INTERNATIONAL JOURNAL OF ADVANCE RESEARCH AND DEVELOPMENT

IJARnD

(Volume 2, Issue 6)
Available online at www.ijarnd.com

Design and Analysis of Hot Rolls Using Finite Element Method

[1] L. Nalini, [2] Dr. P. Vijay Kumar
[1]PG Scholar M. Tech (Machine Design), Dept. of Mechanical Engineering, Raghu Institute of Technology, Visakhapatnam, Andhra Pradesh, India
[2]Professor, Dept. of Mechanical Engineering, Raghu Institute of Technology, Visakhapatnam, Andhra Pradesh, India

ABSTRACT
The main objective of this research work is to study the rolling process in steel manufacturing industries which has been in use to produce high-quality steel products. The entire research work was initially carried out by practical observation of the process in the steel manufacturing industry, along with the introduction of sophisticated technology having a number of stands associated with rolls made of spheroidal cast iron.
The hot billet is passed through the rolls at different stands to the correct size and shape of the billet with a defect-free surface according to the required mechanical properties. With the observation and thorough understanding of the valuable role design methods, and conditions of the application in order to achieve the objective of producing high quality rolled products the material used to manufacture the rolls is analyzed by finite element method using ANSYS 15.0 software after designing a 3D model using CATIA V5 software. The results obtained after preprocessing, shows that spheroidal cast iron or SG iron is the best material than Alloy cast steel which was initially considered to overcome maximum twisting at the center of the rolls when billet is allowed to pass through the grooves optimized with appropriated radius and spacing to balance various parameters such as roll separation force, torque, elongation, spread, and draft. The current techniques and problems of using the element system in hot role design have been presented briefly, further to solve this problem all the possible solutions have been discussed and the essential theoretical calculations are considered in a successfully validate the results with the final element theory with the hot rolled design.

Keyword: Modal, Design Assessment, Roll Separation Force, Torque, Elongation, Spread, and Draft.

1. INTRODUCTION

Rolling is the process of reducing the thickness or changing the cross-section of a long work piece by compressive forces applied through a set of two rolls that revolve in opposite directions, the space between the rolls being less than the thickness of the entering material. In the rolling process, material passed between rolls is plastically deformed.

The rolling process is a widely used industrial process because it makes possible high production and close control of the final product shape and properties. It accounts for about 90 percent of all metals produced by a metal working process. Rolling is one of the oldest processes used in the metal working industry. In view of the tremendous volume and wide variety of rolled products manufactured each year, rolling can be considered to be one of the most important forming processes.

Rolling processes are classified as cold or hot rolling according to whether work hardening occurs. Cold rolling is usually associated with operations performed at room temperature or below the recrystallization temperature at the rolled material. However, hot rolling is usually terminated when the temperature falls to about 50 ° C to 100 ° C above the recrystallization temperature of the material. There IS no work hardening during hot rolling. In this thesis, only hot rolling is considered. The ultimate goal in hot roll pass design is to manufacture the correct size and shape of a rolled product with a defect free surface and the required mechanical properties. In addition, economic condition must be achieved, for example, maximum output and lowest cost, easy working conditions for the rolling crew and minimum roll wear.

2. PROBLEM IDENTIFICATION

In hot rolling process any model designed to predict material flow and loads is invaluable in designing mills to minimize machine forces. The load in the mill spring is made up of several components including: bending of rolls, compression of the bearings, chocks and screws, and stretching of the housing.

Roll mill equipment must be capable of withstanding the roll load i.e. the mill is not overloaded and there is enough power available for the rolling reduction to be made. A roll designer is subjected to limitations applied by the rolling load, the roll strength and torque available for rolling.

Roll force can be reduced by (1) reducing friction; using smaller diameter rolls to reduce the contact area; (2) taking smaller reductions per pass to reduce the contact area; (3) rolling at elevated temperature to reduce the strength of the material; (4) applying longitudinal tensions to the strip during rolling and mainly selecting appropriate material to manufacture the rolls.

3. SPREAD CALCULATION

Ekelund Formula

The Ekelund (1933) formula considers most of the parameters affecting spread, except those of the quality or composition of the steel. The formula is complicated, making it difficult to use in practice

$$W_1^2 - W_0^2 = 2\,[4\,\Delta h - 2\ln[W_1 / W_0]\,(H_0 + H_1)\,]\,(\sqrt{R \times \Delta h})\,\left(\frac{1.6\,\mu\sqrt{R \times \Delta h} - 1.2\,\mu}{H_0 + H_1}\right)$$

Metal Size of Incoming metal – $H_0 = 200$, $H_1 = 180$

Metal Size of Outgoing metal – $W_0 = 200$, $W_1 = 204$

R is rolling radius and Δh is the reduction in the pass

Rolling Temperature (t) - $1200^{o\,C}$

RPM of motor (V) - 0.39 rpm

Roll Diameter (R) - 685 mm

$R = 342.5$ mm

$\Delta h = H_0 - H_1$

$\Delta h = 20$

μ = Coefficient of friction during hot rolling and can be calculated by the formula developed by El Bitar.

$\mu = (1.05 \times k) - (0.0005 \times T) - (0.056 \times (V / 1000))$

K =1

T =temperature of the work-piece should not be less than 700ºC

V=velocity (mm/sec) and not more than 5000 mm/sec

$\mu = (1.05 \times 1) - (0.0005 \times 1200) - (0.056 \times (0.39/1000))$

$= 0.449$

$$W_1^2 - W_0^2 = 2\,[4\,\Delta h - 2\ln(W_1 / W_0)\,(H_0 + H_1)\,]\,(\sqrt{R \times \Delta h})\,\left(\frac{1.6\,\mu\sqrt{R \times \Delta h} - 1.2\,\mu}{H_0 + H_1}\right)$$

$$W_1^2 = [2\,[4\,\Delta h - 2\ln(W_1 / W_0)\,(H_0 + H_1)\,]\,(\sqrt{R \times \Delta h})\,\left(\frac{1.6\,\mu\sqrt{R \times \Delta h} - 1.2\,\mu}{H_0 + H_1}\right)] + W_0^2$$

$$W_1^2 = [2[4x20-2\ln(W_1 / 200)(200+180)](\sqrt{342.5x20})\left(\frac{1.6x0.449x\sqrt{342.5x20} - 1.2x0.449}{200+180}\right)]+(200^2)$$

$$W_1^2 = [2[80-2\ln(W_1 / 200)(380)](82.76)(\underline{59.45 - 0.54})]+(40000)$$

380

$W_1^2 = [2[80-2\ln(W_1 / 200)(380)](82.76)(0.155)]+(40000)$

$W_1 = \sqrt{[2[80-2\ln(W_1 / 200)(380)](82.76)(0.155)]+(40000)}$

$W_1 = 204$ mm

4. ANALYSIS OF ROLLS AND BILLET

The analysis of the Rolls and Billet is done in Ansys 15.0 and the analysis reports are as shown below. The geometry and the mesh model in Ansys are as shown in the Fig.3 and Fig. 4 below respectively.

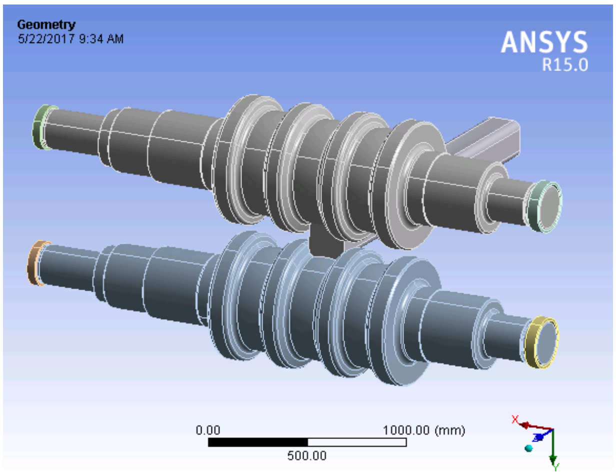


Fig.1 Geometry of the Rolls and Billet

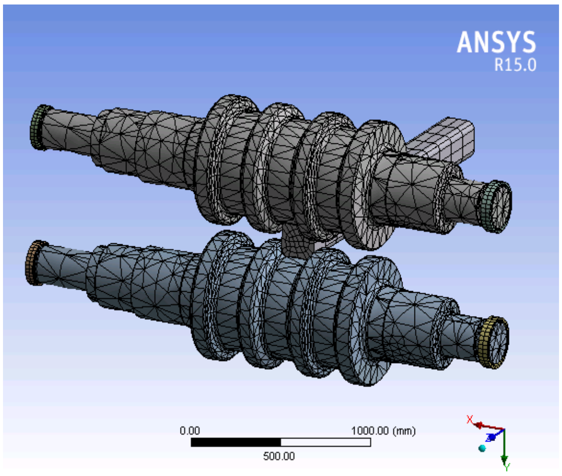


Fig.2 Mesh of the Rolls and Billet

The analysis is carried out for the Spheroidal cast iron and Alloy cast steel and analyzed for different conditions and validated to identify best material.

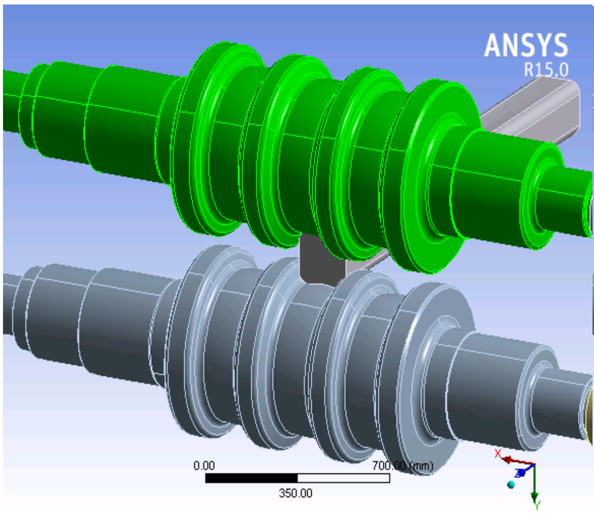


Fig.3 Selecting the Rolls

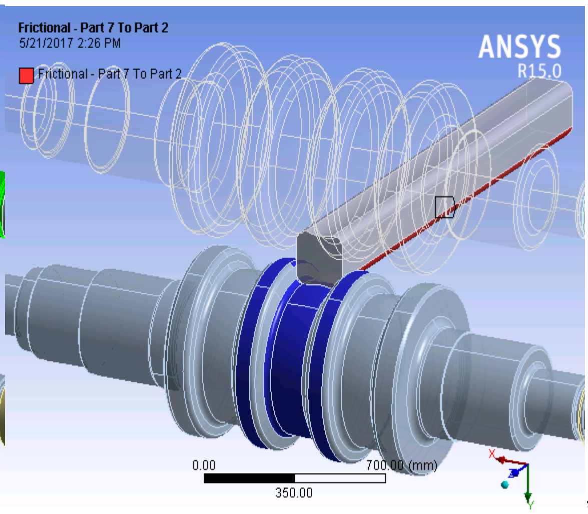


Fig.4 Contact between the Billet and Roll

The Boundary conditions are applied to the rolls to observe revelatory and translational motion in the rolls and the billet, as shown in the Fig: below, also it is observed that the roll load exerts pressure from upper bound downward direction and lower bound upward direction.

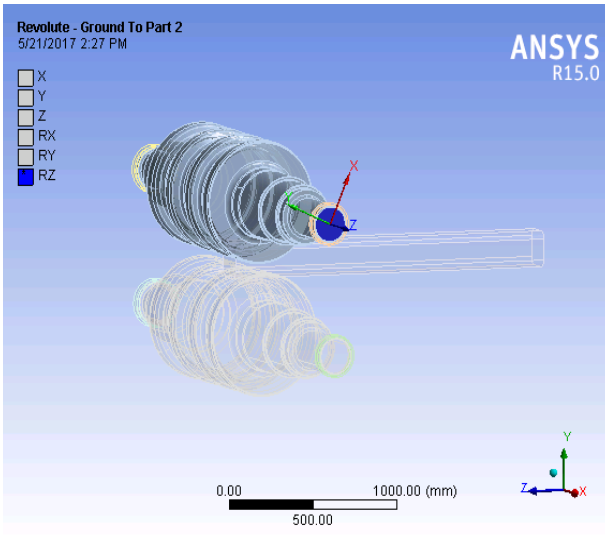


Fig.5 Boundary condition of Rolls

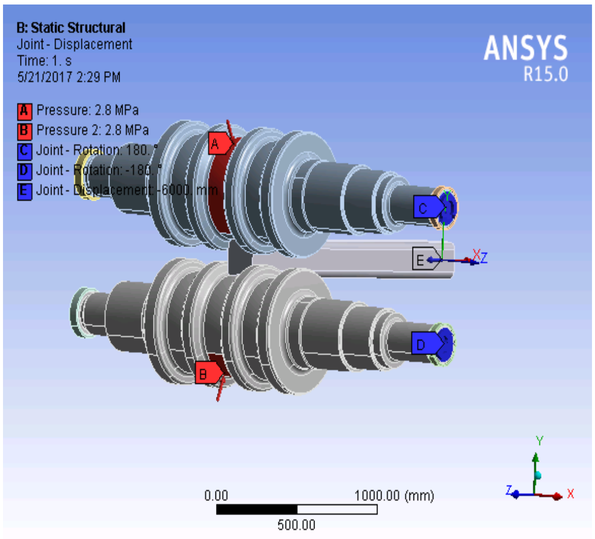
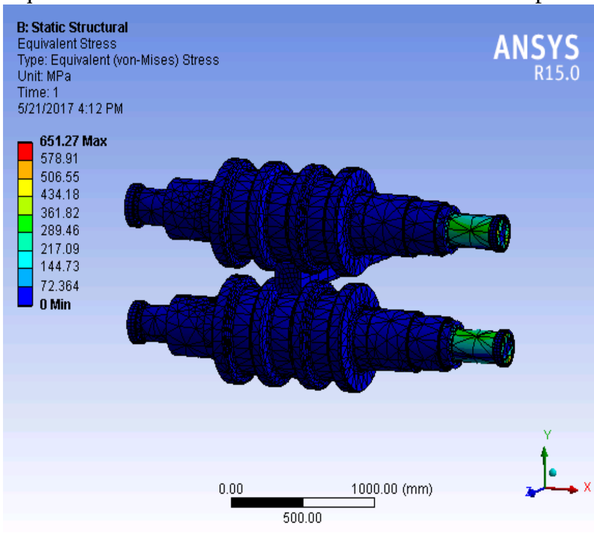


Fig.6Pressure Acting on Rolls

Equivalent stress results are observed maximum up to 651 for spheroidal cast iron and 656.99 for alloy cast steel.



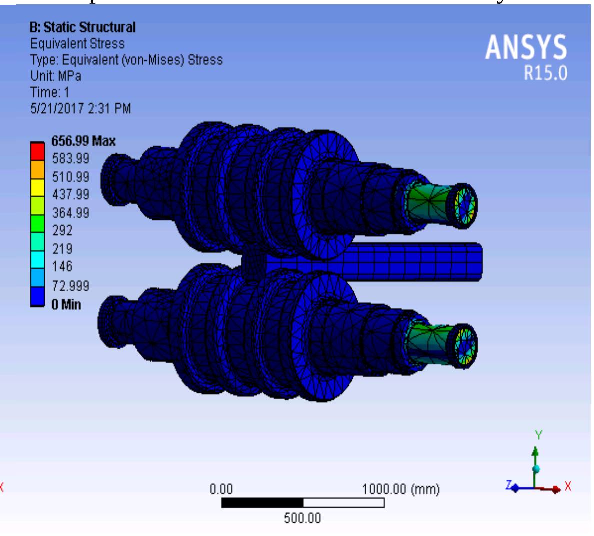


Fig.7 Equivalent stress of spheroidal grey cast iron **Fig.8 Equivalent stress of Alloy cast steel**

Deformation in x axis is up to 7.2 mm in case of rolls made with spheroidal cast iron where as it is 9.2 mm for Alloy cast steel rolls.

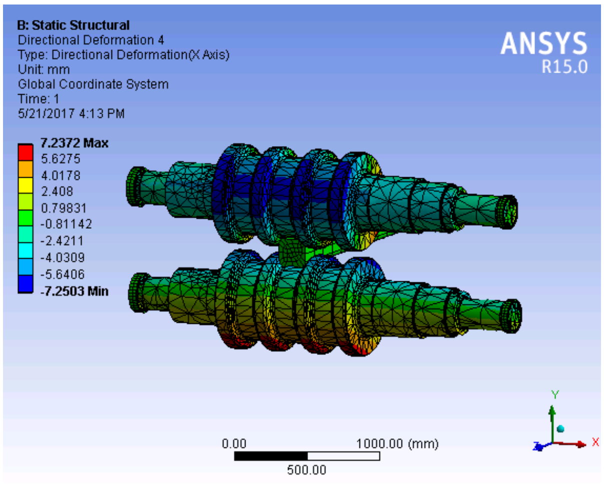


Fig.9 Deformation in x axis of spheroidal cast iron

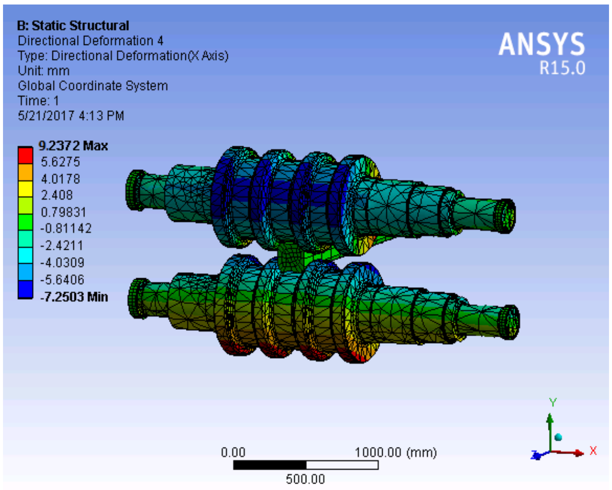


Fig.10 Deformation in x axis of alloy cast steel

Directional Deformation in Y axis is up to 5.83 mm in case of rolls made with spheroidal cast iron where as in case Alloy cast steel it shows 4.02 mm in y axis.

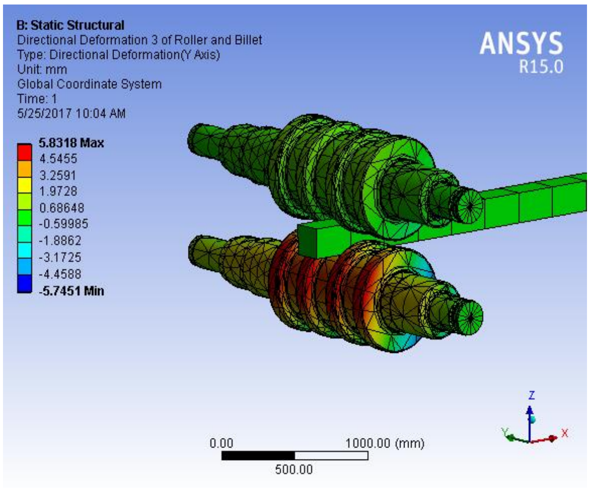


Fig.11 Deformation in y axis of spheroidal cast iron

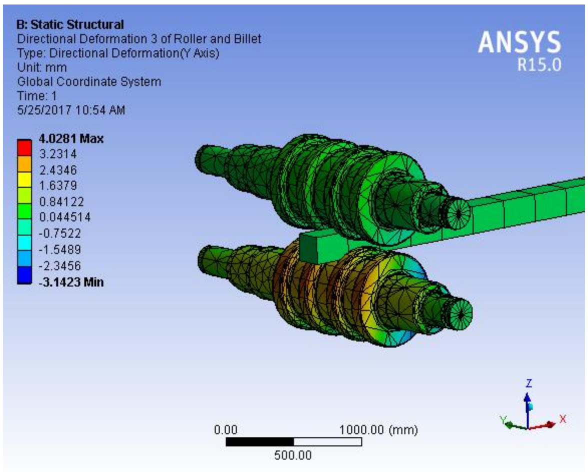


Fig.12 Deformation in y axis of alloy cast steel

4. TABLE

The Below table shows results obtained along x y axis which is validated and observed that that spheroidal cast iron best when compared to alloy cast steel.

Material	Equivalent stress	Deformation X	Deformation Y
Spheroidal cast iron	651.2	7.2	5.83
Alloy cast steel	656.9	9.2	4.02

5. RESULTS AND DISCUSSION

The combination of both Finite element method and Matrix-based hot roll design provides a hot roll design methodology with a systematic approach. It includes the existing formulae, empirical data, experimental graphics, and technical methods for hot roll pass design. This study has included a lot of existing empirical knowledge of experts as well as the results of research into new approaches.

For specific hot rolled products, by comparing the different formulae conditions of application, graphics data and computer simulation results, the optimum formulae and data can be chosen after discussion between the designers using the matrix. The optimum manufacturability of the rolled product is thus ensured from the optimum design, as early as possible in the design stage.

Further; the matrix also provides a systematic viewpoint and facilitates the consideration of hot roll design, not only based on the traditional methods, but also from the more modern techniques such as: Concurrent Engineering (CE), the planning of manufacturing, Computer-aided Design (CAD), Finite Element Method (FEM) and other methods.

6. CONCLUSION

In this thesis, the previous experimental and theoretical studies of hot rolling are reviewed. A thorough understanding of the available methods and conditions of their application is also considered in order to achieve high quality rolled products.

The experimental and practical observation involves the comparison of material analysis of hot rolls under static loading conditions. The results obtained under static loading condition along with the thermal base conditions with two different materials Alloy cast steel and Spheroidal cast iron are validated, and observed that the Spheroidal cast iron for rolls is comparably better than the Alloy cast steel material.

Validation is done with the theoretical calculations of billet sent through roll pass area, and the metal deformation has been validated along with some important design parameters, such as rolling force, torque, spread, elongation and draft and compared with ansys results.

By considering these validated results, high efficiency and high quality rolled products can be obtained by rolling process in steel manufacturing industry.

8. REFERENCES

[1].Beese, J. G. Some Problem Areas in the Rolling of Hot Steel Slabs, AISE Yearbook, pp. 360-363 (2012)

[2].Appleton, E., Jing, L. and Summad, E. “Shape Rolling pass Design”,
“International NAISO Congress on information Science Innovations” [IST'200], March 17- 21, at the American University of Dubai, U.A.E. (2001)

[3].Cook, P.M. and McCrum, A. W. “The Calculation of Load and Torque in Hot Flat Rolling”, BISRA (1958)

[4].Dorf, Richard. C. and Andrew, Kusiak. Handbook of design, manufacturing and automation, John Wiley & Sons. Inc. ISBN 0-471-55218-6 (1994)

[5].Ford, H. and Alexander, J. M. “Simplified Hot Rolling Calculations”, Journal of the Institute of Metals, Vol.92, pp. 397-404 (1963-1964)

