

Rolling - Introductory concepts

1.1 Introduction

Rolling is one of the most important industrial metal forming operations. Hot Rolling is employed for breaking the ingots down into wrought products such as into blooms and billets, which are subsequently rolled to other products like plates, sheets etc.

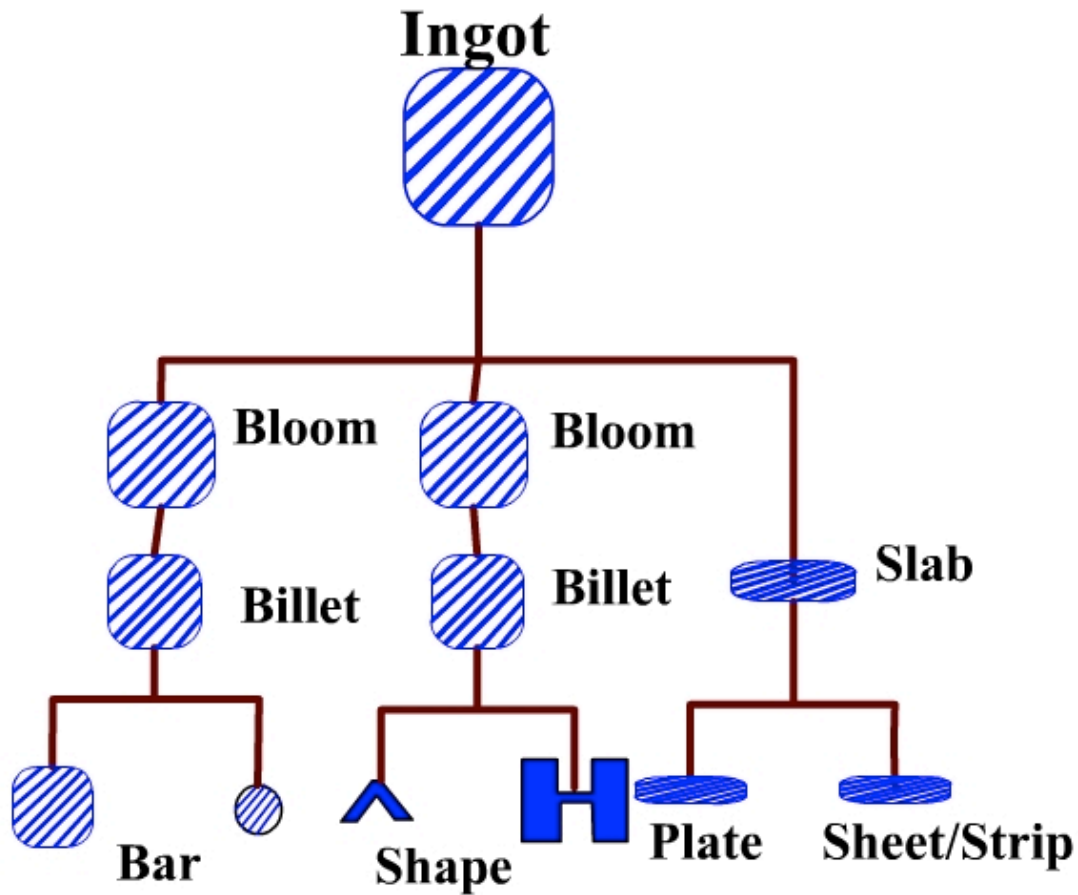
Rolling is the plastic deformation of materials caused by compressive force applied through a set of rolls. The cross section of the work piece is reduced by the process. The material gets squeezed between a pair of rolls, as a result of which the thickness gets reduced and the length gets increased.

Mostly, rolling is done at high temperature, called hot rolling because of requirement of large deformations. Hot rolling results in residual stress-free product. However, scaling is a major problem, due to which dimensional accuracy is not maintained. Cold rolling of sheets, foils etc is gaining importance, due to high accuracy and lack of oxide scaling. Cold rolling also strengthens the product due to work hardening.

Steel ingot is the cast metal with porosity and blowholes. The ingot is soaked at the hot rolling temperature of 1200°C and then rolled into blooms or billets or slabs.

Bloom is has a square cross section, with area more than 230 cm^2 . A slab, also from ingot, has rectangular cross-section, with area of at least 100 cm^2 and width at least three times the thickness. A billet is rolled out of bloom, has at least $40\text{ mm} \times 40\text{ mm}$ cross-section.

Blooms are used for rolling structural products such as I-sections, channels, rails etc. Billets are rolled into bars, rods. Bars and rods are raw materials for extrusion, drawing, forging, machining etc. Slabs are meant for rolling sheets, strips, plates etc.



Rolling sequence for fabrication of bars, shapes and flat products from blooms, billets and slabs

Fig.1.1.1: Flow diagram showing Rolling of different products

Plates have thickness greater than 6 mm whereas strips and sheets have less than 6 mm thickness.

Sheets have greater width and strip has lower width – less than 600 mm.

1.2 Rolling mills:

Rolling mill consists of rolls, bearings to support the rolls, gear box, motor, speed control devices, hydraulic systems etc. The basic type of rolling mill is two high rolling mill. In this mill, two opposing rolls are used. The direction of rotation of the rolls can be changed in case of reversing mills, so that the work can be fed into the rolls from either direction. Such mills increase the productivity. Non reversing mills have rolls rotating in same direction. Therefore, the work piece cannot be fed from the other side. Typical roll diameters may be 1.4 m.

A three high rolling mill has three rolls. First rolling in one direction takes place along one direction. Next the work is reversed in direction and fed through the next pair of roll. This improves the productivity.

Rolling power is directly proportional to roll diameter. Smaller dia rolls can therefore reduce power input. Strength of small diameter rolls are poor. Therefore, rolls may bend. As a result, larger dia backup rolls are used for supporting the smaller rolls. Four high rolling mill is one such mill. Thin sections can be rolled using smaller diameter rolls. Cluster mill and Sendzimir mill are used for rolling thin strips of high strength materials and foils [0.0025 mm thick]. The work roll in these mills may be as small as 6 mm diameter – made of tungsten carbide. Several rolling mills arranged in succession so as to increase productivity is called rolling stand. In such arrangement, an uncoiler and windup reels are used. They help in exerting back tension and front tension.

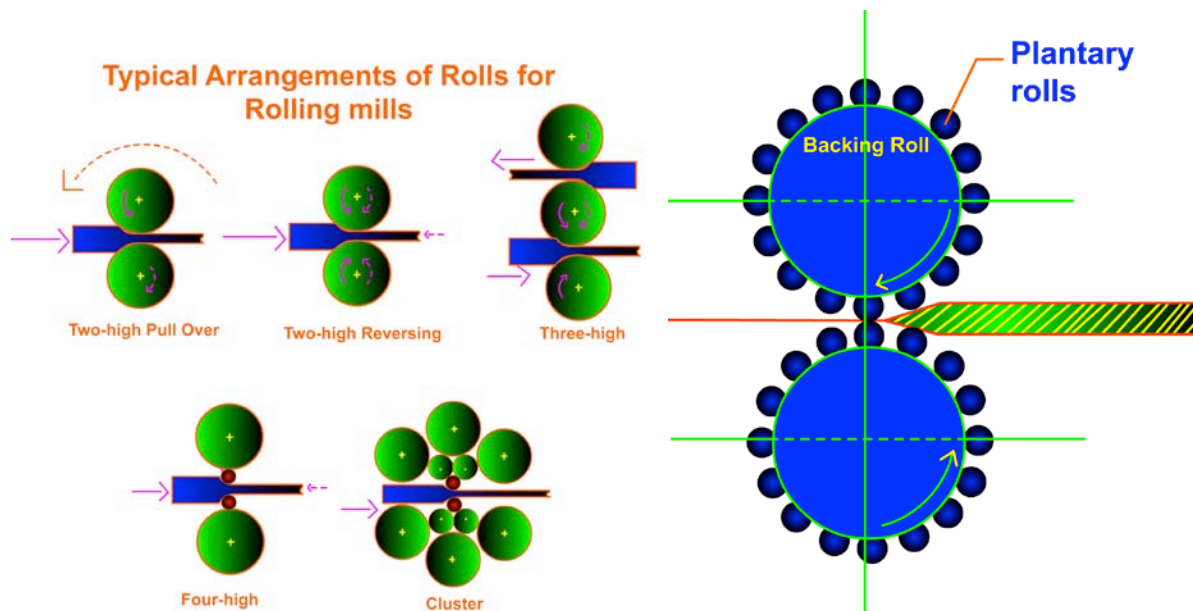


Fig. 1.2.1: Rolling mills

Planetary mill has a pair of large heavy rolls, surrounded by a number of smaller rolls around their circumference. In this mill, a slab can be reduced to strip directly in one pass. Feeder rolls may be needed in order to feed the work piece into the rolls.

Merchant mill is specifically used for rolling bars.

Hot rolling is usually done with two high reversing mill in order to breakdown ingots into blooms and billets. For increased productivity, universal mill has two vertical rolls which can control the width of the work simultaneously.

Non ferrous materials are cold rolled into sheets from hot rolled strips. Four high tandem mills are generally used for aluminium and copper alloys. In order to achieve upto 90% reduction in thickness in cold rolling, a series of rolling mills may be used to share the total reduction.

One important application of cold rolling is the removal of yield point from mild steel sheets using skin pass rolling [temper rolling]. In this the steel sheet is given a light reduction of 0.5 to 1.5% . Such a process eliminates yield point elongation. If yield elongation of steel occurs during sheet metal operation, such as deep drawing, the surface of the sheet metal becomes rough due to formation of Luder bands, also called stretcher strains.

Flatness of rolled sheets can be increased by roller leveling. In this process, the sheet is passed between a pair of rolls which are driven by individual motors and are slightly offset.

Rolls should have high stiffness, hardness and strength. Cast iron, cast steel and forged steel are also used as rolls.

1.3 Grain structure in rolling:

When the wrought or cast product gets hot rolled, the grain structure, which is coarse grained, becomes finer in size, but elongated along the direction of rolling. This type of textured grain structure results in directional property [anisotropy] for the rolled product. In order to refine the grains, heat treatment is performed immediately after rolling, which results in recrystallization after rolling.

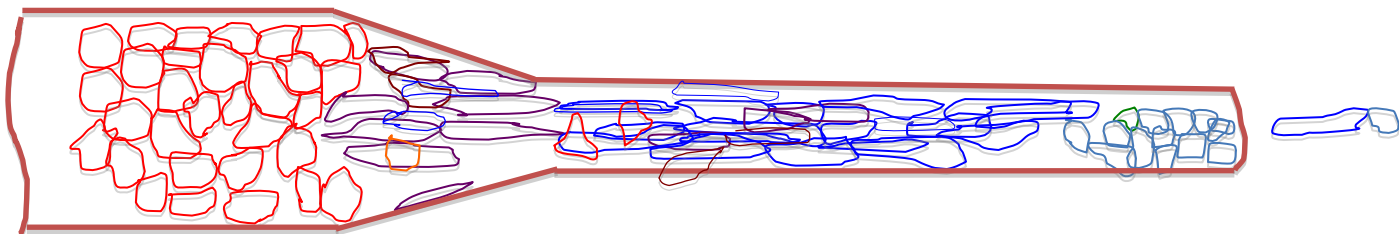


Fig. 1.3.1: Variation of grain structure, size during longitudinal rolling

1.4 Special rolling processes:

Bulk deformation processes such as shape rolling, thread rolling, roll piercing, ring rolling also use pair of rolls. Some of such important processes are discussed briefly below:

Thread and gear rolling:

Threads on cylindrical work pieces can be cold formed using a pair of flat dies or cylindrical rolls under reciprocating or rotary motion. Screws, bolts and other externally threaded fasteners are produced by thread rolling. Thread rolling is a high productivity process involving no loss of

material. Due to grain flow in thread rolling strength is increased. Surface finish of rolled threads is very good. Gears can also be produced by the thread rolling process. Compressive stresses introduced during the process is favourable for fatigue applications. Auto power transmission gears are made by thread rolling.

Shape rolling:

Structural sections such as I-sections, rails, channels can be rolled using set of shaped rolls. Blooms are usually taken as raw materials for shape rolling. Multiple steps are required in shape rolling.

Ring rolling:

Smaller diameter, thicker ring can be enlarged to larger diameter, thinner section by ring rolling. In this process, two circular rolls, one of which is idler roll and the other is driven roll are used. A pair of edging rolls are used for maintaining the height constant. The ring is rotated and the rings are moved closer to each other, thereby reducing the thickness of ring and increasing its diameter. Rings of different cross-sections can be produced. The major merits of this process are high productivity, material saving, dimensional accuracy and grain flow which is advantageous. Large rings for turbines, roller bearing races, flanges and rings for pipes are some of the applications of this process.

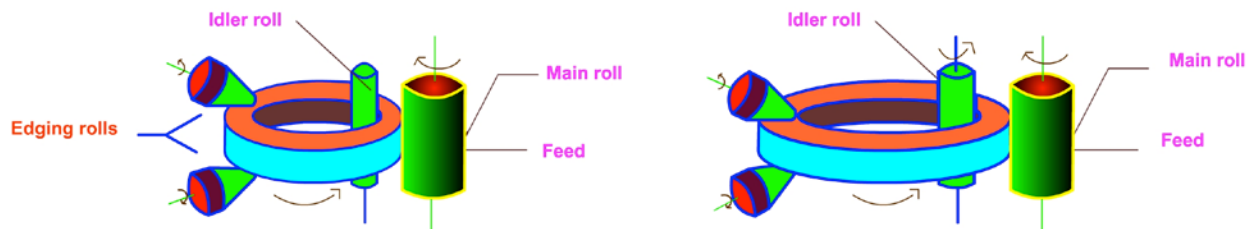


Fig. 1.4.1: Ring rolling process

Tube piercing:

Rotary tube piercing is used for producing long thick walled tubes. Cavity forms at the center due to tensile stress, in a round rod when subjected to external compressive stress – especially cyclic compressive stress.

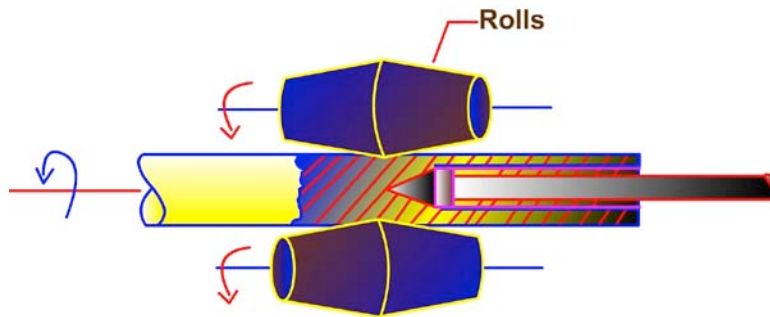


Fig.1.4.2: Mannesmann Mill

The Mannesmann process makes use of a tube piercing in rotary mode. A pair of skewed rolls are used for drawing the work piece inside the rolls. The roll axes are oriented at 6 degrees with reference to axis of work piece. A mandrel is used for expanding the central hole, and sizing the inner diameter. Pilger mill uses reciprocating motion of both work and mandrel to produce tubes. Work is periodically rotated additionally.

Source:

<http://nptel.ac.in/courses/112106153/18>