52\ s$ Answer

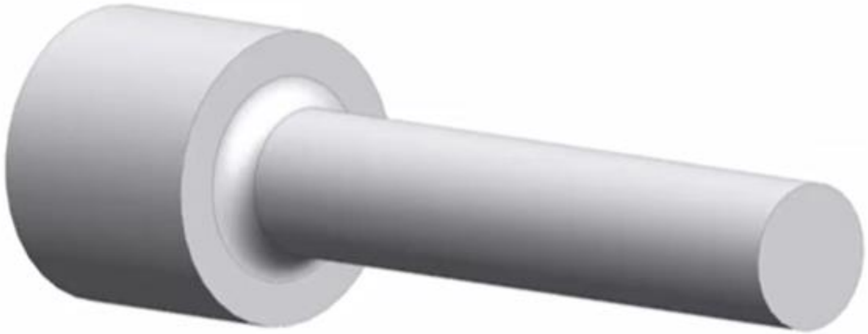
(c) $R_{MR} = wdf_r = 125(6)(385) = 288750\ mm^3/min$ Answer

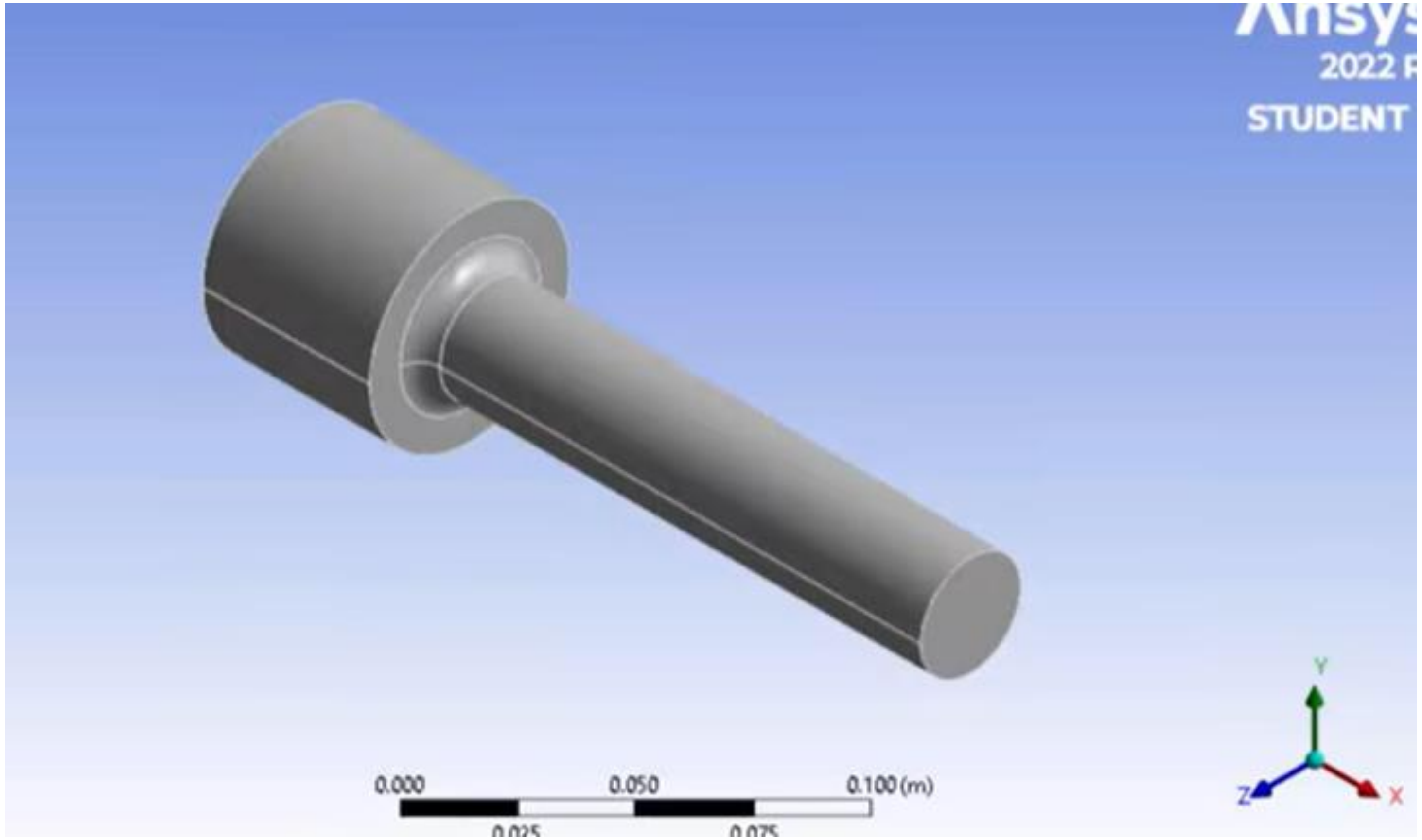
Ansys

Fatigue stress analysis on Stepped bar

Conduct fatigue stress analysis on the given stepped bar and plot the equivalent alternative stress and safety factor.

The bar is fixed at the left side and subjected to a transverse fully reversed load of 1000N at the right side.





2022 R
STUDENT
0.000
0.050
0.100 (m)
0.025
0.075
Y
Z
X


Model (A4)
Geometry Imports
Geometry
Materials
Coordinate Systems
Mesh
Static Structural (A5)
Analysis Settings
Fixed Support
Force
Solution (A6)
Solution Information
Fatigue Tool
Equivalent Alternating Stress
Life
Safety Factor