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ANALYSIS OF SURFACE THERMAL BEHAVIOR OF WORK ROLLS IN HOT ROLLING PROCESS FOR VARIOUS COOLING TECHNIQUES

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Abstract - ***Roll Breakage Failure in rolling mill is one of the basic problems in industry. It happens due to over draft or multiple passes done without stress relieving due to which rolls breakage on its surface. It was seen that there is scope to make the process better to cool the roller by using uniform cooling effect on roller. This procedure has been modeled & analyzed with the GAMBIT and FLUENT ANSYS 16.2 software. The Thermal Analysis is carried out for both steady and transient changes in rolls during cooling to observe the effect of cooling through different arrangement. Traditionally the industries are using hose pipe but there is a possibility to use different shaped nozzle to achieve better and uniform cooling effect on roller which will ultimately reduce the thermal stress in overall volume of the roller and increase its life.***

Key Words: *Hot Rolling, Uniform cooling Effect, Gambit & Fluent Ansys 16.2*

1. INTRODUCTION

Rolling is one of the oldest processes for reducing the cross section of metal sheet, the other metal forming processes like forging, casting, extrusion and others. All these metal forming processes are parameters dependent and tool dependent the project work is carried out in merchant mill of steel industry. The steel merchant mill equipments are very expensive and constitute a high proportion of the manufacturing cost. Therefore, the full utilization of equipments is an important goal for steel merchant mill. When the maintenance takes place, equipment will be down, availability will be reduced and the production capacity will be impacted.

2. LITERATURE REVIEW

2.1 Work Roll Analysis

Martha et al. [26] proposed a heat transfer model for hot rolling work rolls. Three models have been implemented to determine the transient heat flow. Finite-difference method was used for the generation of two models and other one generated by integrating the heat flow to the roll. A fourth model was steady-state based model generated by the integration of the heat flow. Sikdar & John [36] established a model for finding the work roll temperature in a hot strip mill by the effect of water jet orientation and other controlling Parameters. The results explain that the evaluation of surface temperature and heat flux becomes inferior when the temperature measurements are taken too far away from the surface, due to a thin thermal layer. Azene et al. [3] considered a optimization model for Work roll cooling system design. It presents a structure to optimize the design of work roll according to the cooling performance and also develops from a set of finite element analyses of the work roll cooling. A design of testing technique is employed to identify the FEA runs. Hamraoui [18] considered a model for finding out the thermal behavior of rollers during the rolling process. It was seen a numerical study developed to establish the two-dimensional temperature profile in the work roll of a rolling mill. The considered hot rolling mill consists of two hollow cylinders receiving heat in contact with the work piece and cooled by convection on its internal and external surfaces. Hsu et al. [19] considered a three dimensional inverse model for estimate the surface thermal behavior of the work Roll in hot rolling Process. In 3D inverse analysis it employs a different perspective to calculate the thermal behavior of the work roll in rolling process. This analysis is based on the temperature variations taken inside the roll at different locations. Sun et al. [32] proposed a FEM model has been used to determine the two-dimensional temperature profiles of the strip and the roll. Corral et al. [8] presented a hybrid, analytic and numerical model, the thermal response of the rolls used for hot rolling of steel slab has been shown. The model demonstrate flexible behavior to contain the changes in the thermo physical properties of the rolls or for changes in equipped parameters such as temperature profile or the rolling pace or length of slabs.

2.2 Jet impingement heat transfer analysis

Shaibu [38] considered a particular phenomenon modeled and simulated with the help of ANSYS 13 Software. Based on the three dimensional heat equations and temperature fields of a roll were investigated using finite element method (FEM). The method is illustrated to determine the heat transfer coefficient distribution of an array of liquid water spray type which is used to cool the rolls on a steel strip rolling mill. Baonga et al. [4] studied the hydrodynamic and thermal characteristics of a free round liquid jet impinging into a heated disk for nozzle to plate spacing of 3-12times nozzle diameter. Lee et al. [23] taken the experimental study and concluded that the stagnation point Nusselt number increases with increasing surface curvature by using convex surface with low curvature using liquid crystals to measure the local surface temperature at Reynolds numbers ranging from 11,000-50,000. Inada et al [20] investigated on jet impingement on a plate and studied laminar flow between a plane surface and a two dimensional water jet with constant heat flux using the Runge-Kutta method to obtain solutions for the boundary layer momentum and energy equations.

From the past years research works have carried out a wide range of investigation in rolling process to develop the models for the prediction of roll temperature profile and to minimize the thermal fatigue during rolling. Researches works have mainly focused on the thermal profile across the boundary layer temperature variation are not the same at all stands. Recent work with this analysis of work roll and temperature profile in hot and cold rolling has been mentioned in the literature. The angle of bite region and the water cooled region of the roll is analyzed for a limited number of revolutions of the work roll surface. They proposed, to investigate the work roll, have been used both one dimensional and two dimensional models. It also been used to find the temperature profile of the roll with the effect of uniform cooling effect.

3. PROBLEM IDENTIFICATION

By traditional method of hose pipe cooling we observe that due to impingement of water on a small surface area of roller there is non-uniform cooling effect on the roller, due to non uniform cooling effect thermal stresses remain inside the roller and which gradually increases to a level which leads to breakage of roller. Breakage of roller ultimately increases the lead time which reduces the production rate. Factors affecting roll breakage such as improper selection of roller material & cooling water arrangement, improper roller maintenance, drastic increase in temperature leads to fire cracks on roller and over drafting. In order to investigate thermal behavior of work rolls in hot rolling process for different types of jet impingement cooling. The objectives of this investigation are as follows

1. To model the work roll for thermal analysis of its surface.
2. To model jet impingement arrangement for Hose Pipe.
3. To model jet impingement arrangement for Nozzle
4. To find temperature distribution of work roll surface for jet impingement cooling with Hose Pipe.
5. To find temperature distribution of work roll surface for jet impingement cooling with Nozzle.
6. To compare Hose Pipe temperature distribution against Nozzle.

4. METHODOLGY

4.1 Simulation of Hose pipe

1. First of all draw a Model of Roller and Domain in GAMBIT having roller diameter = 7.5 cm & domain = 75 cm. By Feeding this dimensions in GAMBIT Modeler we will get the required model.
2. In modeling process first of plot points according to the dimension of model required, so that by using Edge Tool we can draw the boundary of the model. 3. Then by using Edge option draw circle through given point to make roller and domain diameter.
4. By using point and line tool divide the domain in different section.
5. Now do the edge meshing in which define the definite numbers of element throughout the edge and generate mesh along the edges.
6. Now again do face meshing for roller by Quad/tri and pave meshing scheme and again uncheck the spacing box so that it will generate grid according to the edge meshing.
7. Now start doing the Face meshing by Quad & map scheme. Always remember to uncheck the spacing box so that it will calculate the grid according to the meshing done in edges, and then generate face meshing.
8. After generating mesh, start specifying the boundary condition.
9. Now, define the continuum type for the model in which specifies one of the fluid zone to air and another fluid zone to water. Also specify the solid zone to the roller material.
10. Now open Fluent in ANSYS for CFD work, then read the mesh file. Now check the mesh to find out error in the meshing of model. If there is any error first of all resolve it and then go further.
11. The grid of the mesh and turn on the energy equation check box & set the viscous definition to k-epsilon type, after that define the fluid and solid type.
12. Now define the operating condition in which we define the gravity in negative (-) y direction to 9.81 m/s^2 and the

operating temperature of water to 17 degree centigrade. Now define boundary condition.

13. After giving Operating and Boundary condition, now start Solution Initialization compute from inlet zone. Enter the value of no of iteration to 1000.

14. After complition of iteartion to display the result in graphical format go to the display tab and see the contours for static temperature distribution throught out the roller.

4.2 Simulation of Nozzle

All modeling process, meshing parameters, Operating & Boundary conditions and mass flow rate to the inlet was same as above, but here only the shaped of the nozzle is changed at the inlet.

5. RESULT AND DISCUSSIONS

5.1 Comparison between temperatures distribution graphs of Hose pipe and Nozzle

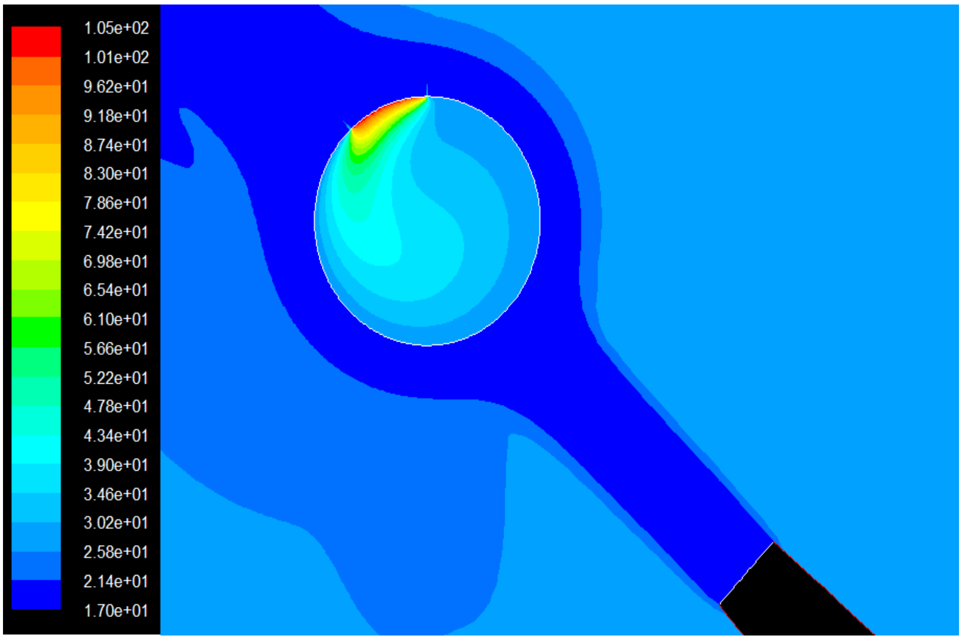

Figure 5.1.1: Temperature distribution graph of Hose pipe

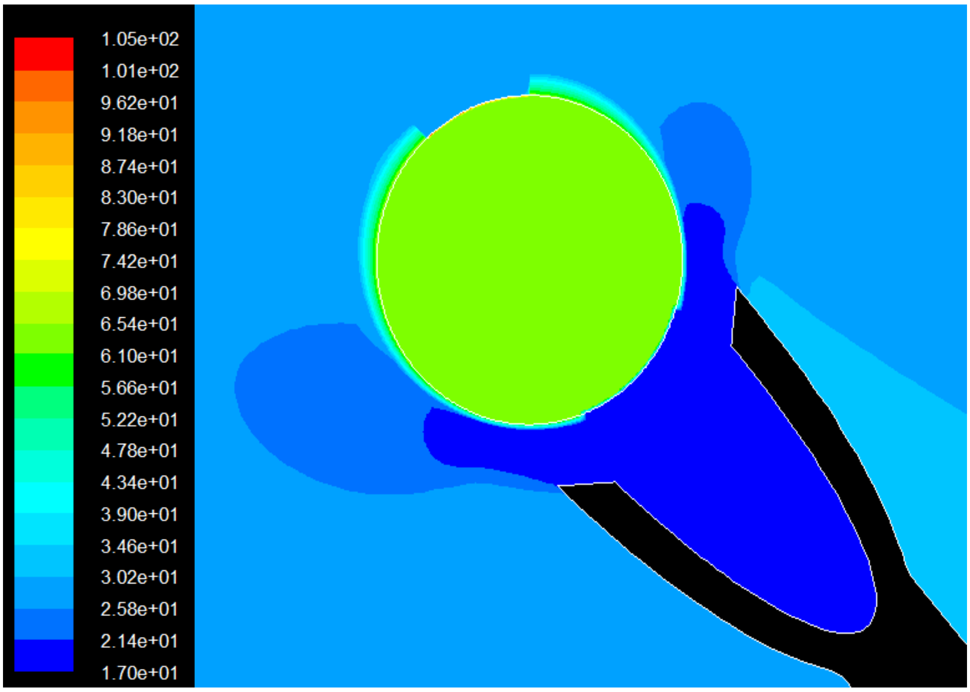

Figure 5.1.2: Temperature distribution graph of Nozzle

CFD Analysis is carried out to obtain the result of cooling on temperature profile & the heat distribution of the roll. From the result we observe that the maximum heat transfer is occurring in the roll bite region of the work roll. The 2D model consists of different area like the roller area, domain area which is divided into 4 zones. One zone is under influence from bite angle, two zones are occupied by atmosphere and the last zone is occupied by the jet impingement. The roll bite region is the contact area in between roll and billet, and hence heat transfer through conduction happens in this region.

In the case of Hose pipe cooling maximum temperature of 105°C is obtained at the roller surface which is in direct contact with Billet & the surface which is in direct contact with jet impingement having minimum temperature of 25°C - 30°C. Throughout the volume of the roller the temperature decreases from the bite angle surface to the surface which is in direct contact with jet impingement.

In the technique in which we use nozzle for cooling the roller the temperature distribution is more uniform throughout the volume of roller which is between 60°C - 70°C, for the same mass flow rate of 0.5kg/sec through nozzle as in the case of Hose pipe.

Hence thermal accumulation in roller is less in this technique which ultimately reduces the thermal stresses which will increase the life of rollers.

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