DESIGN AND OPTIMIZATION OF ROLLING MILL CHOCK

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ABSTRACT

Chocks for rolling mill application are small in capacity so the overall size of chock is very small and components are critical from manufacturing point of view. As these chocks are fitted in a roiling mill it should have minimum noise and vibration. It has been observed that more failure of rolling mill of this type is related to chock which make an entire failure or rolling mill assembly. There is a scope to improve a chock design both theoretically as well as using finite element analysis which will help manufacturer to minimize a failure rate of rolling mill and also maintain a function of minimum vibration level. Here the scope of work is to design, analysis and optimization of chocks whichever sustain maximum loading during operating condition and it will have a minimum stiffness. Modeling using solid works and analysis using ANSYS is done in order to generate a required data for calculationand to validate theoretical result.

Keywords: *Rolling mill, roll chock, modeling, design, analysis and optimization.*

1. Introduction

Roll chocks which accommodate the roll neck bearing for the mil rolls .are sally steel casting designed to fit into the window of the housing such they are intend ant to maintain accurate positioning of the rolls and in the case of backup roll chocks .to transmit the rolling force from the housing to the rolls. Because of the larger size bearing they must accommodate, backup roll chocks are considerably larger than the work roll chocks, so much so that the later are sally designed to fit inside the “wings” or projections of the former. To prevent appreciable moments of the chocks in the housing in a direction parallel to the roll axes, guides or adjusting plates, which are securely attached to the housing on the operator’s side only, are used. in this instance the guides are fitted with adjusting bolts which should be secured by nutshell bolts are not in direct contact with the cockboat with an abrasion rail placed in a groove of the chockablock rail abuts against the guide with its ends lapped above and below show that it is not moved by any displacement of the thenceforth chock does not slide on the adjusting bolts but on the abrasion railing ,the guide abuts directly onto a chipping strip on the chock and is fastened to the housing by means of bolts .fine adjustment can be achieved by adjusting screws. How the guide s may be fitted to the housing.

2. Rolling Mill classification

Rolling mill is used to reduce successively the thickness of the metal strip as per the requirement. Hot rolling mills are used for mass thickness reduction at high temperatures, whereas the cold rolling mills are used as secondary rolling operations to attain more precise dimensional and mechanical properties. Rolling mills having single-stand type are generally operated as “reversing” mills, by which the strip is successively wound and unwound in coil form as it is repeatedly passed back and forth through the mill. Reversing mills are usually used for smaller scale production of the specialty cold-rolled products. For high mass production we use tandem-type rolling mills, whereby the strip undergoes a single pass through a train of rolling stands before being wound into coil form. Among thgose rolling stand configurations, the 4-high variety is the most widely used – both in single-stand and multi-stand tandem mills. The 2-high mill consists of two working rolls only and no other supporting rolls are mainly used for “skin-pass” or temper rolling. Rolling mill configuration and four high stand of reversing cold mill are shown in figure 1 and 2 respectively.

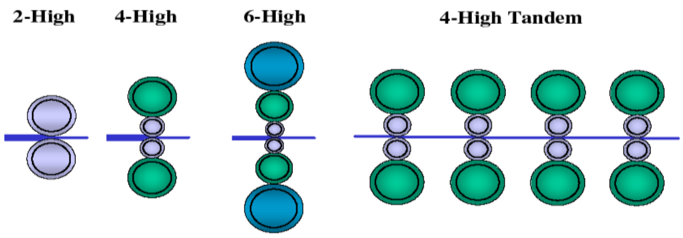

Figure [1] Rolling mill configuration

3. Types of Roll Chocks

The roll chocks are broadly categorized into 4 types which is shown in fig 3Top Back up Roll Chock

1. Top Work Roll Chock
2. Bottom Work Roll Chock
3. Bottom Back Up Roll Chock

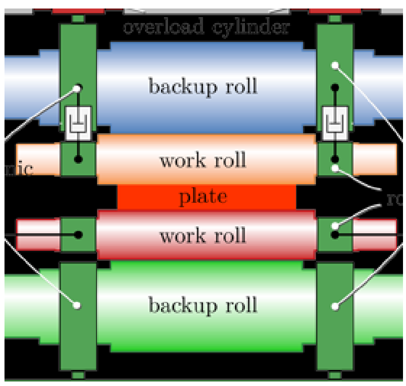

Figure [3] Roll chocks

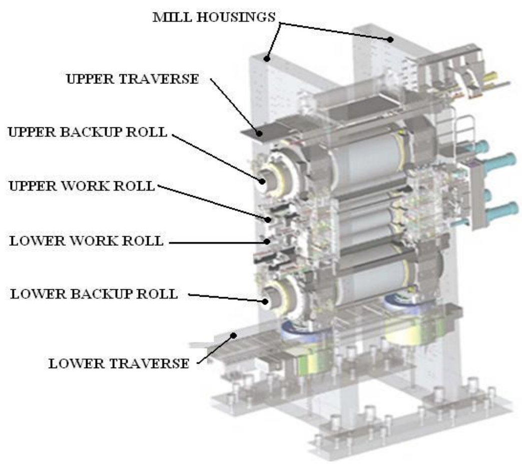

Figure [2] Four high stand of reversing cold mill

4. Design of chocks

The housing of a work roll or backup roll bearing is known as chock. Chock is mounted on the window of the housing between the posts with a small clearness in open bearing. The chock is usually a U-shaped frame of cast steel .in small mills when rolling is carried out with fixed pass setting the linings are usually mounted directly in the chock. In large mills where the roll is adjusted after each pass (blooming, primary, and plate mills), lining in boxes is mounted in the chocks. The lower roll chock is covered to prevent scale getting into the neck bearing, and to the lower part of the upper roll chock is fastened a support with an additional lining for holding up the top roll when the mill is idling. Housings are elements in a rolling mill that enclose and support the chock assemblies, the adjusting mechanism etc., and retain them in their proper positions. They set the rolls in correct vertical and horizontal position. Their construction and dimensions have to take into account the sizes of various other elements. The forces, which act on the rolls during rolling, are completely transferred on to the housing. So, the housing of rolling stand requires high rigidity, sufficient strength for taking the loads, simplicity of design and minimum cost of production.

4.1. Manufacturing Process and material used for roll chocks

The original Roll Chocks are manufactured by fabricating from cast steel or gray cast iron. The cast iron from which such Roll Chocks are manufactured should contain carbon from 0.2% to 0.3%. In cast Iron Roll Chocks, minor welding repair is possible but major welding repair is not possible to these cast iron Roll Chocks because the major welding repair, large amount of welding material is required. Roll Chocks can also be made of steel casting but in this manufacturing process a great diligence and utmost care are required.

4.2. Calculation of roll load and pressure acting on chocks

The force on the frame is the force applied by the rolls. It can be calculated by the most commonly used T-selikov theory. The forces on the roll neck and in the housing posts are identical. The strength of the neck (with a constant relation between its diameter and length) is approximately proportional to $\mathbf{d^2}$**,** Where **d** = diameter of roll neck bearing. For various mills, roll load depends on the roll material. The characteristics of various materials for rolls and roll load have been shown in Table 1 and 2.

Table [1] The structural properties of mild steel material

Properties	Values
Young's modulus	2 e11 N/m^2
Poisson ratio	0.266
Density	7860 kg/m^3
Yield strength	2.5e8 N/m^2

Table [2] Roll load with material

Material	Roll Load, N
Iron rolls	(0.6-0.8)d^2
Carbon steel rolls	(0.8 to 1.0) d^2
Chromium steel rolls	(1.0 to 1.2) d^2

Forces acting 4 High Mill and forces acting on 4 High Mill with intermediate roll is shown in figure 4 and 5 respectively.

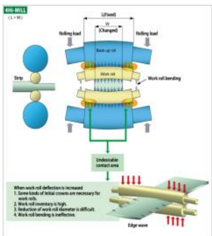

Figure [4] Forces acting 4 High Mill

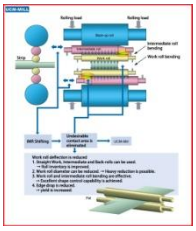

Figure [5] Forces acting on 4 High Mill with intermediate roll

Let Working Pressure = 210 bar, Bore Dia = 400mm, Rod Dia = 350mm, Testing Pressure = 315 bar

Cylinder Force = P x A = 2637.6KN

Pressure Acting on top backup chock, Bottom backup chock, Top Work roll Chock and Bottom Work roll Chock = Cylinder Force/(top backup chock, Bottom backup chock, Top Work roll Chock and Bottom Work roll Chock) Area = 19.53N/mm^2 , 8.04N/mm^2, 13.7N/mm^2, 10.4N/mm^2 respectively

5. Modal Analysis of Roll Chock

The Roll Chocks have been modeled in 3D Modeling Software "Solid Works" for better visualization and interference checking. 3D Models are also required for Structural Analysis and Optimization; therefore accurate modeling of Roll Chokes is required. 3D model of choks are shown in figure 6, 7, 8 and 9 respectively.

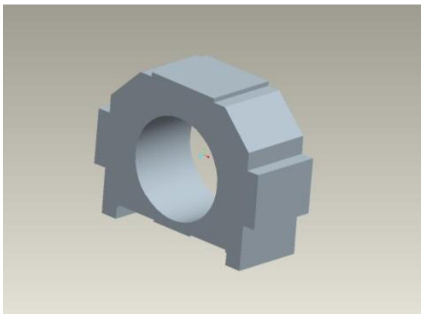

Figure [6] Top Back up Roll Chock

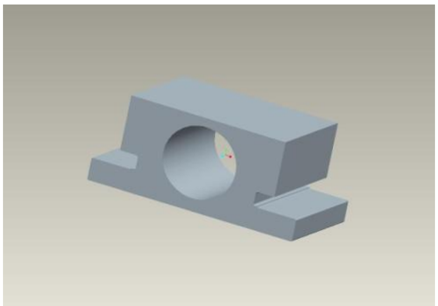

Figure [7] Bottom Work Roll Chock

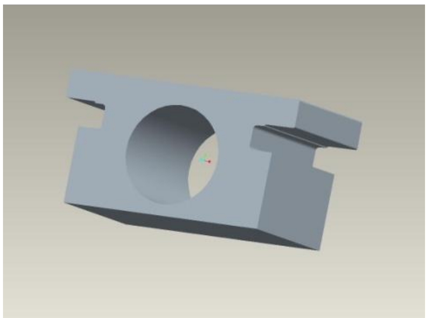

Figure [8] Top Work Roll Chock

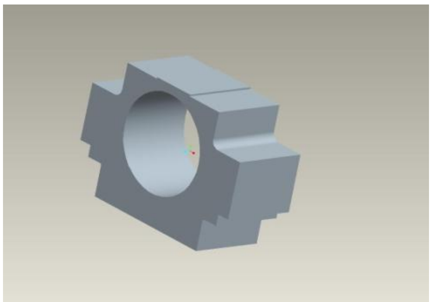

Figure [9] Bottom Back Up Roll Chock

5.1 Material, Element and Constraints

Material Used – Fe 410

(a) Young's Modulus – 200GPa (b) Poisson's Ratio – 0.3

(a) Element Used – Solid 10 Node Tetrahedral (Solid 187) (b)Element Size – 30

The bottom surfaces of the Top Roll Choke were constrained as shown in figure 6.

The Von Misses Contour Plot for Top Roll Chock is shown in table 3 which gives the information about the Natural Frequency of the Top Roll Choke and to check if the natural frequency of the machine does not match the natural frequency of the Top Roll Choke to avoid resonance.

Table [3] Von Misses Contour Plot for Top Roll Chock

Mode	1	2	3	4	5	6	7	8	9	10
Frequency (Hz.)	7.0637	8.2337	13.896	24.336	27.757	28.28	29.517	30.709	40.672	43.793

6. Structural Analysis of Top Back up Roll Chock

6.1 Material

Material Used – Fe 410
(a) Young's Modulus – 200GPa (b) Poisson's Ratio – 0.3

6.2 Element

(a) Element Used – Solid 10 Node Tetrahedral (Solid 187)
(b) Element Size – The appropriate Element Size was found out by using an Initial Element Edge Length to be 50 and then gradually reducing Element Size until the Stress remained constant even if the Element Size reduced. Element Size vs. Deformation information is given in table 4

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Table [4] Element Size vs. Deformation

Sr. No.	Element Size (mm)	Deformation (mm)
1	50	0.197729
2	35	0.198522
3	30	0.198749

Therefore, Element Size 30 can be considered to be the ideal Element Size for the Following Analysis. Also, the Computer Available would require additional hardware to solve the number of equations for Element Size less than 30 is a constraint.

6.3 Forces

Forces acting on the top roll choke are the force of the hydraulic cylinder transferred through the bottom rolls through the material to be rolled and through the top work roll. Top Roll Choke is constrained at the top of the Rolling Mills by an adjustable Power Screw Mechanism. Reaction force is considered as the actual force acting on the choke and the bottom surfaces are considered to be constrained. Therefore, the cylinder pressure is converted to force and applied on the particular area.

6.4 Constraint

The bottom surfaces of the Top Roll Choke were constrained as shown in figure 10

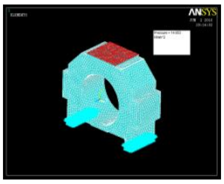

Figure [10] Meshing Diagram for Top Roll Chock

Total Deformation Contour Plot and Von Misses Contour Plot for Top Roll Chock are shown in figure 11 and 12.

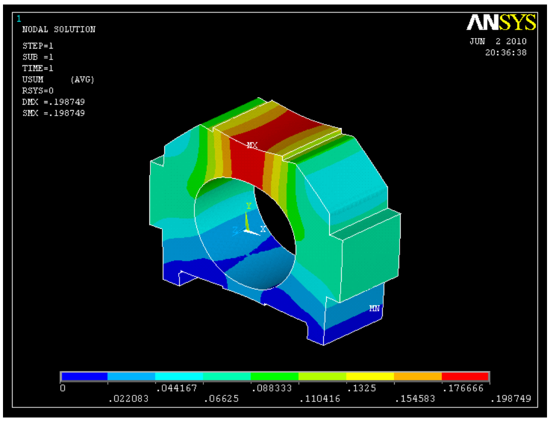

Figure [11] Total Deformation Contour Plot for Top Roll Chock

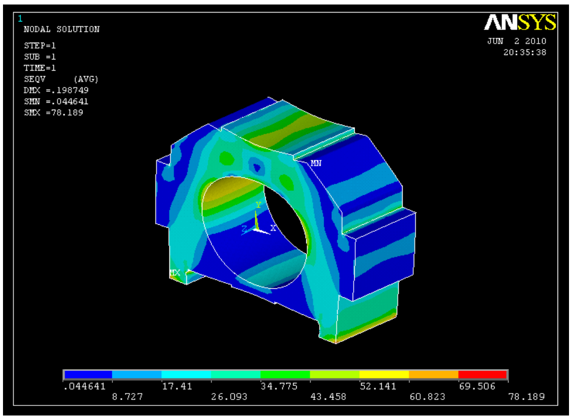

Figure [12] Von Misses Contour Plot for Top Roll Chock

7. Optimization of Top Back up Roll Chock

The primary Stress Contour Plots Obtained was observed and studied. The subsequent Iterations were carried out on the Roll Chok and a substantial weight reduction and thus cost savings was obtained by optimized to a smallest size with Stress Constraints, Bearing Size Constraints.

7.1 Iteration 1:- 3D Model of 1st Iteration, Deformation Contour of Ist Iteration and Von Misses Stress Contour of optimization of Top Back up Roll Chock are shown in figure 13, 14 and 15. Comparison of 1st Iteration and Existing Roll Chock is shown in table 5.

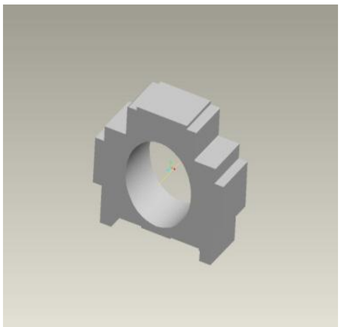

Figure [13] 3D Model of 1st Iteration of Optimization of Top Back up Roll Chock

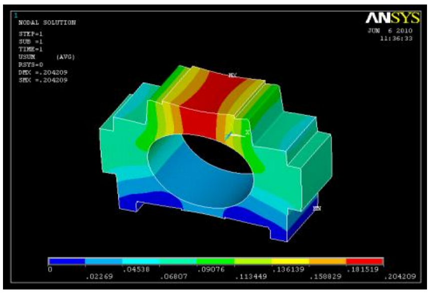

Figure [14] Deformation Contour of Ist Iteration of Optimization of Top Back up Roll Chock

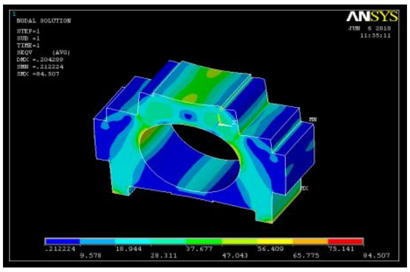

Figure [15] Von Misses Stress Contour of 1st Iteration of Optimization of Top Back up Roll Chock

Table [5] Comparison of 1st Iteration and Existing Roll Chock

Sr. No.	Item	Old	New
1	**Weight**	1816.49	**1693.79**
2	**Deformation**	0.198596	0.204209
3	**Von Misses Stress**	78.444	84.507

7.2 2nd Iteration

3D Model of 2nd Iteration, Deformation Contour of 2nd Iteration and Von Misses Stress Contour of optimization of Top Back up Roll Chock are shown in figure 16, 17 and 18. Comparison of 1st and 2nd Iteration and Existing Roll Chock is shown in table 6. Modes and their corresponding frequencies is shown in table 7.

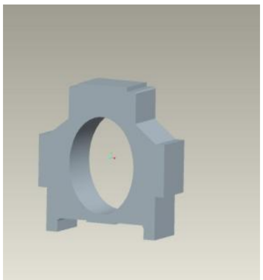

Figure [16] 3D Model of 2nd Iteration of Optimization of Top Back up Roll Chock

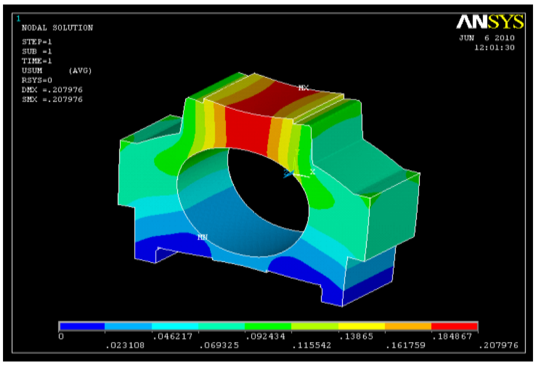

Figure [17] Deformation Contour of Ist Iteration of Optimization of Top Back up Roll Chock

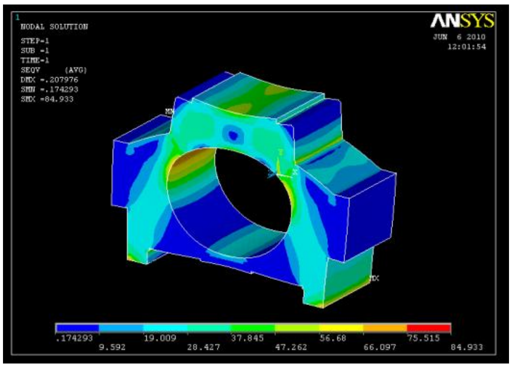

Figure [18] Von Misses Stress Contour of 2nd Iteration of Optimization of Top Back up Roll Chock

Table [6] Comparison of 1st Iteration and 2nd Iteration Roll Chock

Sr. No.	Item	1st Iteration	2nd Iteration
1	**Weight**	1693.79	**1633.4**
2	**Deformation**	0.204209	0.207976
3	**Von Misses Stress**	84.507	84.933

Thus a considerable weight saving is obtained as given below:-

Weight of Existing Roll Chock – 1816.49 kgs

Weight of Optimized Roll Chock - **1633.4 kgs**

Cost Savings – Wt. Reduced x Rs. 50 = 183.495 x 50 = **Rs. 9154.5**

Table [7] Modes and their corresponding frequencies

Mode	1	2	3	4	5	6	7	8	9	10
Frequency (Hz.)	7.5964	7.6924	15.71	22.976	24.667	29.02	29.047	32.248	37.795	43.152
Deformation (mm.)	0.048917	0.035799	0.051504	0.05069	0.060074	0.043498	0.071935	0.038319	0.043885	0.077078

As the deformation is very small compared to the size of the structure, static structural analysis is sufficient for the analysis of the Top Roll Chock

8. Conclusion

Finite element analysis of the actual chock model on the software shows that the chock of the machine experienced higher stresses at the place where the holding of work role and back role occur. In case if there is failure of chock occurs during the process of operation, we can design the new chock for rolling machine by improving the all over safety factor by using finite element methods. Optimization is technique to save the cost and time by giving more life to roll chock. The new chocks have good life compare to failure one and from that chock company daily saving.

9.References

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