"Rolling Process of Re-rolling Mill & Associate Defects & Problems"

Mr. Nilesh bakde,
Asst. Engineer ,TATA Advance System Limited, Nagpur

Abstract: Rolling process is a very common and conventional process which is used in finishing shaping and designing of flat stripes, angles, rods, etc. In this process the product which is to be machined is passed through a set of heavy rollers which are rotating at some speed usually constant due to this rotation of roller the material which is to be machined gets shrinked and takes the shape as of that of the rotating rollers through which it is passed. Generally rolling process is having two types: - 1) Hot Rolling 2) Cold Rolling The present research deals with the various Rolling Procedure, Terminologies use in rolling process & defect in rolling processes. The reason for selecting this Paper among the various problems present in the industry in Rolling processes we want to save the industry from huge lose in the breakdown period which generally occurs in such industries because of roller break down & amp; also to save operators, operating the rollers from any harm when roller break down.

Key Words: - Ignots, Billets, Roller, Hot Rolling, Cold Rolling, Cracks, Fatigue, Re-rolling mills etc.

I. Introduction

Rolling is a major manufacturing process of sheets and other cross sections of large length like I beam, railroads etc. It is one of a metal forming process in which the metal work piece is compressed between a set of rolls where it reduces its cross section area and increases its length. This process gives high production rate, surface finish and grain structure which make it a most suitable metal forming process for large length same cross section work pieces but high set up cost of rolling machine makes it as an alternative process. Rolling process is most common industrial process used for making large length cross section like sheets and plates of steel and aluminum for structure and other works. Rolling mills are used to perform rolling process. These machines are available in different shapes and size according to requirement of the process and due to technical issues. Every rolling mill consist minimum two rolls. These numbers can extend according to the process requirement

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II. Rolling process

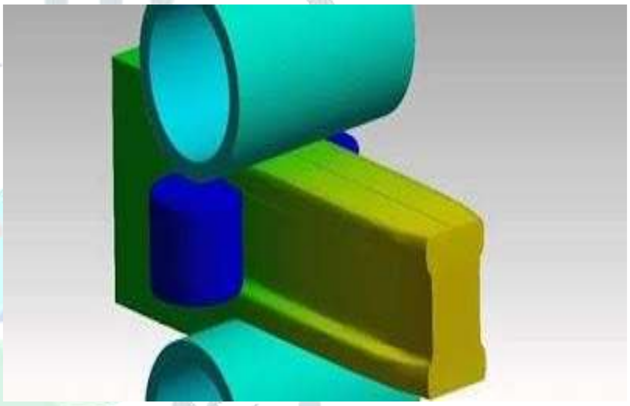
Terminology:

Fig.1. Rolling Process

The most common terminologies used in rolling process are given below.

Ingot:

It is casted structure with porosity and blowholes. Ignot is same as used in **forging**. This ingot is rolled out at hot temperature of about 1200 degree centigrade into blooms. This



ingot may have any size according to the rolling requirement.

Blooms:

It is first rolled product making by rolling ingot at high temperature. It has cross section area more than or equal to 230 square centimeters. This bloom is further rolled to make I section, billet, channel, railroad etc.

Slab:

Slab is made by hot rolling of ingot. It has cross section area greater than or equal to 100 centimeters square and its width is greater than or equal to three times of its thickness. Slabs are used to form plates, sheets, strips etc.

Billets:

Billets are product of hot rolling of blooms. It has greater than or equal to 40 square centimeters cross section area. Billets are used to roll into pipes, bars, wire etc.

Plate:

Plate is product of further rolling of slab. It has greater than 6 mm thickness.

Sheet:

Sheet has less than 6 mm thickness and width greater than 60 cm.

Strip:

Strip is same as sheet but have width less than 60 cm.

III. Working Principle

Rolling works on same as any other metal forming process. When a compressive force applied by a set of rolls on ingot or any other product like blooms or billets, plastic deformation takes place which decrease its cross section area and convert it into required shape. These rolls are designed according to the final product requirement. They are cylindrical in shape and fitted with the die of the required shape which to be rolled on blooms or billets. Rolling can be done in both hot and cold way.

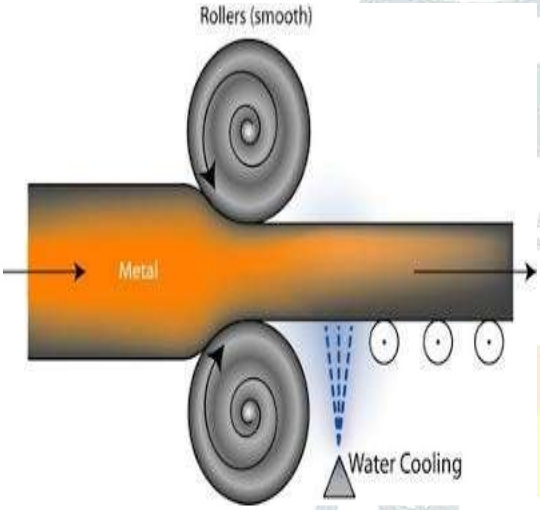


Fig. 2. Rolling process

Hot rolling is done at above recrystallization temperature. It is used to large deformation. It gives residual stresses free product but gives poor dimension accuracy and surface finish due to scale formation.

Cold rolling is another method witch is done at below recrystallization temperature. It is done to get final product. This process gives high mechanical strength, dimension accuracy and surface finish.

A. Types of Rolling Processes:

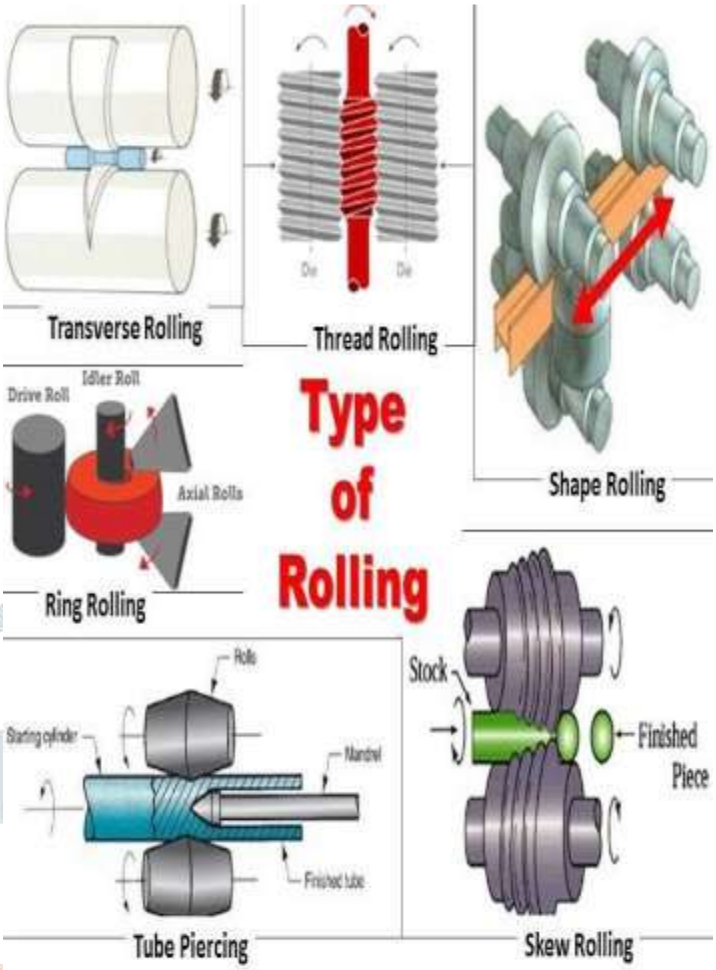


Fig. 3. Types of Rolling

a) Thread or Gear Rolling:

This process is used to cut **threads** or **gear** on cylindrical blank. In this process threaded dies are fitted on cylindrical rollers of rolling machine. This threaded roller pressed against cylindrical blank and roll against the faces which displace the material and form threads on cylindrical blank. This process gives high strength and surface finish and used to mass production of screw, bolts etc.

b) Shape Rolling:

Shape rolling is used to cut various shapes on metal work piece. It does not involve appreciable change in thickness. It is used to rolled I section, T section, railroads etc.

c) Ring Rolling:

Ring rolling is another method of rolling which is used to rolled rings of large **bearings**, **turbines** etc. In this process, two rollers (Main Roller and Idler Roller) are arranged as shown in figure and rotate in same direction to each other. The ring rotates due to rotation of roller and the rollers start move closer to each other. This will increase the diameter of rings. A pair of edge rollers is used to maintain the height of ring which does not allow to metal flow in the direction of height. This process gives high accuracy and material finish.

d) Tube Piercing:

It is another rolling process in which a stationary mandrel is used at the center of tube and cavity form due to tensile stress in a cylindrical rod when subjected to external compressive stress. In this process two opposite rolls are rotate in opposite direction which compress the tube and feed it against mandrel which create hollow cavity in it. This process is used to making seamless hollow tubes of thick wall.

e) Skew Rolling:

Skew rolling is used to make balls of ball bearing. In this process round bar or wire is fed directly into special designed rollers which continuously form spherical balls by rolling action. This process is used for mass production of small size spherical balls.

f) Transverse Rolling:

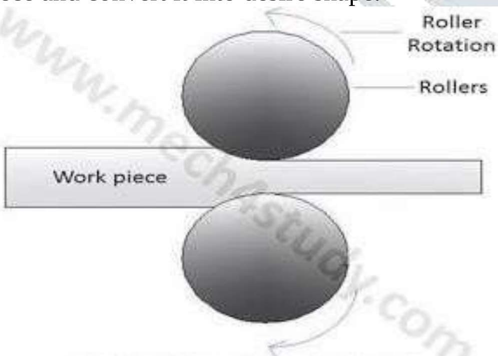
Transverse rolling is another type of rolling which is used to make tapper shaft, **leaf springs** etc. in this process both rollers are rotate in same direction and the bar is fed transversely. The rolls are fitted with special kind of tapped section which used to form tapped cavity of cylindrical work piece.

B. Types of Rolling Mills:

According to the number and arrangement of rolls, this machine can be classified into following types.

Two High Rolling Mill:

This mill consist two rollers arranged as shown in figure. Both the rollers rotate in opposite direction for desire movement of work piece. Work piece is feed between the rollers which apply a compressive force and tends to plastically deform work piece and convert it into desire shape.



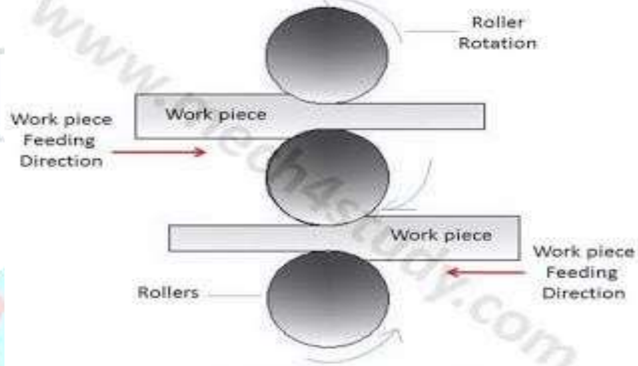
TWO HIGH ROLLING MILL

This machine can further classified into two types. The first one is two high non reversible machine in which the rollers can rotate in only one direction (Either clockwise or anticlockwise) and thus work piece can feed only in one direction (Either left to right or right to left). One big problem arises in this machine is that every time the work piece carried back over the front side of mill to feed again for reduction in thickness.

The other one is two high reversible machine in which both the rollers can be rotate in both directions. In this machine no need to carry work piece at front side. We have to just change the direction of rotation of rollers to again pass the work piece through rollers for decrease thickness.

Three High Rolling Mill:

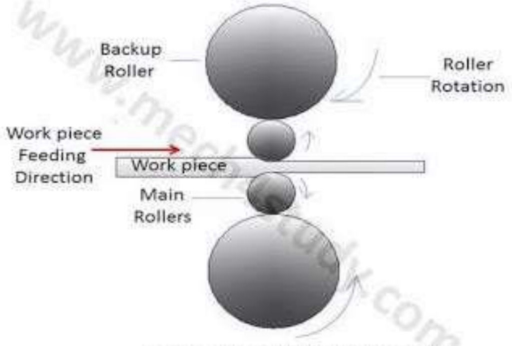
This type of rolling mill consist three rollers arrange parallel to each other. In this machine the middle roller rotate in opposite direction of other two rollers. This machine is used to reduce two times thickness in one pass. In this machine, the work piece is feed between bottom and middle roller in one direction and top and middle rollers in opposite direction. This machine can handle two work pieces in single run.



THREE HIGH ROLLING MILL

Four High Rolling Mill:

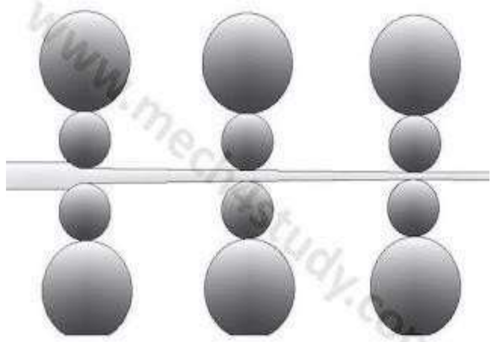
These machine consist four rollers (two small and two big). These rollers are arranged as shown in figure. Small rollers are in direct contact with work piece and rotate in opposite direction. Big rollers works as backup rolls and they also rotates in opposite direction with each other and also with contact roller.



FOUR HIGH ROLLING MILL

Tandem Rolling Mill:

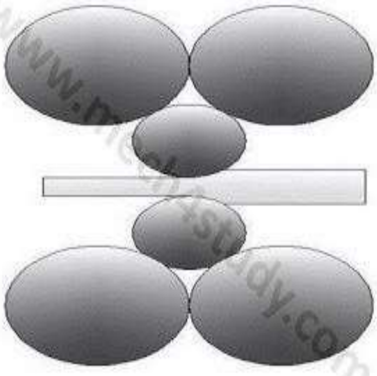
Tandem rolling is also known as continuous rolling in which two or more set of four high rolling mill arranged in a series in which each set is called stand. These stands are arranged so they can roll the work piece in decreasing cross section. It is used for rolling thick work piece in single pass.



TANDEM ROLLING MILL

Cluster Rolling Mill:

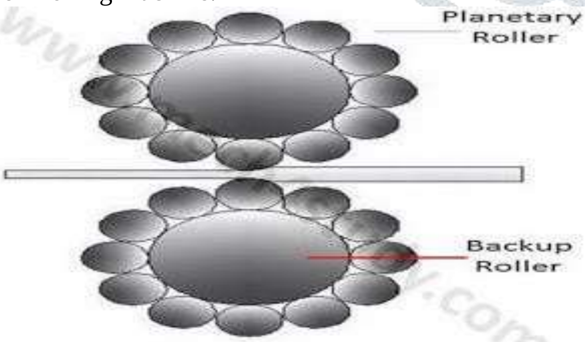
In this type of rolling mill, each of working roller is backup by two or more of larger backup roller. These rollers are arrange as shown in figure. This machine is used for rolling hard material.



CLUSTER ROLLING MILL

Planetary Rolling Mill:

In this type of rolling machine, a large backup roller is surrounded by various numbers of planetary working rollers as shown in figure. Each planetary roll gives constant reduction. It is used to reduce large thickness in single pass of steel strip. Its rolling capacity is more than cluster machine but less than tandem rolling machine.



PLANETARY ROLLING MILL

IV. Roll defects

A. Roll Wear Criteria and Rates

The properties required of rolls differ in detail at the various stages of the rolling line. While at the initial stage of rolling process the heat shock resistance and the general strength of the material are the dominating requirements, at later stages, resistance to abrasive wear becomes the most important necessity.

In addition, there are different perceptions of "roll wear" amongst rolling mill operators, designers and roll producers. Roll "performance" is a vague term that may concern: mass or length of hot steel produced per millimetre of machined roll diameter, or per mass of roll material used; or total tons of the product processed per set of rolls or per roll change. Calibre rolls have wear resistances of about several hundreds tons of hot rolled steel per millimetre of machined roll diameter (t/mm), whereas typical flat rolls have "lives" about $5{\cdot}10^3$-$20{\cdot}10^3$ t/mm [1,7,8]. Such a variety of roll wear criteria makes objective comparison of roll performances impossible. This problem might be overcome by defining roll wear in terms of "radial wear (mm) per sliding path" [7].

With calibre rolls, non-uniform wear (Fig. 1) should be observed, because the points of extreme wear determine the total depth of subsequent machining [9]. Generally, differences in wear (eg along the groove meridian, among the roll calibres, between the top and bottom roll, among the different stands) decrease roll life and obscure the rolling process.

B. Roll Wear Modes:

Before arriving at a selection methodology for materials and/or other system parameters to mitigate roll wear, it is useful to identify what wear processes are possible. Various interactions can affect the wear modes, eg the loss or transfer of surface material may lead to loss of fit or alignment (in addition to generating debris, which is a potential abrasive), with resultant changes in loads and friction, generating subsequent wear damage [10]. Experience has shown that roll wear rate increases rapidly after production of a specific amount of rolled steel; hence roll changes should be conducted after rolling a characteristic tonnage, to avoid catastrophic wear.

To identify wear processes, it is necessary to refer to some of many published wear classification systems. An example of the useful approximation to wear categorisation is shown in Fig. 4 [1].

Abrasion is among the dominant ever-present components of the total roll wear process [12,13]. Generally, abrasion can be conceptualised as two-body or three-body wear. Considering the common presence of oxide scales of high hardness and low plasticity, on hot steel surfaces, three-body wear would be expected to be an important mode of roll wear [6,1]. Further sub-classification distinguishes micro-ploughing, micro-cutting, micro-fatigue and micro-cracking [1]. Depending on the shape and hardness of the abrasive particles, there occurs either micro-cutting or plastic deformation of the surface and sub-surface layers by sliding; sub-surface deformation can result in crack formation [14]. Such a sub-classification generally has not been recognised in research of roll wear, and hence a further specific analysis of abrasive mechanisms is needed pertaining to this field.

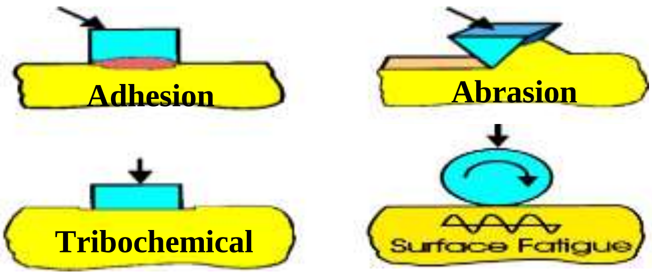


Fig. 4. Schematic diagram of the four main wear mechanisms [1]

Thermal fatigue is widely known as a mechanism of roll wear [6,8,11,12]. Any point on the roll surface is alternately heated by contacting hot steel and cooled by water. Consequently, compressive and tensile stresses are generated at a frequency of the roll rotation. If the compressive stress exceeds the compressive yield limit of the roll material during the heating stage, the outer layer will deform plastically. On the contrary, in cooling, a high tensile stress will be imposed on roll surface without plastic deformation, because the ductility of the roll material is not sufficient at these lower temperatures. When the fatigue limit of the material is reached, crack nucleation begins and the characteristic overall "firecrack" pattern will result. Heavy bending stresses will accelerate the process of crack propagation.

Various forms of corrosion attack eg fatigue or stress corrosion are also responsible in some measure for roll wear [12]. On the other hand, Ohnuki [2] has highlighted the benefits of oxides formed by high temperature oxidation at roll surfaces: at specific temperatures, dependent on the roll material grades, a hard and smooth black magnetite scale film is formed on the roll surface and excellent resistance to abrasion wear obtained.

Adherence ('seizure') of bands of oxide layers derived from rolled steel surfaces has been reported by some authors [2, 13]. This phenomenon defined as "the transfer of part of the work material surface to the roll surface, causing loss of product quality" occurs more readily at high reduction passes. Intermittent seizure leads to hot rolled material "pick up", roll surface roughening and increase in friction coefficient. Occasionally, associated uniform "prints" can be identified as periodic damage along the finish product surface.

Rolls can wear through slip during initial passes and hence the bite must be improved by increasing friction or by decreasing the reduction per pass. Knurling, produced on grooved roll surfaces to increase the angle of bite, can be rubbed out by skidding and the biting ability can thus be adversely affected [4,14].

IV. Conclusion

Steel rolling is recognised as one of the most important industrial processes. Rolling using grooved rolls (as a category different from groove-less rolling) is the most common practice in production of steel sections. Key tools in this process are the rolls that contribute up to 15 % of production costs. A main cause of roll consumption is due to continuous wear, complex process where mechanical and thermal fatigue combines with impact, abrasion, and corrosion. The necessity to compensate for the non-uniform wear during machining is an additional aspect of roll consumption. An area of specific interest is concerned with abrasive wear within the environment of rolling in grooves, where the nature of the deformation zone can accelerate roll surface deterioration.

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