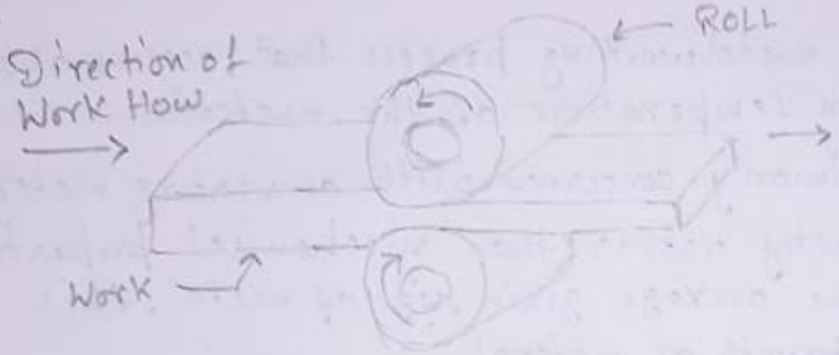
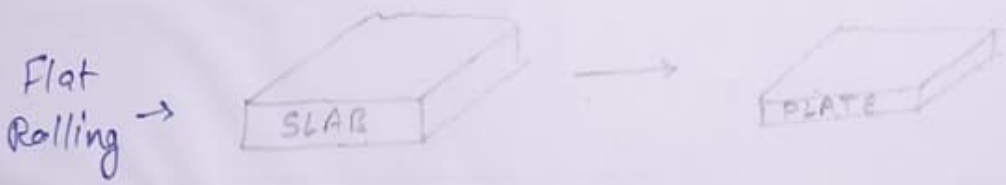
ROLLING

- The process of plastically deforming metal by passing it between rolls.
- Rolling is a bulk deformation process.
- The metal is subjected to high compressive stresses as a result of the friction between the rolls and the metal surface
- It is used to reduce the thickness or changing the cross-section of a work-piece by compressive forces exerted by a pair of rotating rolls.



The rolls rotate to pull and simultaneously squeeze the work between them, called Flat rolling.

A process in which a square cross section is formed into a shape [such as an I-beam shape] called ~~Rod~~ Shape Rolling



Based on workpiece geometry

(a) Flat rolling (b) Shape Rolling.

Types of Rolling

(1) Based on Work-piece geometry :

(a) Flat Rolling : Used to reduce thickness of a rectangular cross-section.

(b) Shape Rolling : Square cross-section is formed into a shape [I-beam etc.]

(2) Based on Work temperature :

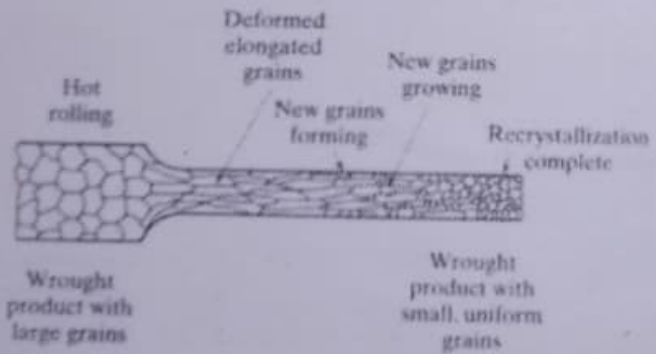
(a) Hot Rolling.

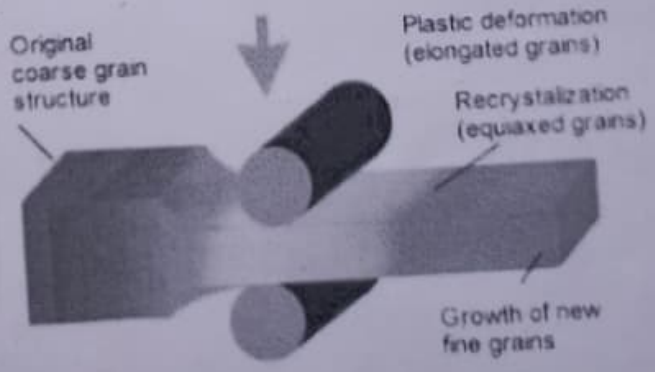
(b) Cold Rolling.

> for hot working 'hot' may not be written but for cold working "cold" is written

HOT ROLLING :

- Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material.
- Hot rolling is primarily concerned with converting material shape and geometry rather than mechanical properties.
- It will reduce the average grain size of metal, this improves the strength of material.
- It is used mainly to produce sheet metal or simple cross-sections such as rail tracks.





COLD ROLLING:

Cold rolling occurs with the metal below its recrystallization temperature (usually at room temperature).

- It also improve the surface finish and attain good tolerances.
- Due to smaller size of the workpieces and their greater strength than hot rolled ingot/stock, four-high or cluster mills are used.
- Commonly cold rolled products include sheets, strips and rods.

* Hot rolling produces thinner cross sections than cold rolling processes with the same number of stages. Hot rolling due to recrystallization, will reduce the average grain size of a metal while maintaing a certain soft microstructure, where as cold rolling will produced a hardened microstructure.

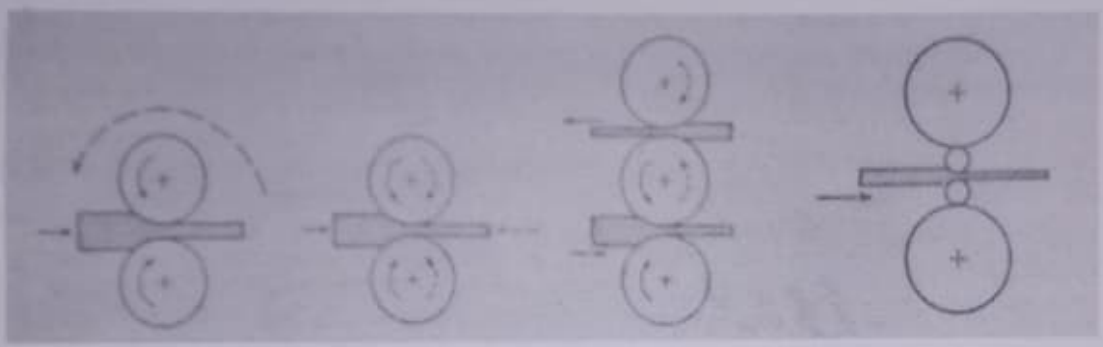
ROLLING MILLS

(classified as number of arrangements of mills)

1. Two high mill
2. Two high reversing mill.
3. Three high mill
4. Four high mill
5. ~~Cluster mill~~.

A large decrease in the power required for rolling can be achieved by the use of small-diameter rolls.

5. Cluster mill
6. Planetary mill
7. Continuous mill.



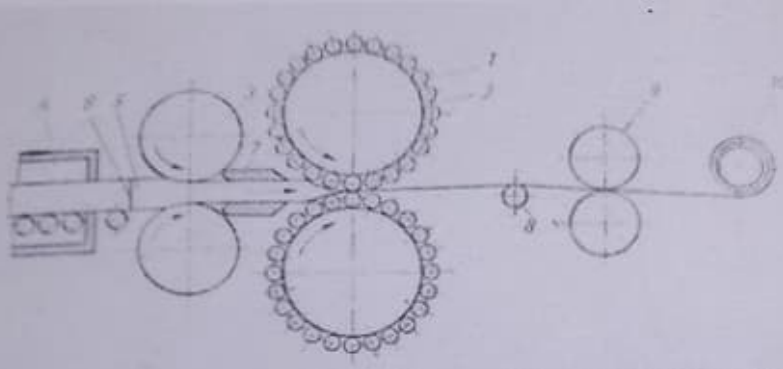
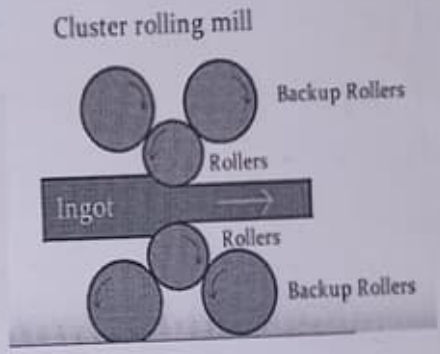
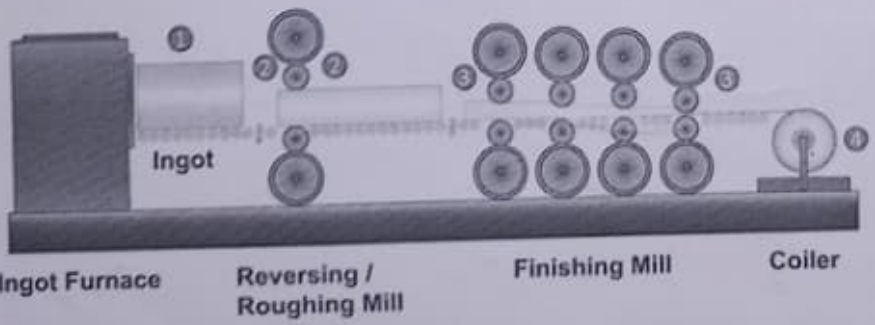


FIG. 2 —Planetary rolling mill. *1* working rolls, *2* supporting rolls, *3* driving rolls, *4* furnace, *5* slab, *6* contact area of slabs, *7* guides, *8* tension roller (looper), *9* planishing rolls, *10* coiler





TYPES OF ROLLING PROCESSES

(1.) CONTINUOUS ROLLING:

The objective is to decrease the thickness of the metal with an increase in length and with little increase in width. It will used for making sheets.

(2.) RING ROLLING:

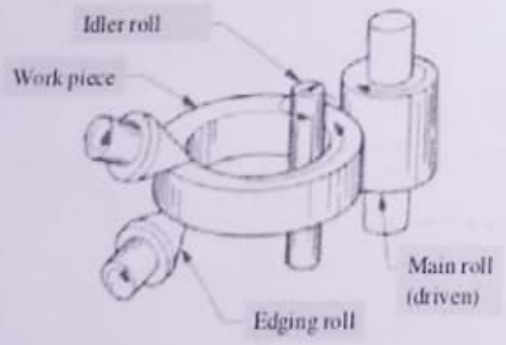
- It is used for increase the diameter of a ring and tube.
- Most of the mass is present at the periphery.
- Increase in diameter will decrease in thickness.
- Ring rolls are made up spherodized graphite bananate or pearlitic matrix or alloy cast steel base.

(3.) ROLL BENDING:

- Three rollers are used in this process. upper roller is used to control the degree of curvature.
- Lower rollers are fixed at a point but moving.

(4.) SHAPE ROLLING:

- Flat slab is progressively bent into complex shapes.
- Suitable for producing moulded section such as irregular shaped channels & trim.



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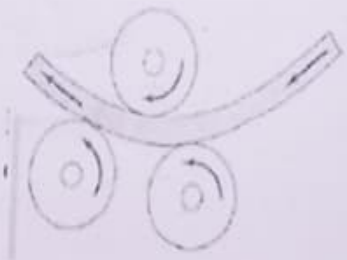

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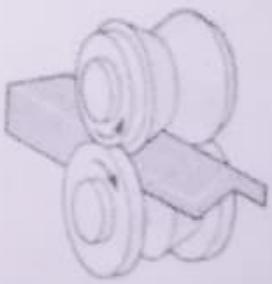


(4)

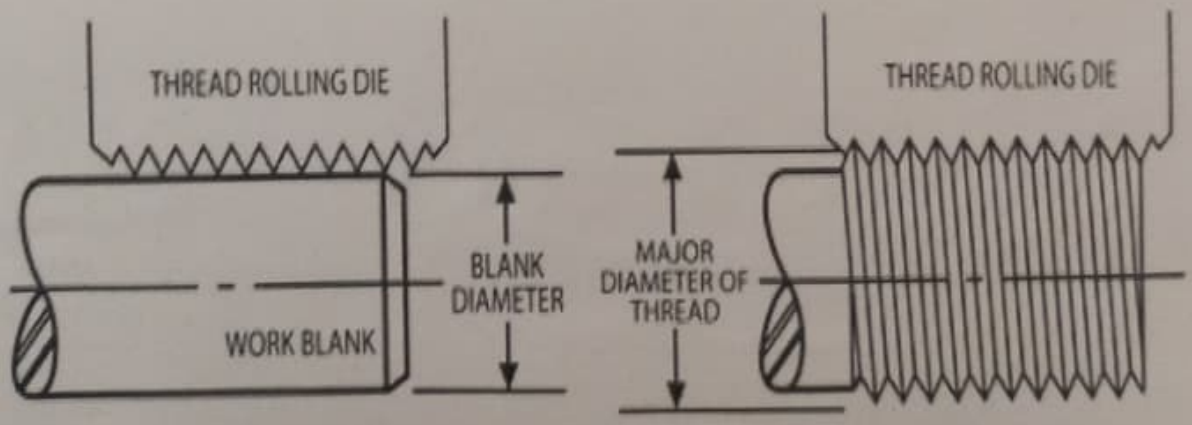
PACK ROLLING:

- It involves hot rolling ~~process~~ multiple sheets of the material are rolled at ones.
- Improved productivity gets by this process.
- Used in packing industry.
  e.g-> Aluminium foil (Aluminium sheets)
  (a) Matte, Satin side : foil to foil contact.
  (b) Shiny bright side: foil to roll contact due to high contact stresses with polished rolls.

* A thin surface oxide film is provided between the layers to prevents their welding.

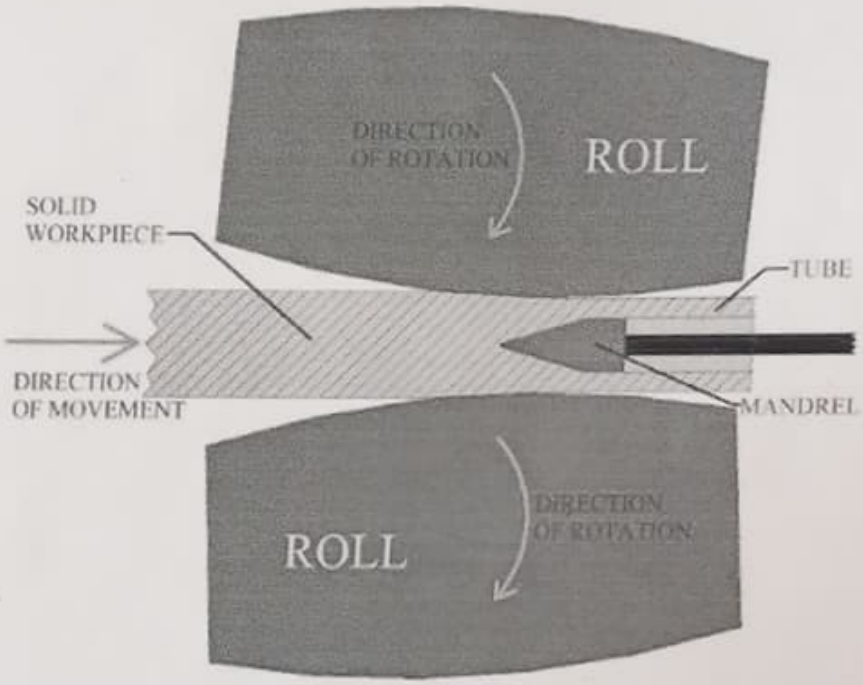
THREAD ROLLING:

- It is a cold rolling process, no heating is required.
- Only used for Ductile material.
- Best quality thread in the world and in mass production with high rate are produced by thread milling.
- Rolled threads are produced in a single pass.
- Dies are pressed against the surface of cylindrical blank. As the blank rolls against the in feeding die faces, the material is displaced to form the roots of the thread and the displaced material flows radially outward to form the thread's crest.



ROLL PIERCING:

- It is the process used for making seamless tube (Hollow tube)
- The billet or stock is rolled between the two rolls, both of them rotating in the same direction with their axes at an angle of 4·5-6·5°.
- Due to the angle there is a linear movement of the workpiece in addition to the rotary motion.



Lubrication

- Hot rolling of ferrous metals donot require lubricant.
- for Non-ferrous metals we use emulsion and oil in water.
- Cold rolling lubricants are oil based/water based.
  (fatty acids, Mineral oils, Emulsion)

DEFECTS IN ROLLING:

1) Surface defects:- Defects generate on the surface.
   Scales, Rust, Scratches, Pits & Cracks.
   Causes: Inclusion and Impurities in the materials.

2) Wavy Edges :- Sheet is thinner along its edges than its centre.
   cause: Due to roll bending edges elongates or distorts.

3) Alligatoring: Edge breaks.
   Reason: Non-uniform thickness due to material.

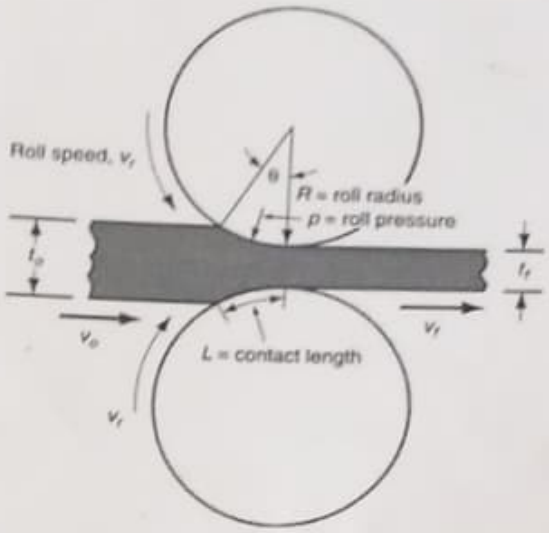
ROLLING TERMINOLOGY

DRAFT: Amount of thickness reduction.

$$d = t_o - t_f$$

where

d = draft
t_o = Starting thickness
t_f = final thickness.



REDUCTION: Draft expressed as a fraction of starting stock thickness.

$$r = d/t_o$$

r = reduction.

CAMBER:

- Due to centrifugal force the roller bends & get distorted and we obtain non-uniform thickness of the sheet. [thick at the centre and thin at the edge].
- To get uniform thickness we use cambered rolls where camber is given in the opposide direction to distoration.
- Camber can be used to correct the roll deflection.

ROLL STRIP CONACT LENGTH

$$L = R\theta$$

θ must be in radians.
R = Roll radius.
L = Contact length.

$$\cos\theta = 1 - \left[\frac{T_o - T_f}{\text{Diameter of the rolls}}\right]$$

For Easy (Unaided entry)

$$\mu \geq \tan\theta$$

μ = Coefficient of friction between the workpiece and the roll.

Maximum Draft

$$(\Delta t)_{max} = \mu^2 R$$

Maximum Possible thickness

$$t_o - t_f = \mu^2 R.$$

Number of Pass needed

$$n = \frac{(\Delta t)_{required}}{(\Delta t)_{max.}}$$ [If 4.7, 4.2 then take it is 5]

Continuity Equation

- Rolling increases the work width from an initial value of b_o to a final one of b_i and this is called spreading.
- Vol^m of Inlet material = Vol^m of Outlet material.

$$t_o b_o v_o = t_i b_i v_i$$

v_o ↓ Entering velocity

v_i Exit velocity.

Elongation factor / Elongation Co-efficient.

For Single pass $E = \frac{\text{Final length}}{\text{initial length}} = \frac{\text{Initial Area}}{\text{final Area}}$.

for n pass $E^n = \frac{\text{Length after the n pass}}{\text{initial length}} = \frac{\text{Initial Area}}{\text{Area after the n pass.}}$