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ROLLS FOR HOT ROLLING MILLS: A STUDY IN DESIGN AND ANALYSIS

Ajay Singh* & Dr. Vineet Singla**

* PG Scholar, Department of Mechanical Engineering, Maharshi Dayanand University, Rohtak, Haryana.

** Assistant Professor of Mechanical Engineering Department, Maharshi Dayanand University, Rohtak, Haryana

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Abstract:

This research article presents a complete examination of the design and analysis of rolls used in hot rolling mills. Rolls are essential components in the metalworking industry for lowering the material thickness and enhancing the mechanical qualities of the finished product. In the metalworking process known as "hot rolling," the metal is heated to a temperature higher than its recrystallization point before being reduced in thickness by being fed through a set of rollers. Rolls are instruments that have a cylindrical shape and are used in processes that expose them to high temperatures and a variety of mechanical pressures. Because of this, the design of rolls and the materials used in their construction are very important to the success of the process and the final result. This study investigates the materials, design requirements, and finite element analysis that are used in roll production. Additionally, it examines the frequent failure mechanisms and maintenance practises that are utilised to maintain optimum performance and durability of rolls used in hot rolling mills.

Key Words: Hot, Rolling, Design, Requirements, Durability

1. Introduction:

The metalworking industry relies heavily on the hot rolling process since it is an essential component that plays a crucial part in the process of shaping and moulding metals into the appropriate shapes and dimensions. The rolling mills, and more especially the rolls that are housed inside the rolling mills, are the primary components of this operation. Because of the harsh working circumstances that these rolls are put through, which may include high temperatures, heavy loads, and abrasive environments, it is imperative that they be carefully designed, that the appropriate materials be used, and that they be analysed. Rolls used in hot rolling mills are charged with lowering the thickness of metal slabs while simultaneously enhancing their mechanical qualities and surface polish. This is accomplished by rolling the slabs between two sets of rolls. In this process, the metal is heated to a temperature that is higher than its recrystallization temperature, and it is then fed through a succession of rollers, with each set of rolls lowering the thickness even more. The structure and the material qualities of these rolls are very important since they have a direct impact on the effectiveness of the rolling process, the quality of the end product, and the longevity of the rolls themselves. Rolling mills are divided into several categories based on the number of rolls that are included inside each stand, which in turn is determined by the product, the design of the mill, or the temperature. The number of rolls that may be stored in a stand determines whether the stand is "two-high," "three-high," "four-high," "twelve-high," or "twenty-high." Cluster mills are another name for mills that include six rollers or more than one cluster of rollers. Rolling is a procedure that is used to change materials that have considerable cross-sectional dimensions into materials that have much smaller cross-sections that have a variety of forms. The application of compressive force via a succession of rollers results in the desired deformation of the material. The hot continuous rolling process for producing rods or bars is widely used in industry as a result of the high production rates it is capable of, in addition to its precise control over the shape and characteristics of the final product. This approach has been of tremendous assistance to the development of metalworking methods in a significant number of countries. It is common practise to gauge a nation's economy and general standard of living based on the quantity of steel used on a per capita basis. The product is the culmination of an intricate economic operation that is predicated on the existence of well-established lines of communication between the manufacturers of raw materials and the end users of completed items. Over "90% of all metals produced via metalworking processes" may be attributed to this factor. The process of rolling is one that has been around for a very long time and is used widely in the field of metalworking today. As a result of this, rolling is responsible for the manufacture of a wide and varied range of rolled goods each year, which underscores the significance of rolling as a key method for shaping. Rolling procedures may be broken down into two main groups: hot rolling and cold rolling. The primary difference between the two types of rolling is whether or not work hardening takes place throughout the process.

2. Literature Review:

V. Yadav, A.K. Singh and U.S. Dixit in this work, Utilising observations of the exit strip's temperature and slip, inverse analysis is performed in order to get the material characteristics for the power law and the coefficient of friction. This is done by taking the data. A finite element model is used to analyse the deformation, and an analytical technique is used to determine the temperature. This methodology combines the two methods. In order to bring the flow stresses that were measured and those that were anticipated into alignment with one another, a heuristic optimisation technique is employed.

Rudolf Pernis, J. Kasala, This study's primary objective is to investigate how relative deformation is distributed over the rolling zone, with the intention of drawing attention to the relevance of this topic owing to the fact that relative deformation varies along the length of the contact arc. As a part of the mathematical analysis of relative deformation distribution, the study of elliptic distributions is included in order to accomplish this goal. In addition, the average relative deformation in the rolling zone is computed as an integral value, which provides a more precise description of the overall deformation that was experienced.

S M Byon, S I Kim and Y Lee, The primary emphasis of this paper is placed on a hot-plate rolling experiment carried out in a laboratory setting, and it also includes an integration of a three-dimensional finite element analysis using the suggested model. An investigation of the degree of accuracy achieved by the suggested constitutive model was carried out. In the process of heavy-reduction rolling, a complete constitutive model that is capable of precisely estimating roll force and torque has just been presented.

Kristina Nordén, As stated in this thesis, the fundamental purpose of this study is to analyse the development of fractures during the process of shape rolling as well as methods for mitigating their effects. In order to accomplish this goal, bars made of high speed steel are subjected to careful machining that creates fake fissures running longitudinally throughout their length. The fissures may be seen in a variety of uniformly dispersed spots throughout the perimeter, spaced out at intervals of 45 degrees.

3. Objectives:

- Maintenance of roll bending resulting from temperature reduction.
- In order to prevent damage to bearings and couplings, it is important to take certain precautions.

4. Methodology:

Hot rolling mills take ingots fresh from the furnace and turn them into thinner strips via a rolling process. After being rolled, the thickness of the billets might change from a starting point of 100 millimetres to a final range of 0.7 millimetres to 1.5 millimetres. The manufactured strips might have widths between 100 and 150 mm. The billets are reshaped to the proper thickness after being heated and soaked on a conveyor table inside the reheating furnace to a temperature of 1000 degrees Celsius. The roughing mill receives the billet after it has been heated.The billet is thinned to 50 mm in thickness and cooled to about 800 °C over the course of numerous passes in the 3-high roughing mill of the specialist hot strip mill. Two primary work rolls and two secondary support rollers are included in each of the three-high roughing mills. The next step, intermediate rolling, is performed at temperatures between 700°C and 650°C, depending on the grade of the metal being rolled. The fine milling process follows the rough milling.

5. Experimental Work:

The size of the billets have been given painstaking consideration throughout the process of determining the capacity of the furnace and mill. In accordance with the agreed design criteria, the billets will be manufactured with the dimensions of 100 by 100 by 342.9 millimetres (mm).

Table 1: Standard billet dimensions for the hot rolling manufacturing process (Dimension in mm)

Square Size	100x100	100x100
Length	342.9	342.9

A simulation model centred on a billet with the dimensions 100x100mm x 342.9mm was produced as part of this research project. Using the programme SOLIDWORKS, a model of the billet was created.

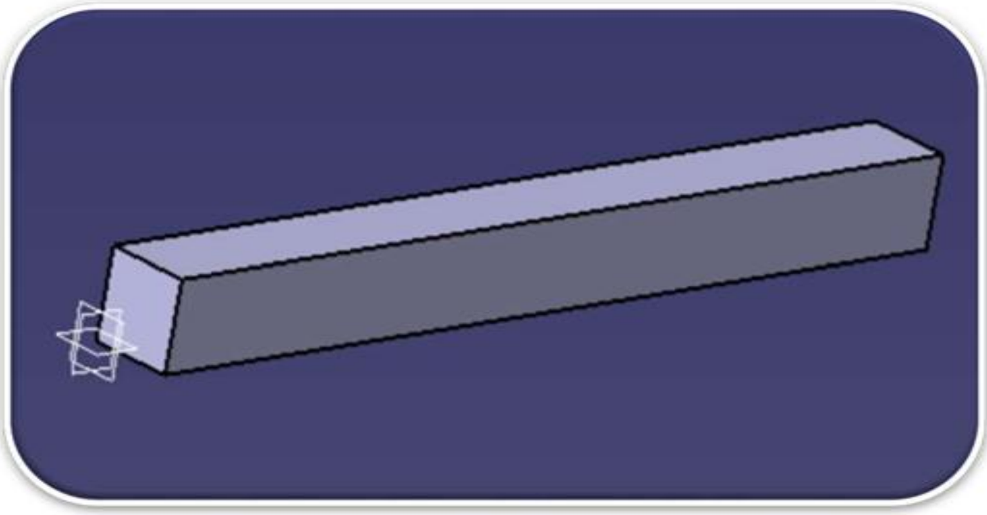

Figure 1: The Billet Sizes are 100x100 x 342.9mm

5.1 Raw Material [Billet]:

Material: MILD STEEL

Figure 2: Standard 100x100x342.9mm Billet.

Figure 3: Billets are pushed into a reheating furnace by a mechanical pusher.

Table 2: Metals' Innate Physical Characteristics

Metal	Density (kg/m^3)	Melting Point (°C)	Thermal Conductivity (W/m° C)	Coefficient of Linear Expansion at 20°C (μm/m/°C)
Aluminums	2700	660	220	23.0
Brass	8450	950	130	16.7
Bronze	8730	1040	67	17.3
Cast Iron	7250	1300	54.5	9.0
Copper	8900	1083	393.5	16.7
Lead	11 400	327	33.5	29.1
Monel Metal	8600	1350	25.2	14.0
Nickel	8900	1453	63.2	12.8
Silver	10 500	960	420	18.9
Steel	7850	1510	50.2	11.1
Tin	7400	232	67	21.4
Tungsten	19 300	3410	201	4.5
Zinc	7200	419	113	33.0
Cobalt	8850	1490	69.2	12.4
Molybdenum	10 200	2650	13	4.8
Vanadium	6000	1750	—	7.75”

6. Discussions:

Factors like mill speed and the contact zone between the rollers and the billet were examined via the use of mathematical calculations and the programmes AutoCAD 2012. The primary goal of a static analysis was to ascertain the distribution of deformation and stress across the rotating rolls and the billet under the rolling load and at the requisite rolling temperature. To do this, the distribution of stress and deformation throughout the spinning rollers was analysed. The billet deformation that happens inside the deformation zone is analysed in Chapter 6, which gives a succinct summary of the techniques and input variables required in doing so. The chapter will also elaborate on the findings that resulted from the examination of these input variables. This will guarantee a comprehensive analysis and interpretation of the findings.

7. Conclusion:

This comprehensive study has delved into the multifaceted aspects of design, material selection, and analysis of rolls used in hot rolling mills, elucidating the paramount significance of these components in the metalworking industry. The rolls, subjected to extreme temperatures and mechanical stresses, demand meticulous attention to detail in terms of their design, material composition, and maintenance practices to ensure optimal performance, product quality, and longevity.The exploration of various materials available for manufacturing rolls, including alloyed steels, cast iron, and sintered carbide, has highlighted the trade-offs between hardness, toughness, and thermal conductivity. This study emphasizes that the choice of material should be intricately aligned with the specific application and operating conditions to ensure resilience against wear, thermal cracking, and other potential failure modes. The design, material selection, and maintenance of rolls in hot rolling mills is a complex yet critical endeavor, requiring a holistic understanding of the operational conditions and potential failure modes. This research paper contributes to this understanding, offering practical insights and guidelines that can be utilized to enhance roll performance and reliability. While significant strides have been made in this domain, the ever-evolving nature of manufacturing technologies and materials science presents ongoing opportunities for further research and innovation. Future endeavors in this field should aim to explore novel materials, coatings, and design optimization techniques, with the ultimate goal of achieving unparalleled efficiency, product quality, and equipment lifespan in hot rolling mills.

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