International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June 2018 www.irjet.net p-ISSN: 2395-0072

Effect of Inbuilt Cooling System in Work Rolls

M. Ramagopal [1], K. Ramanaiah [2]

[1]PG Scholar, Department of Mechanical Engineering, VRSEC, Vijayawada, Kanuru.

[2]Senior Assistant Professor, Department of Mechanical Engineering, VRSEC, Vijayawada, Kanuru.

Abstract - *In the process of operating work rolls they are exposed to alternative cycles of heating and cooling modes. The cyclic process of heat gain and loss will deteriorate the surface finish of component. So it is necessary to observe the thermal behavior of work roll. The whole work roll has been geometrically prepared and analyzed in the Ansys Software to predict the temperature value. The effect of inbuilt cooling by a liquid flow and some part of exterior air convective cooling, along with angular heat flux input has been taken into consideration for this study. The spiral liquid path has been traced by the computation fluid dynamics for the study of velocity variation in the component inside. All virtual models are carried on for both transient state and steady state for temperature changes in the work rolls.*

Key Words **: Cyclic process, Thermal behaviour, Inbuilt cooling, Steady state, Transient State, Work Rolls, Velocity Variation.**

1. INTRODUCTION

Rolling is the process of reducing thickness of the given component and dimensional changes will takes place so that uniform thickness will appear in the component at the end. Rollers are classified as two types mainly, one is hot roll and another is chill roll. In hot roll we give heat input to the roll using hot fluid flow inside so that when we start working the component gets heated along with pressure application, this will ensure us more precise work. Chill rolls are type of work rolls which we have taken in our consideration in this project. In chill rolls we are keeping cool liquid so that at high temperature conditions the whole work piece heat will get transformed to the work roll and now from work roll to the liquid.

1.1 Work Roll Type

In the present taken rolling process we are dealing with rollers which can handle fluid flow inside the cylinder. of work roll is mono-flow double shell model in this the fluid will be flown in between two cylinders one is the external hollow open type cylinder and another is the internal closed type cylinder. In external nozzle spray cooling of rollers the common defect observable in the final work piece are uneven Distribution of temperature.

1.2 Work Rolls Care

Regular cleaning and brushing must be done on work rolls, corrosion may happen due to air or liquid so storage cautions must be taken, we can utilize the rust–binder solution, rollers are helpful in conveying materialistic loads also so we must be careful in proper functioning of the work rolls to avoid sudden failures. The temperature must be uniform. High temperature zones more amount of material will accumulate due to easy deformation and in cooler zones less amount of material will accumulate this disturbs the flatness of the work piece produced this is the main problem.

2. LITERATURE REVIEW

Heat exchange phenomenon between any two work rolls with the consideration of the frictional effects is explained in this paper. The two work rolls are cooled with the help of convective cooling technique using fluids. They have derived a numerical model to calculate the temperature values in the case of steady state [1]. They have developed a numerical solution model to calculate the two dimensional heat distributions in the work rolls during rolling mill process. The work is carried on work pieces where two hollow cylindrical work rolls are given with input of heat flux to some angular portion then roll is cooled by external convective air cooling and internal homogenous liquid cooling [2]. They have studied the three dimensional analysis of temperatures field of work roll and thermal stresses values using the finite element method. These are more important values in predicting lifetime and thermal fatigue of component. They have divided the work roll into many zones naming conduction zone, convection zone, radiation zone in terms of heating mode and cooling modes It is also confirmed that the variation in maximum and minimum temperatures grows up as the time value is increasing. As we are going deeper into the surface layer the inner temperature shows only little modifications. It is also confirmed that the variation in maximum and minimum temperatures grows up as the time value is increasing. As we are going deeper into the surface layer the inner temperature shows only little modifications. Decision making in design is difficult due to presence of uncertainties, uncertainty means input variability, they have proposed a mathematical modelling for this. They have compared the stress and temperature variations. They also imposed constraints in this process of calculation. The temperature

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June 2018 www.irjet.net p-ISSN: 2395-0072

predicted is taken as the difference between temperature value of roll after process and before starting of process.

3. GEOMETRICAL MODEL AND SIMULATION

3.1 Double Shell Mono Flow Work Roll model

Outer Shell			Inner Shell		
Outer Diameter	Inner Diameter	Length	Outer Diameter	Inner Diameter	Length
200	180	500	140	130	340

Table -1 : Geometrical Dimensions used in the construction of work roll in Catia software (All dimensions are in mm).

With the reference from American roller company industrial data, We have utilized below tabular values to construct the work roll in the Catia software so that it can be directly imported as external geometry file into the ANSYS workbench. This will give us the opportunity to analyze the cooling method, temperatures on the surface and inside the work roll and thermal profile during the rolling process.

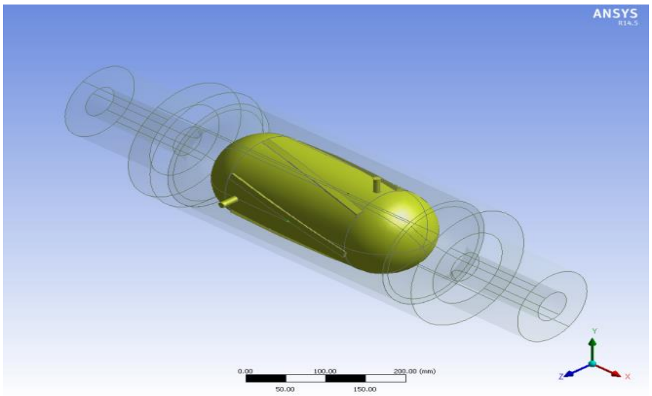


Fig-1: Internal cylinder with baffles construction

Nomenclature

q Heat flux……….. W mm^{-2}

T Temperature……K

h Heat transfer coefficient….. W mm^{-2} K^{-1}

V Linear velocity…………..m s^{-1}

Greek Symbols

ω Rotational speed……..rad s^{-1}

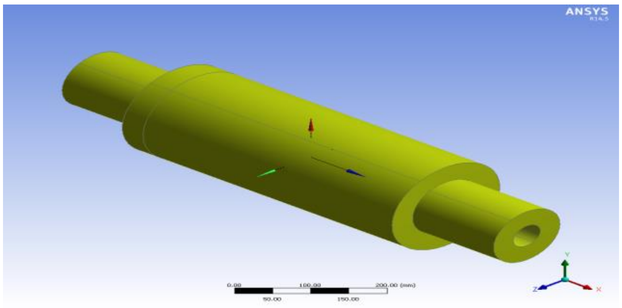


Fig-2: Final Work Roll in CATIA software

Initially we have constructed the internal cylindrical geometry to this part we have added the spiral baffles and later added supports to this internal cylinder for connecting with external cylinder. Spiral baffle will be useful in pushing the liquid flow in upward direction against the gravity while work roll is rotating. The supports are for connection between cylinders to maintain the common central axis for both the cylinders.

3.2 Fluid flow Simulation process:

In this analysis we have imported Catia file of work roll into Ansys and then generated the component. In meshing we have opted for simple tetrahedral mesh. We have allocated the materials in the setup column, water for fluid and copper for external cylinder and rubber insulation for internal cylinder. For whole external cylinder, internal cylinder, and fluid, we have given input rotational motion value (ω) = 15 rad s^{-1}, 5 rad s^{-1} using moving frame option in the setup part and given inlet linear velocity (V) = 5 m s^{-1} to fluid separately. We have given heat flux (q) = 1000 W m^{-2} input over complete angular portion on the external surface of cylinder while rotation. Then we did the solution initialization and took the results at around 2000 number of iterations.

3.3 Transient thermal simulation process :

We have used the combination of copper and ethyl glycol with the input heat flux (q) = 0.3 W mm^{-2}, For Aluminum and water the input heat flux (q) = 0.1 W mm^{-2}. In the boundary conditions, we have given heat flow value as zero for perfect insulation condition for the internal cylinder component. Liquid is given as convection at T_{liquid}= 15^0C and h = 0.015 W mm^{-2} K^{-1}, condition in which heat will flow from external cylinder internal surface to the cold fluid which is in between shells. The heat flux input is given to external cylinder . The left portion of the external cylinder is under the air-convection process at T_{air} = 22^0 C and h = 0.005 W mm^{-2} K^{-1}.

4. NUMERICAL RESULTS

We have done fluid flow analysis and transient state thermal analysis on the double shell mono flow work roll.

4.1 Fluid flow analysis

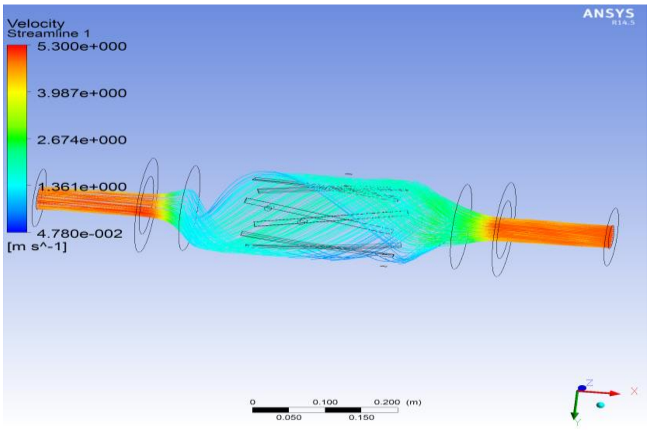


Fig-3 : Fluid Flow inside cylinder at (ω) = 15 rad s^{-1}

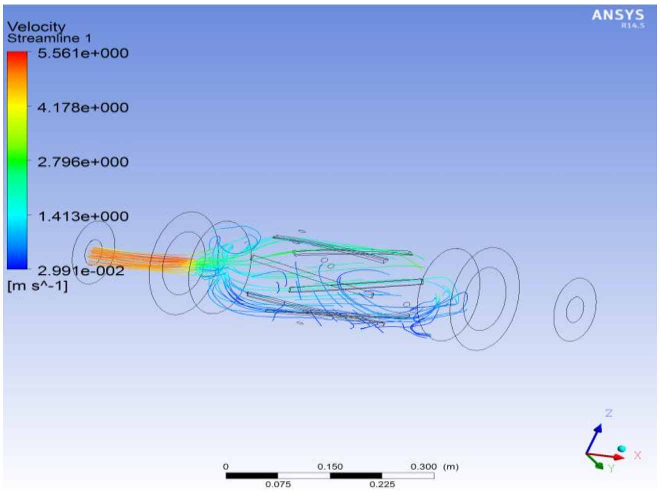


Fig-4 : Fluid flow inside cylinder at (ω) = 5 rad s^{-1}

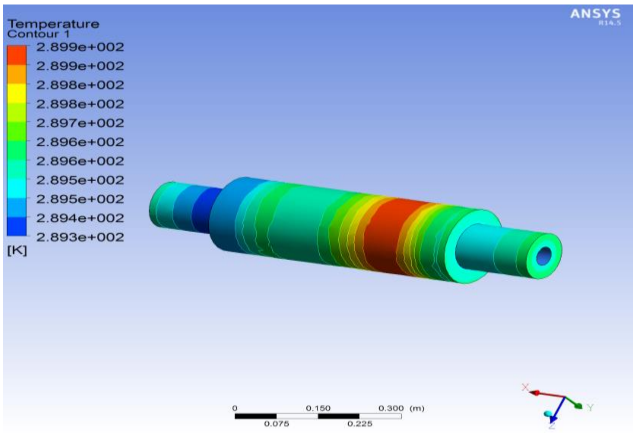


Fig-5 : Temperature on External surface at (ω) =15 rad s^{-1}

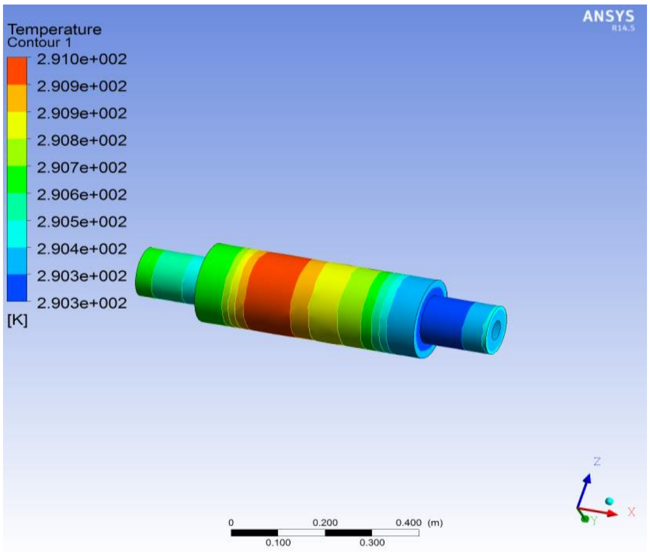


Fig-6 : Temperature on external surface at (ω) = 5 rad s^{-1}

When the work roll is rotating at high speeds for one complete revolution of the work roll more amount of fluid will be trying to be attached to cylinder this will increase the heat transfer enhancement, for this purpose only we have placed the baffles but they alone can't fulfill this purpose of filling the whole cylinder with fluid. If this speed value is too low then this will increase the difference between maximum value of temperature at hot zone and minimum value of temperature at chill zone this we can observe. The rotational speed of work roll must be set such that work roll must be able to get uniform state of temperature with in the short time. The uneven expansion of work piece due to high temperature and uneven contraction of work piece due to low temperature will be reduced which increase surface finish. To maintain maximum amount of fluid-work roll contact surface we must maintain reasonable rotational speed, It should not be very low, when work roll rotation is very slow the fluid will rotate slowly thus chances of having empty space is more. The fluid is absorbing more amount of heat at high speeds than low speeds from contour we can observe, fluid temperature reached at rotational speed (ω) = 15 rad s^{-1}, case is (T) = 364^0 C, and in (ω) = 5 rad s^{-1}, the fluid temperature is (T) = 274^0 C. The roller surface maximum temperatures in (ω) = 15 rad s^{-1}, case is (T) = 289.9^0 C, where as in (ω) = 5 rad s^{-1}, is (T) = 291^0 C. When we are able to control these peak temperature differences then we are surely able to control surface finish of the work piece that is produced.

4.1 Transient thermal analysis

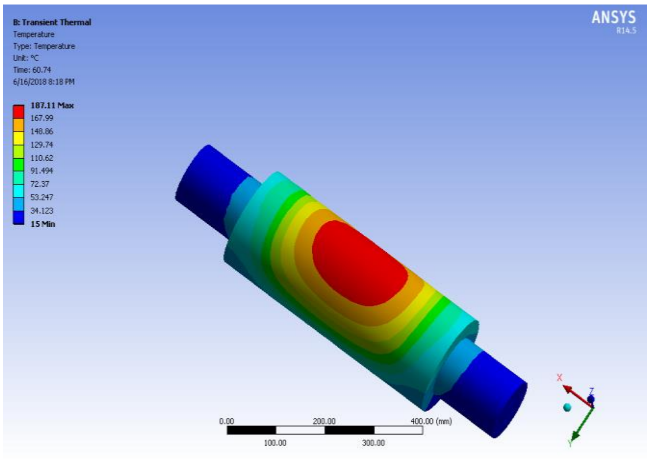
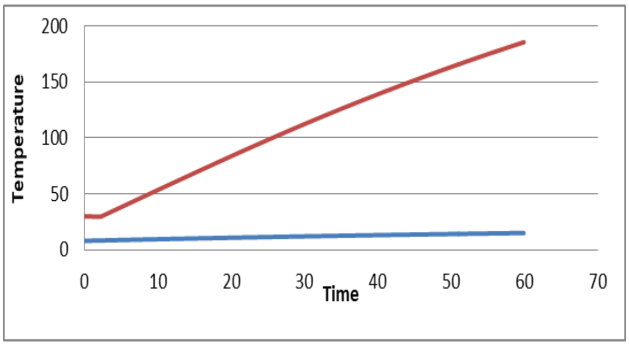


Fig-7: Temperature variation with Copper-Ethyl Glycol



Graph-1: Max (red) and Min (blue) temperature variation in work roll for copper

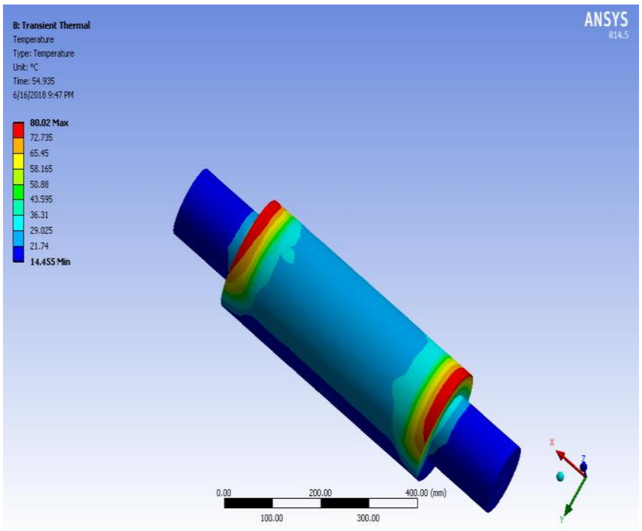
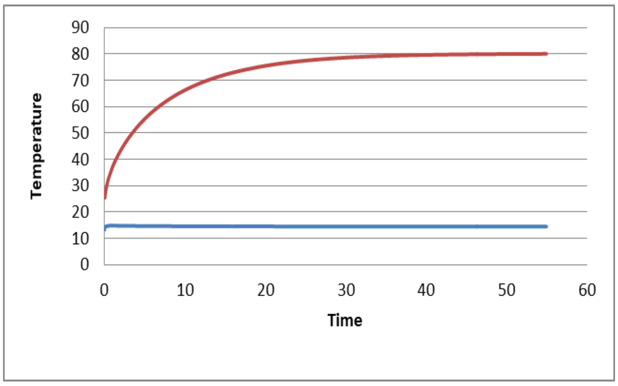


Fig-7: Temperature variation with Aluminium -water



Graph-2: Max(red) and Min(blue) temperature variation in work roll for Aluminuium

We have given the input heat flux and manufactured the roller with Copper material and taken the Ethyl glycol as fluid inside the cylinder as the time is progressing with process the hot surface of external cylinder will be cooled by the fluid flow, here the fluid boiling temperature is very high, then fluid can take the much of the heat from the roller that is why in contour we have less surface area shaded in red color which is at very high temperature. In the next combination we have utilized aluminum work roll with water fill then based on the heat absorbing ability of the liquid it has performed its work of decreasing work roll temperature. In all those cases the temperature with respect to time for work roll surface is decreasing and for fluid it is increasing.

5. CONCLUSION

A numerical model was developed for the analysis of heat transfer inside the roller, which takes into account the temperature distribution in the presence of fluid flow. This approach is much more realistic than that adopted by many authors, which consider the fluid as full of single cylinder. The numerical results obtained from the developed model highlighted the inter-related roles of fundamental parameters considered in the present work: the rotational velocity, the heat flux input and type of fluid. The numerical results show particularly that rotational speed controls the influence of the two other parameters. When the rotational velocity is around (ω) =15 rad s^{-1} then heat transfer rate is more than comparing with other case.

In the transient thermal case the combination of copper and ethyl glycol, we have given heat flux (q) = 0.3 W mm^{-2} and fluid has absorbed lot of heat because it has very high boiling point in varying condition temperature distribution on external surface is varying from center to ends in a gradual manner and distribution is symmetric on that surface, coming to aluminum-water situation when we gave (q) = 0.1 W mm^{-2} the temperature value is low in the middle and high at both the ends.

REFERENCES

1. M. Hamraoui, Z. Zouaoui, Modelling of heat transfer between two rollerin dry friction, International Journal of Thermal Sciences 2009; vol 48, pp.1243-1246.

2. Mohamed Hamraoui, Thermal behaviour of rollers during the rolling Proccess, Elsevier - Applied Thermal Engineering 2009; vol 29, pp. 2386-2390.

3. Kingston Gene zak and wendy xuwang, Adhesive bonding of sheet for laminated metal tooling, Queen's Univeristy, Kingston, Kingston, ON, Canada, 1999;

4. Yoshiro serizawa, Heat transfer technology for steel rolling process, Nippon steel & sumitomo metal technical report 2016; No. 111.

5. Pete Eggen, Dave Grishaber, Controlling the web temperatures, Published in Nippon Steel And sumitomo metal technical report, flexible packaging Magazine 2008;

6. Mikulionok, Technique of Parametric and Heat Computations of Roller for Processing of plastic and rubber compounds, Russian Journal of Applied Chemistry 2010; vol 83, pp.125-138.

7. T. S. Skoblo, O. Yu. Klochko, A. I. Sidashenko, an R. G. Sokolov, Heat Treatment of Two Layer Alloyed iron Roller, Stal international journal publications Springer Link 2013; vol 43, pp. 77-80.

8. Haozhen Zhang, Cheng Zhou, Chunxiao Wei Numerical Simulation of Thermal Field of Work Roll during Top Side-pouring Twin-roll. Casting of Steel, ISIJ Advance Publication by J-Stage, 2017; vol 57, pp.1811-1820.

10. R. Zahradník, J. Hrabovský, M. Raudenský, Study of the work roll cooling in hot rolling process with regard on service life, Brno University of Technology, La Metallurgia Italiana 2014; vol 4.

11. Hyung-Jun Changa, Heung Nam Han, Prediction model for surfacetemperature of roller and densification of iron powder during hot roll pressing , International Journal of Machine Tools & Manufacture.2007; vol 47, pp.1573-1582.

12. N. V. Telin and N. N. Sinitsyn, Roller Temperature in Metallurgical Machines with Scale Formation, published in Izvestiya Vysshikh Uchebnykh Zavedenii, Chernaya Metallurgiya 2016; vol 46, pp.463-466.

13. N. V. Telin and N. N. Sinitsyn, Roller Temperature in Metallurgical Machines with Scale Formation, published in Izvestiya Vysshikh Uchebnykh Zavedeni, Chernaya Metallurgiya 2016; vol 46, pp.463-466.

14. S. Serajzadeh, Effects of rolling parameters on work-roll temperature distribution in the hot rolling of Steels, International Journal of Advanced Manufacturing and Technology 2008; vol 3, pp.859–866.

15. Y.T. Azene, R. Roy, D.Farrugia, Work roll cooling system design Science optimization in presence of uncertainty and constrains, CIRP Journal of Manufacturing and Technology, Science direct, Elsevier publications. 2010; vol 2, pp.290-298.