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Rolling Process in Metal Forming: A Brief Review

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Abstract: ***The present study is about a brief review regarding rolling process. Metal forming process also known as solid state manufacturing process and rolling process is widely used conventional manufacturing method. In rolling technique, the raw metal passes between a rotating rolls which rotates in opposite direction resulting in reduction in thickness and change in cross section of the metal to achieve a desired shape. The permanent deformation of metal takes place due to compressive force applied by the rotating rollers on the work piece, the high compressive stress develops due to friction between the rollers and the surface of raw material. Length of contact between the rolls and workpiece is generally much smaller than the width of the sheet passing through it. The shape produced by rolling process may be plate, sheet, strip and sections such as rails, beams, channels, angles rods, bar etc.***

Keywords: Rolling, hot rolling, cold rolling, rolling mills, ingots, billets.

I. INTRODUCTION

Most important metal forming process is rolling where raw material is plastically deformed by the application of highly compressive force when it passes between two rotating rolls rotating in opposite directions. Rolling process plays a major role while manufacturing steels in construction and other industrial applications. Rolling process first comes into picture in the year 1783 by Henry Cort using grooved rolls. Rolling is also used for making glass in which a ribbon of molten glass passes between two rollers, but the surface quality of glass produced is not so high due to its contact with metal rollers [1]. In rolling process depending on the direction of rotation of the rolls, the input raw material enters the gap between the rolls from one end and comes out from the other end with a reduced cross-section, the roll gap area being kept less than the cross-sectional area of the input material (rolling stock). For obtaining the desired final shape of rolled material, it is generally necessary to pass the material through the rotating rolls several times. During each of the passes, the roll gap is adjusted by bringing the two rolls closer to each other, or by allowing the material to pass through different set of roll gaps with diminishing cross-sectional area. The entire assembly of the rolls mounted on bearings is held in bearing blocks (called chocks), which in turn are held between the gaps of two cast frames (called housings), complete with roll gap adjustment facilities and roll driving arrangement. The entire set up is called a rolling mill stand. One or more number of rolling stands in combination with other necessary and related equipment to obtain finished rolled products from one or similar group of input materials is called a rolling mill or rolling plant [2]. At least, more than 95% of the ferrous and non-ferrous metals are produced to desired shapes through rolling. These desired metal shapes include plates, foil, strip and various sections such as bars, beam, rail and seamless pipe. There are numerous rolling processes, namely hot rolling, cold rolling, flat rolling, and controlled rolling [3].

II. LITERATURE SURVEY

In rolling process, the deformation takes place when a compressive force is applied by a set of rolls on ingot or any other product like billets, blooms, sheets, slabs, plates, strips, etc. This deformation decreases the cross-section area of the metal and converts it into the required shape. The main purpose of rolling is to decrease the thickness of the metal. Steel, magnesium, aluminium, copper, and their alloys are the materials commonly rolled. As a result of the friction between the rolls and the metal surface, the metal is subjected to high compressive stresses. High production rate, grain structure, and surface-finish are obtained, which makes it a most suitable metal forming process for large length cross-section workpieces like plates and sheets of steel and aluminium for other works and structure. However, the high set up cost of the rolling machine makes it an alternative process. The rolling process is done both hot and cold, which is accomplished in rolling mills. A rolling mill is a complex machine having two or more supporting rollers, working rollers, drive motor, roll stands, working rollers, coupling gear, flywheel, etc. According to the requirement of the process and technical issues, these rolling machines are available in different shapes and sizes. Each rolling mill consists of a minimum of two rolls. As per the process requirement, these numbers can extend even. Depending upon the shape of the rolled product, the rollers may be grooved or plain. The shape of the metal changes gradually during the period in which it's in contact with the two rollers. Compared to forging, rolling is a more economical method of deformation when metal is required in long lengths of uniform cross-section.

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The hot rolling process occurs with the initial breakdown of ingots into billets and blooms. This is followed by further hot rolling into the sheet, plate, bar, rod, rail, and pipe. It's done at the above recrystallization temperature and used for large deformations. Hot rolling gives residual stresses free product, but due to scale formation, it gives poor dimension accuracy and surface finish. A major role in the industry is played by the cold rolling of metals by providing sheet, strip, foil with high mechanical strength, good surface finish, along with dimension accuracy. The cold rolling which is done to get the final product is done at below recrystallization temperature [4]. There are five rolling mills which are commonly used for rolling metals: Two-High Rolling Mills, Three-High Rolling Mills, Four High Rolling Mills, Tandem Rolling Mills, Cluster Rolling Mills [5]. In common industrial manufacturing industry, the ingot or continuous casting is hot rolled into a bloom or slab. In addition to producing a useful shape for further processing, the hot rolling process converts the cast grain structure into a wrought grain structure. The initial cast material will possess a non-uniform grain structure, typically large columnar grains that grow in the direction of solidification. These structures are usually brittle with weak grain boundaries. Cast structure characteristically contains many defects such as porosity caused by gases, shrinkage cavities, and solid inclusions of foreign material that becomes trapped in the metal, such as metallic oxides. Rolling a metal above its recrystallization temperature breaks apart the old grain structure and reforms a new one. Grain boundaries are destroyed, and new tougher ones are formed, along with a more uniform grain structure. Metal rolling pushes material, closing up vacancies and cavities within the metal. In addition, hot rolling breaks up inclusions and distributes their material throughout the work. The advantages of metal forming are not just in the creation of useful geometric forms but also in the creation of desired material properties as well[6]. Material must be ductile and malleable to be rolled. Soft metals like aluminium and copper are ideal since they are easily bent and shaped. The tensile, yield, and elongation are desirable qualities of rolled metals since plastic deformation is often required to achieve the final desired shape. Additionally, most rolled materials have high tensile strength so they don't fail under the pressure of the hot or cold rolling mill. Unsurprisingly, the machines used in the rolling process are dictated by the material itself [7].

III. CONCLUSIONS

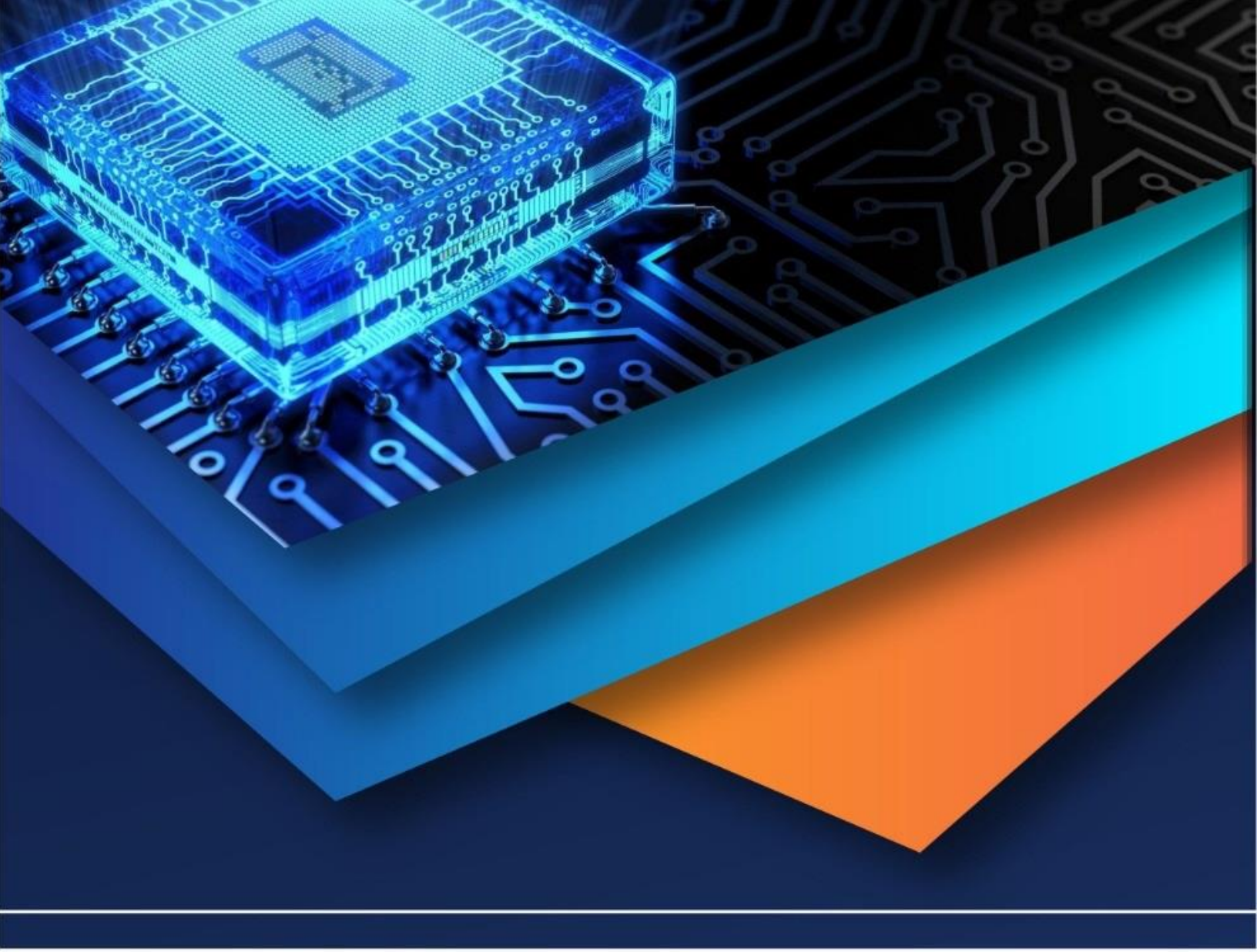
Rolling process is a fast and time saving resulting in high production rate well suited for mass production. High efficiency in material utilization capable of producing complex profile with very close tolerances. The surface quality of rolled products required secondary finishing operations.

IV. DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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