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RESEARCH ARTICLE

STRUCTURAL ANALYSIS OF WORK ROLL CHOCK AND BACKUP ROLL CHOCK IN COLD ROLLING MILL

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ABSTRACT

Rolling is defined as a process in which metal is formed through a pair of revolving rolls with plain or barrels with different shaped grooves. The metal converts its shape during the period in which it is in contact with the two rolls. Rolling is a major and a most widely used mechanical working technique. A Rolling mill is a complex machine for deforming metal in rotary rolls and performing auxiliary operations such as transportation of the stocks to the rolls, disposal of metal after the rolling operation, cutting the metal strips, metal strip cooling, melting. The problem of failure of Rolling mill housing was there in industry, which can be efficiently solved by using CAE. The present work involves the design optimization of work roll chock and backup Roll chock in cold rolling mill, to control the failure of choke in the cold rolling mill for retain the material cost and longer life of the roll chock. The roll chock had stress distribution has been analysis by software ANSYS from which maximum static stress at critical areas have been calculated. Structural behavior of Roll chock under the given loading and boundary conditions using an analytical model are very difficult. Therefore 3D solid model was chosen in order to predict the stress and strain response detail. We have made a prototype of chock of optimized design of scale so as to verify our results that have been given by the analysis of work roll chock and backup roll chock on analysis software

Keywords: Cold rolling choke, roll load, Stress analysis, roll chock, Backup roll chock, Optimization.

INTRODUCTION

Chocks are almost invariably the highest stressed component in a manufactured item, and so are most susceptible to invariable the financial losses incurred as a result of chock failure will be far greater than the actual value of the chock instantiated delivery of chocks because of manufacturing presetting failure could stop a production failure at the assembly stage is almost certain to halt production if only one or two chocks out of a large batch.[1] No manufacturer would willingly assemble goods that are suspecting failure in serviceable the most catastrophic consequences example failure of cold rolling mill chock is very likely to result in the complete destruction of the cold rolling mill. Failure of chocks in a cold rolling mill is basically because of higher stressed generated during start up and shut down condition of rolling mill so for a design of chocks for a cold rolling mill it is essential to know the maximum load acting on a chock to prevent from a failure fatigue failure beachwear of cyclic loading is also a criterion of chocks design. Second most important function of to work as an isolator case of cold Rolling mill also it has to perform this function. So design of chock should have a required stiffness to transmit a vibration from a source to receiver.[2]

While designing a chock for cold rolling mill two factors is very important i.e. strength of chock to sustain a maximum load and stiffness of a chock to transmit lesser vibration. Over the course of time, finite element models have gained much importance, and the research work has been carried out to establish supportive results to software calculation. Computer models have been develop to provide trimly and economical simulations for results of a component under extremely Sever loading conditionals simulations can be used to target sensitive parameters that affect the overall design, cost and safety. 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 leveling has been observed that more failure of rolling mill of this type is related to chock which make an entire failure or rolling mill assemble. 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 achieve a function of minimum vibration level. Here the scope of work is related to specific condition of chock and with a constraint on it so here is still large scope for understanding and control of the design of chock.[3]

2. Design of chocks

The housing of a work roll and backup roll bearing is called a chock. It 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.

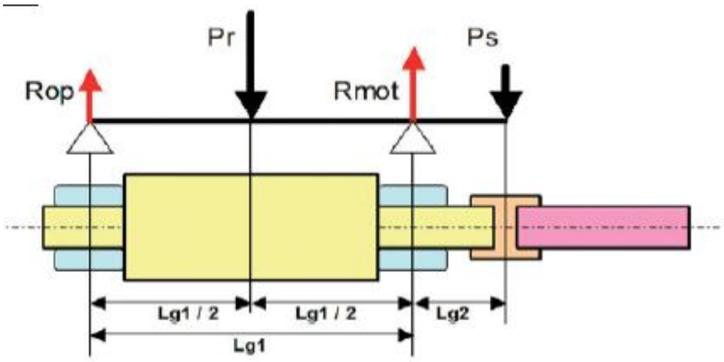

Figure 1. - Forces acting on mill rolls through rolling chock

Forces acting :-The above figure shows how the forces act on rolls through the rolling chocks. The chock strength can be ascertained approximately allowing for screw-down pressure and the tilting moment due to friction forces from the housing preventing the turning of the chock.

3. Material Used For Chocks

The original Roll Chocks are manufactured by fabricating from cast steel or gray cast iron. The Roll Chocks which are manufactured by cast iron 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.

4. Calculation of roll load

The force on the frame is the force applied by the rolls. It can be calculated by the most commonly used T-selikov theory.[4] 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 d^2
Where d = diameter of roll neck bearing.
In rolling mills, roll load is related to the roll material.
The properties of different materials for rolls have been shown in Table 1.

Table 1 - The structural properties of mild steel material

Property	Values (Unit)
Young's modulus	2e11 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	$(0.8 – 1.0)d^2$
Chromium steel	$(1.0 – 1.2)d^2$

5. Modeling of chocks

The Roll Chocks were modeled in 3D Modeling Software "Unigraphics 6 (UG-6) " for better visualization and interference checking. 3D Models are also required for Structural Analysis and Optimization; therefore accurate modeling of Roll Chokes is required.

The Order of the Models is according to their placement from top to bottom, in the Rolling Mill. [5]

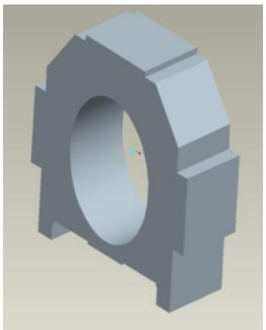

Figure 2 - 3D model of Top Back up Roll Chock

6. Modal Analysis

Modal Analysis is done to find out 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.[6]

1) Material Used – Fe 410
    a. Young's Modulus – 200GPa
    b. Poisson's Ratio – 0.3
2) Element
    a. Element Used – Solid 10 Node Tetrahedral (Solid 187)
    b. Element Size – 30
3) Constraint
    a. The bottom surfaces of the Top Roll Choke were constrained as shown in figure 4.1

Table 3 - Von Misses Contour Plot for Top Roll Chock

Mode	Frequency (Hz.)
1	7.0637
2	8.2337
3	13.896
4	24.336
5	27.757
6	28.280
7	29.517
8	30.709
9	40.672
10	43.793

Also, the deformation for various Modes was plotted as shown in Figure 7

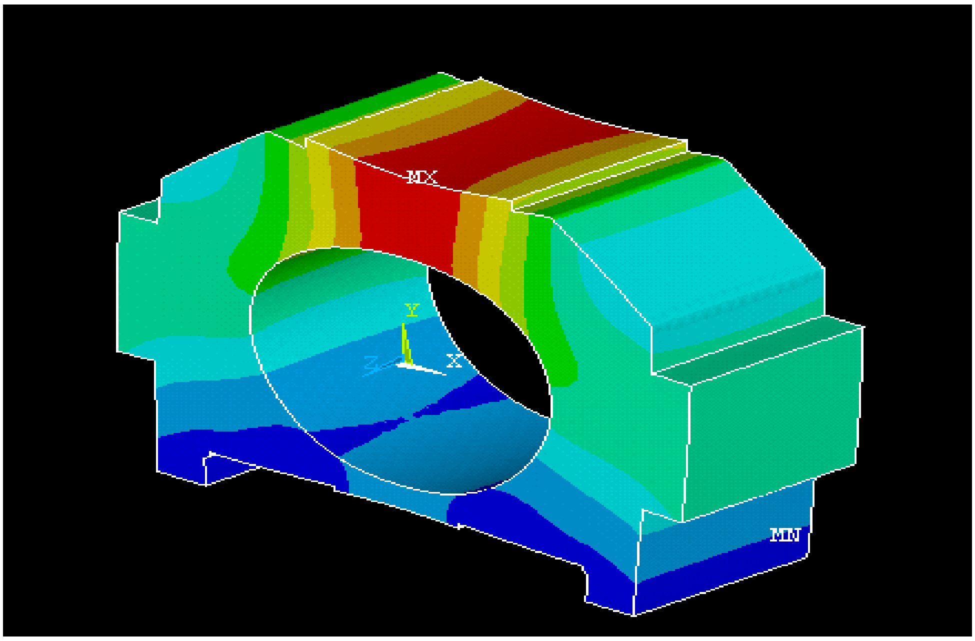

Figure 2 - Total Deformation Contour Plot for Top Roll Chock

7. Structural Analysis

1) Material

Material Used – Fe 410

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

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. The Table 4 clearly indicates the above

Table 4 - Element Size vs. Deformation

Element Size (mm)	Deformation (mm)
50	0.197729
35	0.198522
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.[7]

3) Forces

1. The Forces acting on the Top Roll Choke is the Force of the Hydraulic Cylinder transferred through the Bottom Rolls through the material to be rolled and through the top work roll. [8]

2. The Top Roll Choke is constrained at the top of the Rolling Mills by an adjustable Power Screw Mechanism.

3. The Reaction force is considered as the actual force acting on the choke and the bottom surfaces are considered to be constrained as shown in the figure 8.

4. Therefore, the cylinder pressure is converted to force and applied on the particular area as shown in the

figure 2.

4) Constraint

The bottom surfaces of the Top Roll Choke were constrained as shown in figure 8.

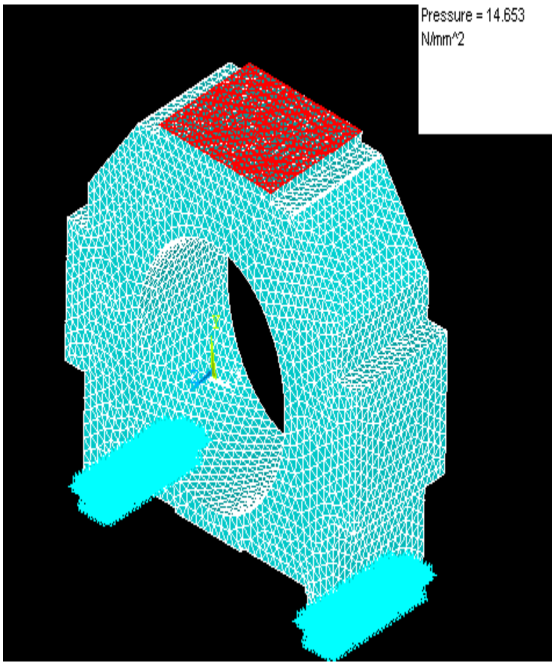

Figure 3 - Meshing Diagram for Top Roll Chock

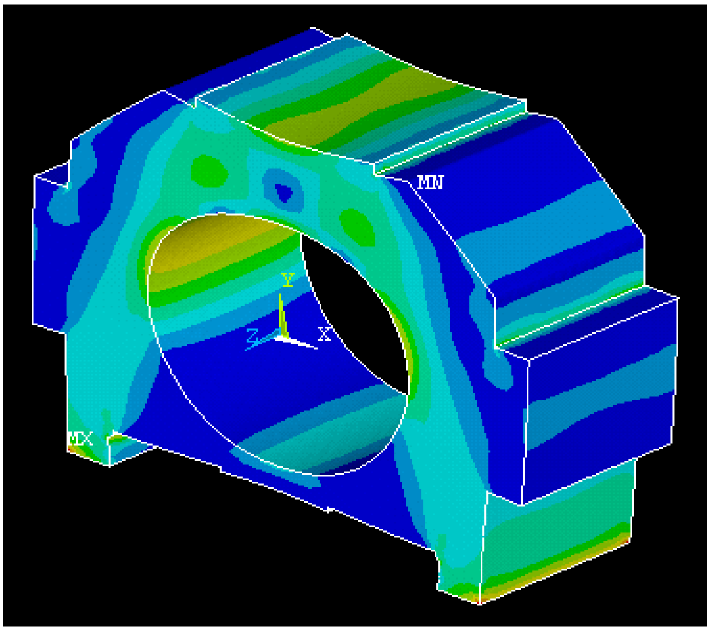

Figure 4 - Von Misses Contour Plot for Top Roll Chock

Optimization of Top Back up Roll Chock

The Top Roll Choke is optimized to a minimum size with Stress Constraints, Bearing Size Constraints. The Initial Stress Contour Plots Obtained was observed and studied. It was found out that parts of the roll choke had very little stress induced in them and could be removed.[9]

The Following Iterations were carried out on the Roll Choke and a considerable weight reduction and thus cost savings was obtained.

1st Iteration -

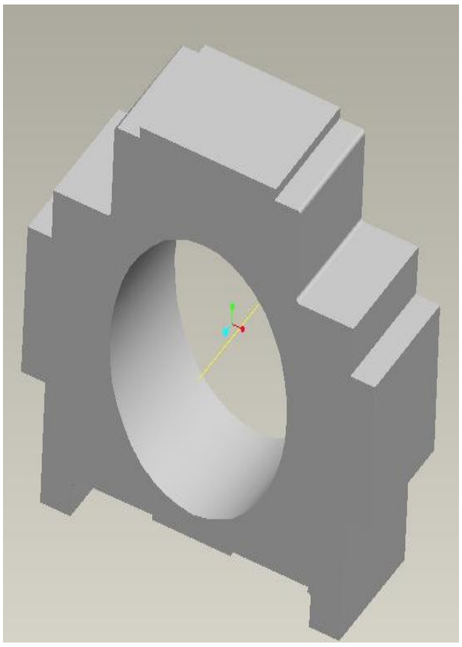

Figure 5 - 3D Model of 1st Iteration of Optimization of Top Back up Roll Chock

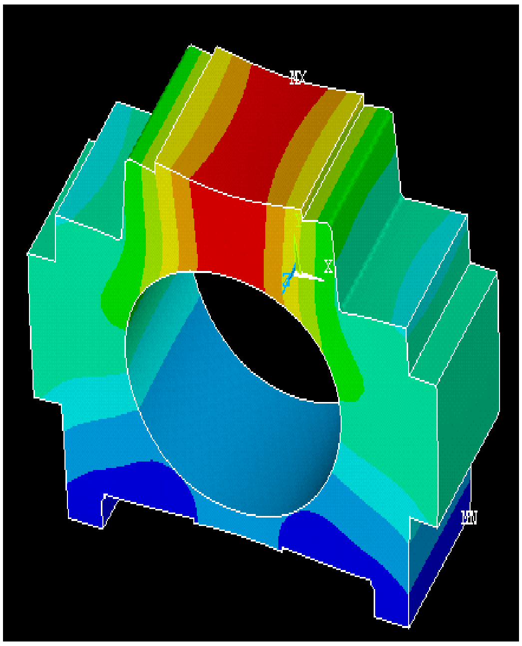

Figure 6 Deformation Contour of 1st Iteration of Optimization of Top Back up Roll Chock

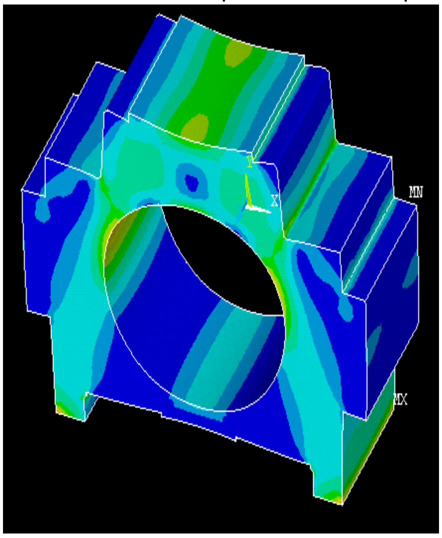

Figure 7 - Von Misses Stress Contour of 1st Iteration of Optimization of Top Back up Roll Chock

Table 5- Comparison of 1st Iteration and Existing Roll Chock

Item	Existing	1st Iteration
Weight	1816.49	1693.79
Deformation	0.198596	0.204209
Von Misses Stress	78.444	84.507

2nd Iteration -

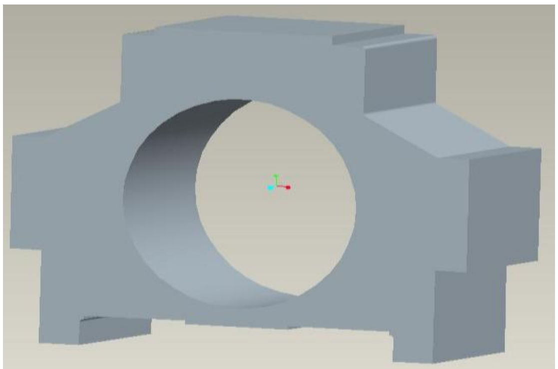

Figure 8 - 3D Model of 2nd Iteration of Optimization of Top Back up Roll Chock

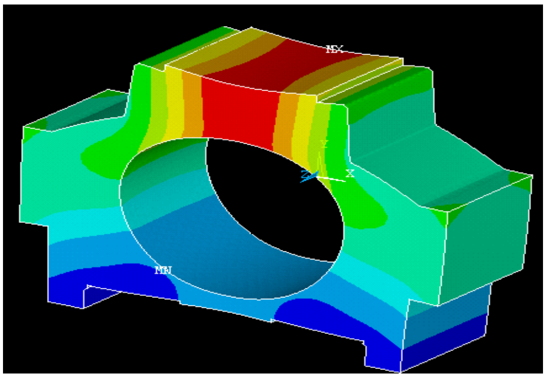

Figure 9 - Deformation Contour of 1st Iteration of Optimization of Top Back up Roll Chock

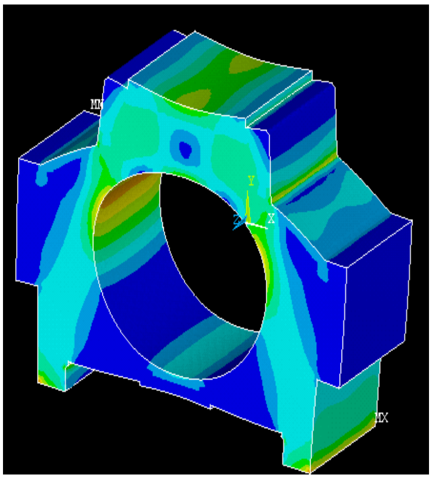

Figure 10 - Von Misses Stress Contour of 2nd Iteration of Optimization of Top Back up Roll Chock

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

Item	1st Iteration	2nd Iteration
Weight	1693.79	1633.4
Deformation	0.204209	0.207976
Von Misses Stress	84.507	84.933

Thus a considerable weight saving is obtained as given below:-
Weight of Existing Roll Choke = 1816.49 kg.
Weight of Optimized Roll Choke = 1633.4 kg.
Cost Savings =Wt. Reduced x Rs. 50
= 83.495 x 50
= 9154.5 Rs.

Modal Analysis of Optimized Roll Choke
The Modes and their frequencies are given in Table 7

Table 7 - Modes and their corresponding frequencies

Mode	Frequency (Hz.)	Deformation (mm.)
1	7.5964	0.048917
2	7.6924	0.035799
3	15.710	0.051504
4	22.976	0.05069
5	24.667	0.060074
6	29.020	0.043498
7	29.047	0.071935
8	32.248	0.038319
9	37.795	0.043885
10	43.152	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 Choke.[10]

8. CONCLUSION

This is the totally new concept ,where we are going to save the cost and time by giving more life to roll chock. By simulation of the actual chock model on the software it was revealed that the chock of the machine experienced higher stresses at the place where the holding of work role and back role occur. In the company there is failure of chock that occur during the process of operation so we designed the new chock for rolling machine by improving the overall safety factor. The new chocks have good life compare to failure one and from that chock company daily saving.

REFERENCES

[1] William L.Roberts (1938), "Manufacturing engineering and materials processing/2", Cold Rolling Of Steel.
[2] A.G.Davenport, "The application of statistical concept to the wind loading of structure", proc.Inst.Civil Engg. London 19(1961)449-472.
[3] Ginzburg Vladimir B."High-Quality Steel Rolling Theory and practice [M].Newyork", USA,Marcel Deker Inc.(1993).
[4] A.I. Tseliko and V.V. Smirnov, M.H.T. Alford (1965), Rolling Mills.
[5] Kurt Maute, 'an interactive method for the selection of design criteria and the formulation of optimization problems in computer aided optimal design", Computers Volume 82, Issue 1 , January 2004, Pages 71-79
[6] J. H. Rong, "An improved method for evolutionary structural optimization against Buckling" Computers &

Structures, Volume 79, Issue 3, January 2001, Pages 253-263.

[7] Theodore G. ToRidis, "Computer analysis of rigid frames, Computers", Volume 1, Issues 1-2, August 1971, Pages 193-221.

[8] Rafael Febres, "Modeling of local buckling in tubular steel frames subjected to cyclic Loading", Computers & Structures, Volume 81, Issues 22-23, September 2003.

[9] G. P. Steven, "Multicriteria optimization that minimizes maximum stress and maximizes stiffness", Computers & Structures Volume 80, Issues 27-30 , November 2002, Pages 2433-2448.

[10] William Prager , "Conditions for structural optimality", Computers & Structures', Volume 2, Issues 5-6, 1972, Pages 833-840