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Design and Analysis of Grinding Roller in Bowl Mills

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Abstract: Grinding roll is a major component of the bowl mill, which is considered as the grinding component, where in the raw coal lumps are crushed to the desired micron level by crushing in between grinding roll and bowl and fed to the boiler for efficient combustion. The prime purpose of this paper is to focus upon the stress analysis of the grinding roll and further optimize the design. The component is analysed for Von- Moises Stress. The Software package used for 3-d modelling of component was Autodesk Fusion 360, for stress analysis the software package used was ANSYS 17.2 Mechanical APDL.
Keywords: Grinding Roll, Von-Moises Stress, Bowl mill, ANSYS 17.2, Mechanical, APDL.

INTRODUCTION

India is a seventh largest country and has a very large population. To maintain growth rate, rapid growth in energy sector is needed. About 70.6% of power generation comes from thermal power plants, in which 61.5% generation comes from using coal as fuel. The demand of electricity is increasing day by day and has raised the necessity of improved power generation technologies or to improve the performance of existing power plants. Coal is the major fossil fuel in India and continues to play a prime role in the energy sector. The coal combustion process produces many pollutants, and in turn leads to acid rain and climate change like global warming. Operating a boiler that is not optimized further leads to increase levels of unburnt carbon, increased excess air requirements, incorrect primary and secondary air to fuel ratios, reduced boiler efficiency and increased slagging etc.

Hence it is necessary for all thermal power plants to optimize the combustion. Coal mills grind pea-sized coal into a powder, which is blown into the furnace of a power plant. Normally, there are a number of mills that supply the ground coal to the furnace and the amount of coal going into the furnace is controlled by the amount of feed to each mill and by the number of mills on line. In the mill considered, the bowl of the mill turned at a measured speed of 58.5 rpm. Three grinding rollers were forced against the coal bed by compression springs. There are stops on each roller to prevent loading on a bowl with no coal. Once the coal is fed into an operating mill the roller lifts off the stop. For 100% coal feeder loading, the coal bed on the bowl has a thickness of about one inch.

NOMENCLATURE AND RANGE

Nomenclature

1003 XRP bowl mills 100 stands for diameter of the bowl mill in inches. If the number is even then its shallow bowl mill. If the number is odd then its deep bowl mill 3- Number of rollers X- Frequency of power cycle is 50 cycles. R- Raymond, inventor of bowl mills P- pressurized type with P.A fan before mill. Range BHEL manufactures Bowl Mills in the following Ranges (corresponding to Bowl diameter in inches):

1. 60” series: 583,603 and 623 XRP/XRS
2. 66” series: 663 XRP
3. 70” series:703 XRP,703 HP
4. 80” series: 763,783,803 XRP, 803 HP
5. 90” series: 883 XRP
6. 100” series: 1003 XRP

LITERATURE REVIEW

Ren Jianxing [1] studied a 300 MW Coal fired unit using three kinds of mixed coal A, B and C. Under the rated load conditions characteristics of coal and burning characteristics were studied. The objective was to optimize combustion and enhance boiler efficiency by undergoing experimental analysis based on parameters such as burning status, flame transparency, unburned combustible in flue gas and exhaust gas temperature. Based on results of experiments, the results showed that mixed coal A was found better than mixed coal B and C on above mentioned parameter and hence it helps to optimize combustion and boiler efficiency. Avadhesh [2] explained in detail about performance modelling and behaviour analysis of coal handling system of a thermal power plant . This paper describes the behaviour analysis of coal handling system of a thermal power plant. The detailed study was done on various handling systems. On the basis of various factors analysis of coal handling system was done. The performance modelling is explained in detail. Nayan S Adhina [3] has primerily focused upon the stress analysis for the Bowl and Bowl Hub Assembly and to check whether the design lies within the safe working load conditions, and further optimize the Design. The component has been analysed for the failure criteria – Von Mises Stress. The software packages used for 3D modelling of the component was Solid Works, for the stress analysis the software package used was ANSYS-14.

Sorabh Gupta [4] have given the information about Simulation model for coal crushing system of a typical thermal power plant. In this paper Coal Crushing Activities and various processes involved for this in thermal power plant are explained. Simulation Model helps to understand the Coal Crushing System of a thermal power plant. Samira Rashidi [5] has concentrated on industrial applications and trade off studies in comparison with semi-autogenous and ball milling circuits. Benyuan Huang[6] to optimize coal combustion based on flame image processing technique and concept of introducing RES into combustion control circuit of coal fired power plant. It showed that by optimal control strategy, we can ensure stability of load and main steam pressure by adjusting secondary air for optimized A/F flow rate and there by strengthened and stabilized combustion conditions can be achieved in furnace. Also boiler efficiency increased and NOx emissions reduced at optimized operating conditions.

Hao Zhou[7] introduced an approach to predict the nitrogen oxides emission characteristics of large capacity pulverized coal fired boiler with artificial neural networks. The NOx emission and carbon burnout characteristics were investigated through parametric field experiments. The effects of over fire air flow rates, coal properties, boiler load, air distribution scheme and nozzle tilt were studied. On the basis of experimental results, an ANN was used to model the NOx emission characteristics and the carbon burnout characteristics. It is noted that when compared with other modelling techniques, such as CFD approach, the ANN approach is more convenient and direct, and can achieve good prediction effects under various operating conditions. It is concluded that it is convenient to employ the ANN model and optimization method developed in this paper to model the combustion characteristics using large amount of training data downloaded from DCS. Risto V Filkoski[8] applied a method for handling two phase reacting flow for prediction of pulverised coal combustion in large scale boiler furnace and to assess ability of model to predict existing power plant data. This paper presents principal steps and results of numerical modeling of furnace. The CFD/CTA approach was utilised for creation of three dimensional models, including platen super heater in upper part of furnace. Standard k epsilon model was employed for description of turbulent flow. Radiation heat transfer is computed by means of simplified P-N model. Simulation results concerning furnace walls, thermal efficiency and combustion efficiency shows good results corresponding with plant data.

MODELLING OF GRINDING ROLL

In this chapter, geometric modelling of the grinding roll is explained. The analysis of the grinding roll has been done and complete description of the material properties for the grinding roll, element type and finite element analysis has been done 4.2 Modelling of grinding roll the geometric model of the grinding roll was constructed according to the dimensions specified on the BHEL manual. The grinding roller is tapered in shape. The taper roller has the outer diameter of 1304 mm and inner diameter of 845 mm on one side and the tapered roller has a outer diameter of 990 mm and inner diameter of 717.5 mm and width of the roller is 483 mm. developing the geometry of model several sub domains are created for the meshing facilitation. The model is divided into two main structural domains that correspond to two constructional materials: Nihard and Gray cast iron. The inner surface of the grinding roller is made up of gray cast iron and the outer diameter is made up of Ni hard material.

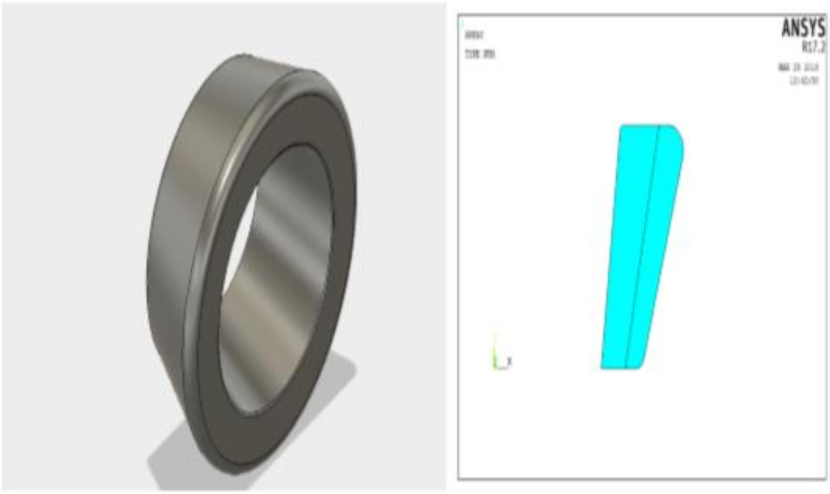


Fig-1: Design of Original Grinding roll

RESULTS AND DISCUSSIONS

The results obtained from the static structural analysis of grinding roll design are discussed and the behaviour of the grinding roll under different pressure loads is studied.

Static structural analysis of grinding roll

When the pressure of 24 MPa is applied, Static analysis of the grinding roll is performed and Finite element analysis has been done using ANSYS 17.2 and the contours obtained for normal stresses (hoop and radial) in grinding roller are shown below-

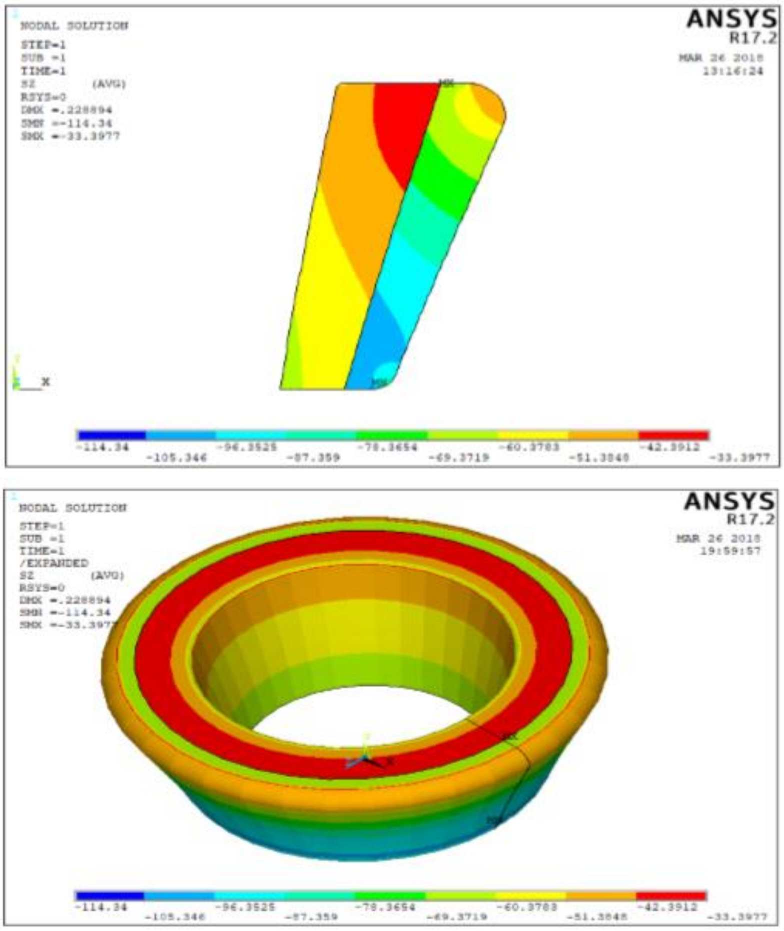


Fig-2: Contour for hoop stress in original grinding roll

The maximum hoop stress in the grinding roll is -33.3997 MPa and it is obtained at the top of the inner layer.

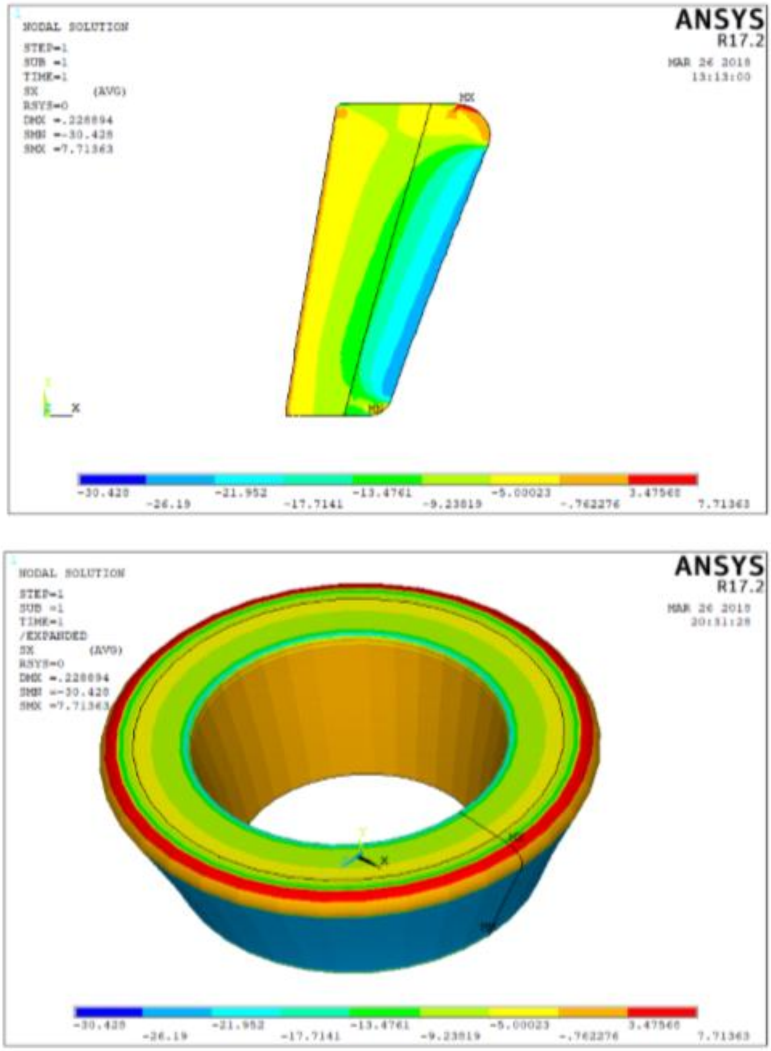
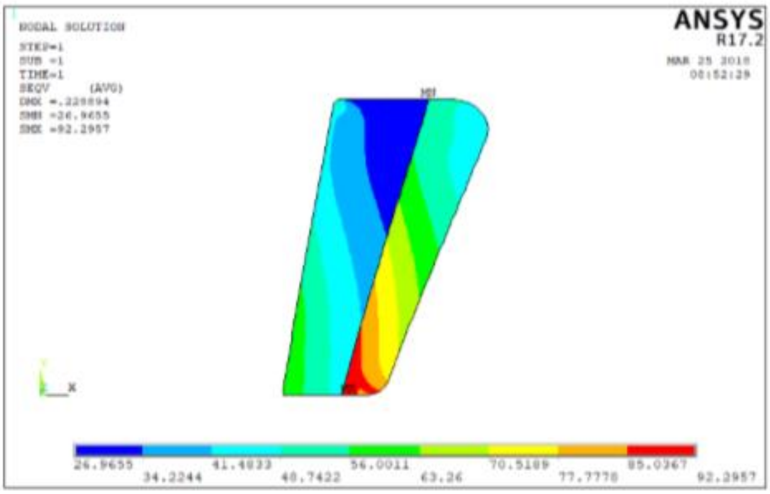


Fig-3: Contour for Radial stress in original grinding roll

The maximum Radial stress in the grinding roll is 7.71363 MPa and it is obtained at the fillet region of outer layer.



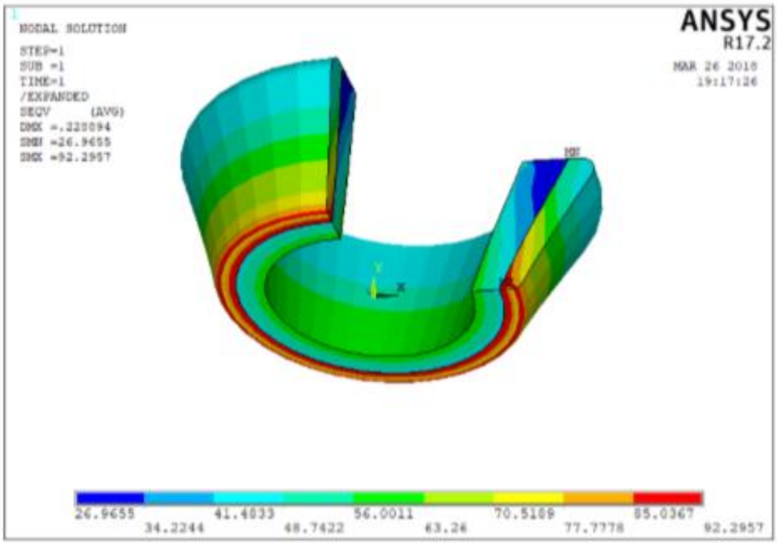
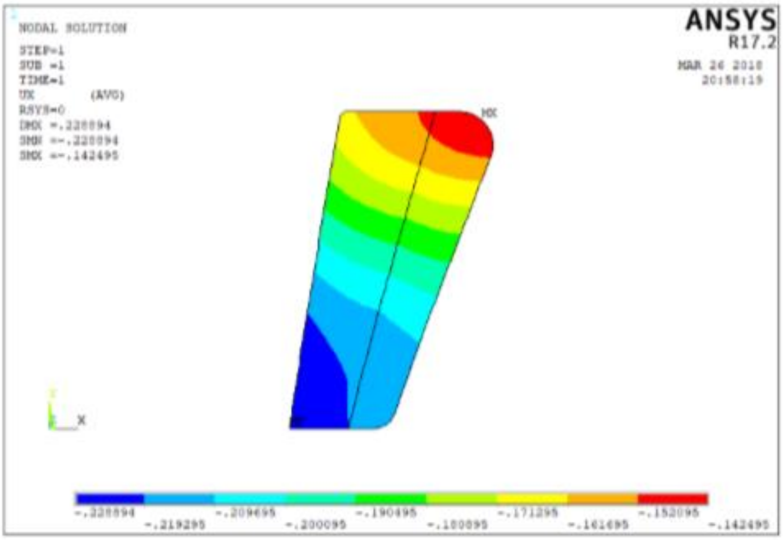


Fig-4: Contour for Von-Moises stress in original grinding roll

The maximum Von-Moises stress in grinding roll is 92.2957 and it is obtained at the bottom of the inner layer.



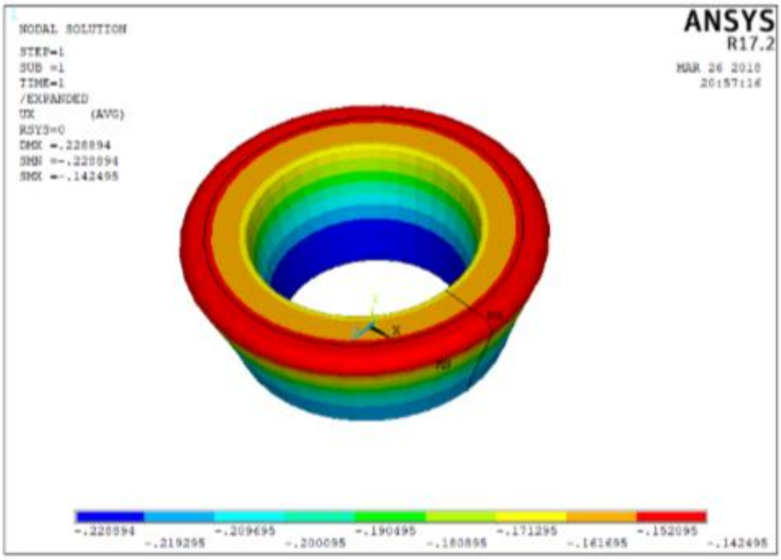


Fig-5: Contour for radial displacements in original grinding roll

The maximum radial displacement in grinding roll is -0.142495 and it is obtained at fillet region of the outer layer.

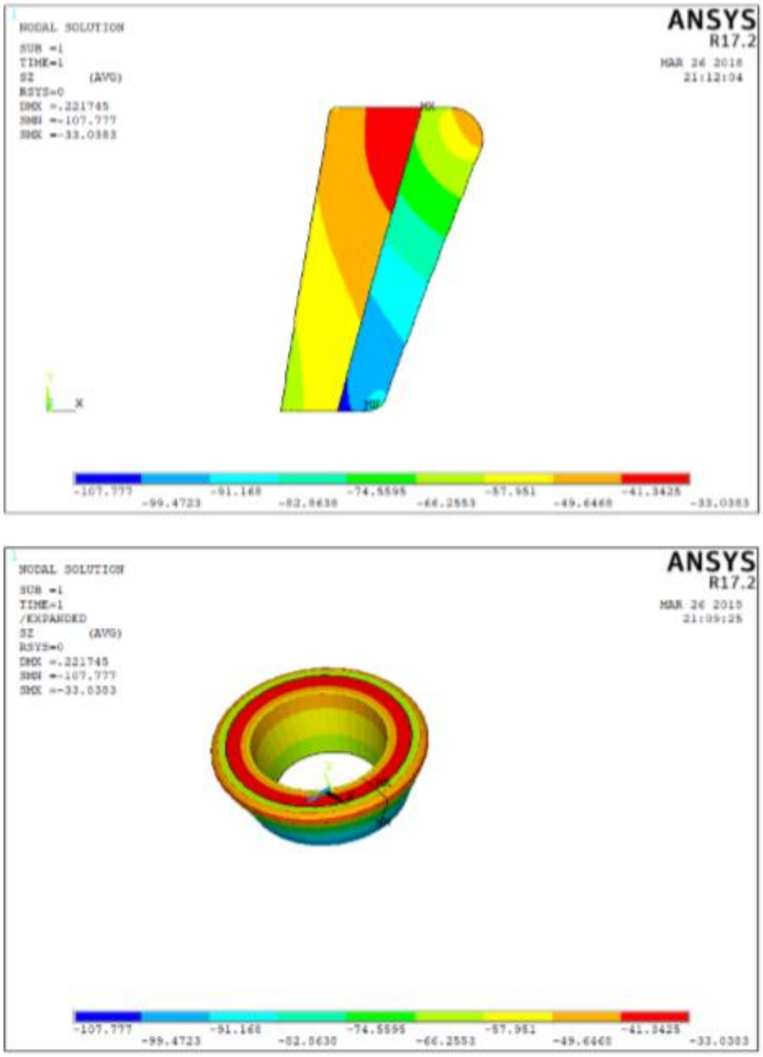


Fig-6: Contour for hoop stress in modified grinding roll

The maximum hoop stress in modified grinding roll is -33.0383 and is obtained at top of the inner layer.

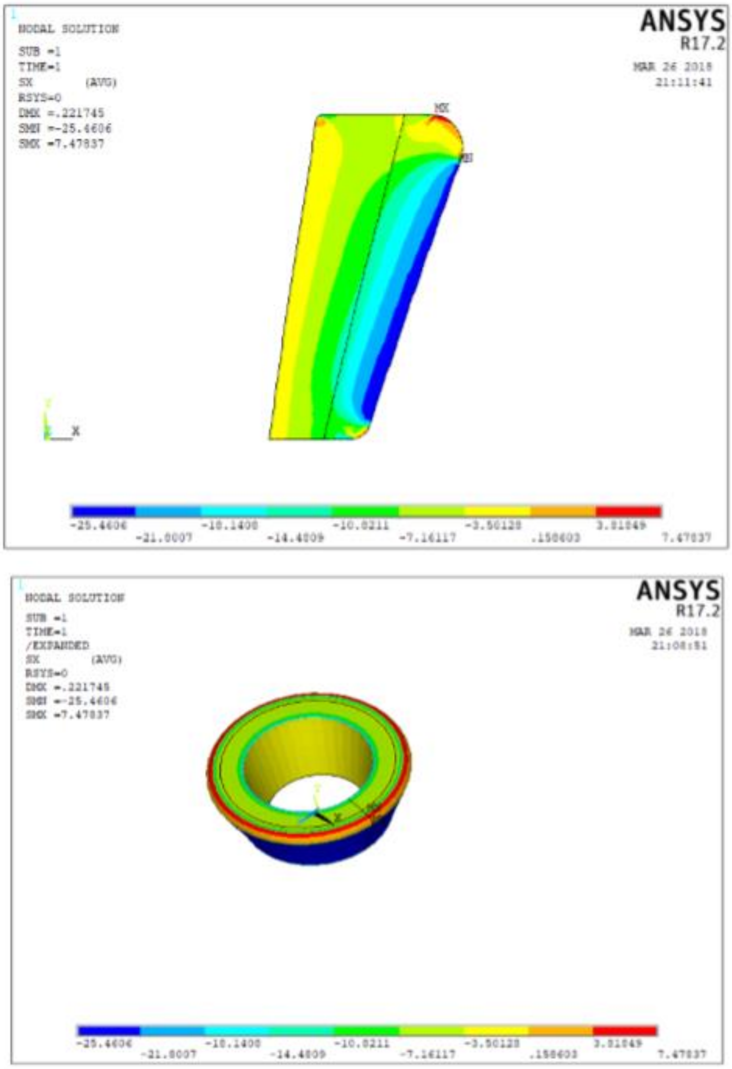
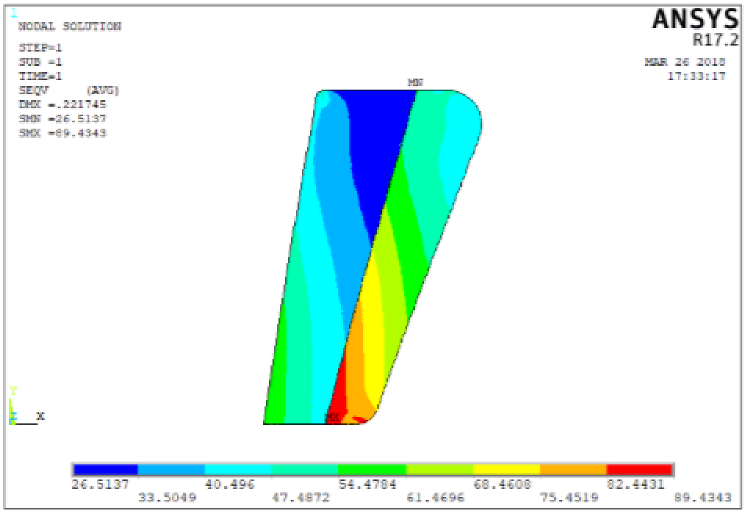


Fig-7: Contour for radial stress in modified grinding roller

The maximum radial stress in modified grinding roll is 7.47837 and it is obtained at fillet region.



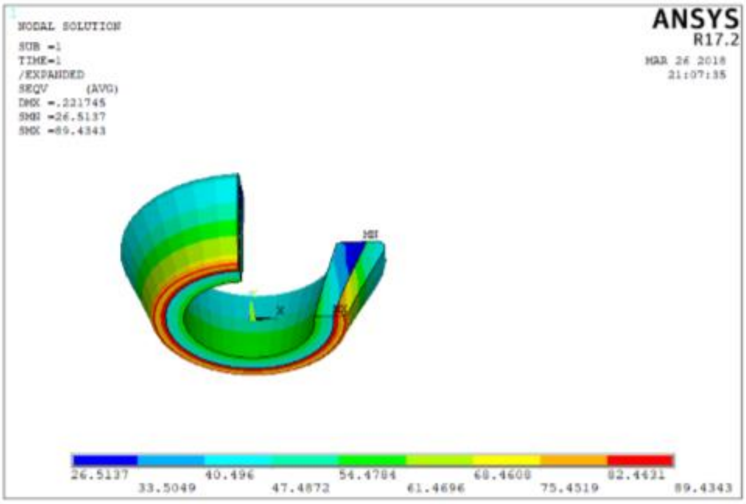


Fig-8: Contour for Von-Moises stress in modified grinding roller

The maximum von-moises stress in modified grinding roll is 89.4343 and it is obtained at bottom of the inner layer.

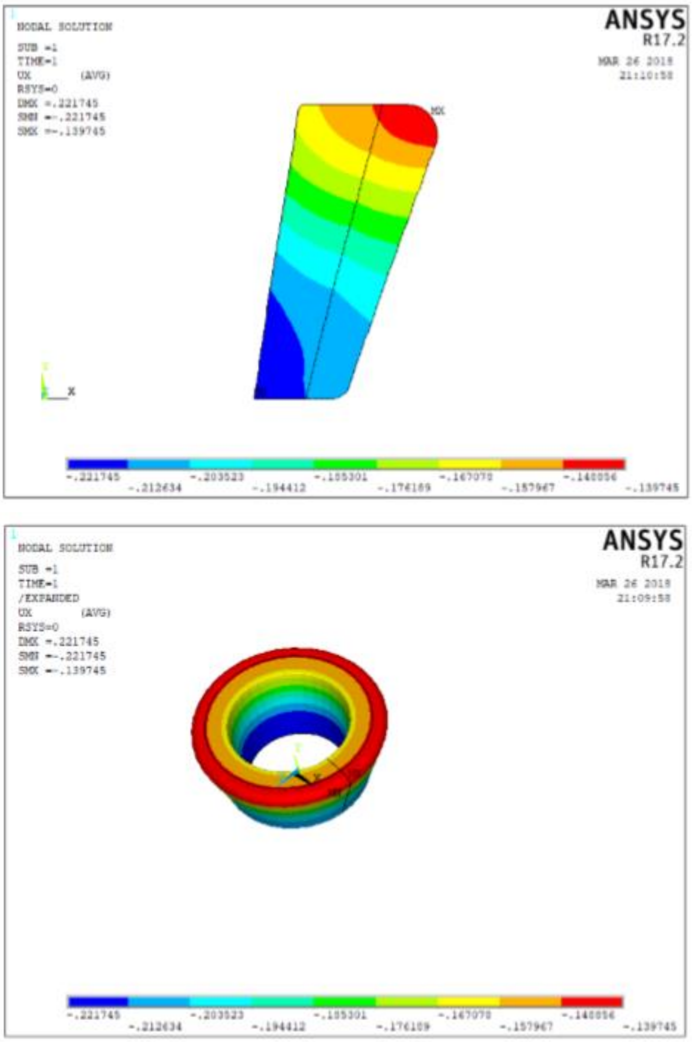


Fig-9: Contour for radial displacement in modified grinding roll

The maximum radial displacement in modified grinding roller is -0.139745 and it is obtained at the fillet region.

Comparison of Von-Moises Stress: The Von Moises stresses obtained for original and optimized design are compared.

S No	Grinding Roller	Equivalent (Von-Moises) Stress (MPa)
1	Original	92.2957
2	Optimized	89.4343

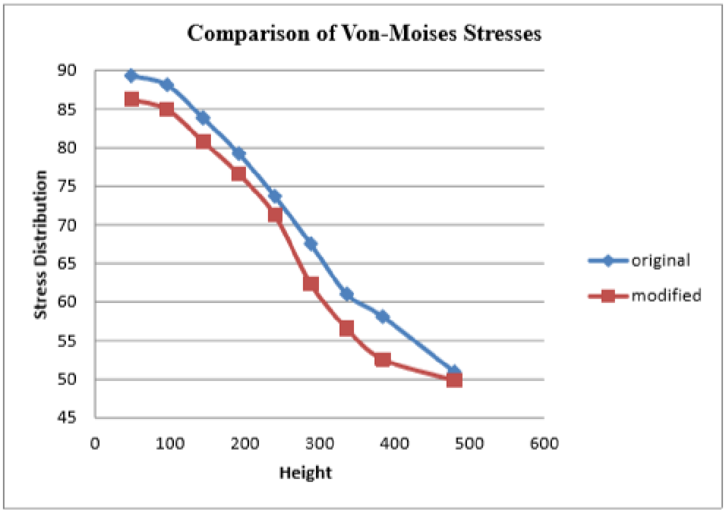


Fig-10: Variation of Von-Moises Stress across the height of the roller from bottom Layer to top layer

Variation of the Von-Moises stress across the height of the grinding roll is shown in the figure 10. The Height of the roller is taken from bottom layer to top layer and both original and optimized design Von-Moises stress are compared and maximum Von-Moises stress is obtained at 92.2957 MPa for original roller and 89.4343 MPa for optimized roller.

Comparison of Radial displacement

Table-1: Observations for Von-Moises Stress Results

S No	Grinding Roller	Radial Displacement in mm
1	Original	-0.142495
2	Optimized	-0.139745

Variation of the radial displacement across the height of the grinding roll is shown in the fig 11. The height of the roller is taken from bottom layer to top layer and radial displacements for both orginal and optimized design are compared. The maximum radial displacement for the original roller is -0.142495 mm and for the optimized roller is 0.139745.

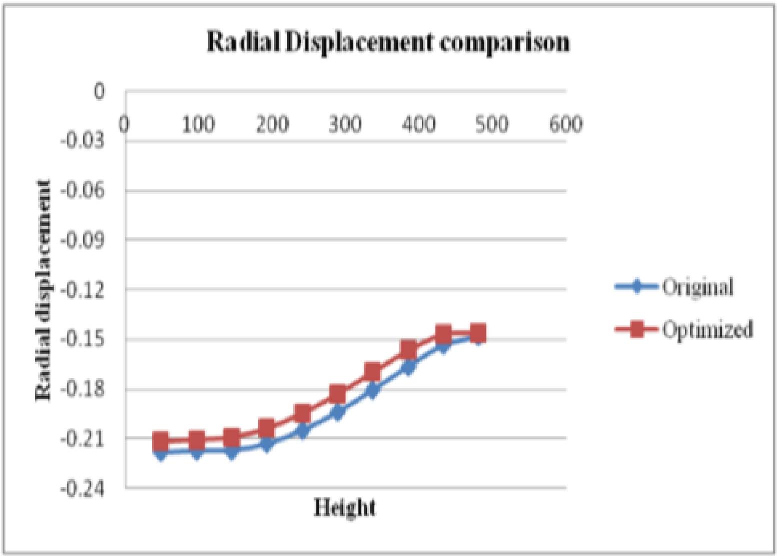


Fig-11: Variation of radial displacement across the height of the roller from bottom to top layer

Analysis of roller at different pressure loads

Analysis is carried out for the pressure load of 24 MPa and the above is repeated for different pressure loads of 21.5 MPa and 19.2 MPa and stresses and radial displacements are compared.

Table-3: Comparison of stresses at various pressure loads

Pressure (MPa)	Hoop Stress (MPa)	Radial Stress (MPa)	Von-Moises Stress(MPa)	Radial Displacement(mm)
19.2	-26.6267	7.3263	73.8344	-0.114012
21.5	-29.9284	7.5199	82.6792	-0.12767
24	-33.3997	7.71363	92.2957	-0.142495

It is concluded that from the above table, for the pressures of 19.2 MPa, 21.5 MPa and 24 MPa, the hoop stress, radial stress, Von Moises stress and radial displacement all are varying linearly.

CONCLUSIONS

The stresses and radial displacements are calculated for both original and optimized design and the following conclusions are drawn

- The hoop stress of -33.0383 N/mm2 obtained in the optimized design is less than hoop stress of -33.3997 N/mm2 obtained in original design and maximum hoop stress is obtained at top of the inner layer.
- The Von-Moises stress of 89.4343 N/mm2 obtained in the Optimized design is less than hoop stress of 92.2957 N/mm2 obtained in original design and maximum Von-Moises stress is obtained at the bottom of the outer layer.
- As the stresses in the Optimized design are reduced when compared to Original design, the wear and tear of the material has also been reduced which will increase the working hours of the grinding roll and increase the life time of the grinding roll.
- The radial displacements are also calculated for both original and optimized design and it is concluded that radial displacement of 0.139745 mm obtained in the optimized design is less than radial displacement of 0.142495 mm obtained in original design

REFERENCES

1. Jianxing R, Fangqin L, Qunzhi Z, Jiang W, Yongwen Y, Qingrong L, Hongfang L. Research of Multi-Fuel Burning Stability In A 300MW Coal-Fired Utility Boiler. Energy Procedia. 2012 Jan 1;17:1242-8.
2. Avadhesh explained in detail about performance modeling and behaviour analysis of coal handling system of a thermal power plant.2012.
3. Nayan S Adina, Mohammad Adil M Patil, Dr. A. M. Shirahatti "Stress Analysis and Optimization of Grinding component for Bowl Mills", International Journal for Scientific Research & Development Vol. 3, Issue 06, 2015
4. Gupta FA, Third CP. Simulation model for coal crushing system of a typical thermal power plant. International Journal of Engineering and Technology. 2009 Jun 1;1(2):156.
5. Rashidi S, Rajamani RK, Fuerstenau DW. A Review of the Modeling of High Pressure Grinding Rolls. KONA Powder and Particle Journal. 2017;34:125-40.

6. Huang B, Luo Z, Zhou H. Optimization of combustion based on introducing radiant energy signal in pulverized coal-fired boiler. Fuel Processing Technology. 2010 Jun 1;91(6):660-8.
7. Chu JZ, Shieh SS, Jang SS, Chien CI, Wan HP, Ko HH. Constrained optimization of combustion in a simulated coal-fired boiler using artificial neural network model and information analysis☆. Fuel. 2003 Apr 1;82(6):693-703.
8. Joseph TJ, Thapa DS, Patel M. Review on Combustion Optimization Methods in Pulverised Coal Fired Boiler.2017.