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CFD Studies on Multi Lead Rifled [MLR] Boiler Tubes

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ABSTRACT
This paper reports the merits of multi lead rifled [MLR] tubes in vertical water tube boiler using CFD tool. Heat transfer enhancement of MLR tubes was mainly taken in to consideration. Performance of multi lead rifled tube was studied by varying its influencing geometrical parameter like number of rifling, height of rifling, length of pitch of rifling for a particular length. The heat transfer analysis was done at operating conditions of an actual coal fired water tube boiler situated at Apollo Tyres LTD, Chalakudy, India for saturated process steam production. The results showed that the heat transfer increased when compared with existing inner plane wall water tubes.
Keywords - CFD, Coal fired water tube boiler, Geometrical parameters, Multi Lead Rifled [MLR] tube, Operating conditions

I. INTRODUCTION

The increasing cost of energy in the past years aroused the need for using more efficient energy systems. This in turn encouraged researches in the field of augmenting heat transfer in heat exchangers. Several techniques were recognized for the study of heat transfer enhancement; out of which, rifling is found to be a powerful heat transfer enhancing tool. In this study three main geometrical parameters of rifled tubes are taken in to consideration. The three parameters are number of rifling, height of rifling, and length of pitch of rifling.

The influence of geometrical parameters are depend upon the operating conditions means operating pressure, temperature ,mass flow rate etc .So optimization of the geometry used for a particular operating condition is an important criteria for improving heat transfer. In this study the heat transfer of multi lead rifled boiler tube was analyzed with the real operating conditions of a coal fired boiler which is situated at Apollo Tyres LTD , Chalakudy,India, where the steam produced at saturated condition for the processing of vulcanization of rubber of automobile tyres. In the real condition the boiler water tubes are plane walled .So the optimized rifled geometry performance was compared with the performance of inner plane walled tube.The analysis of the tube flow was done using Ansys 14 and geometry and was modeled using Solid Works 2012 ,meshing was done using Gmabit 2.4.6.Material properties of steel and water was copied from the data base of Ansys Fluent software.

II. PROBLEM SETUP AND MODELING

In this 3 dimensional CFD study a tube of 5.08 cm outer diameter with a thickness of 0.35 cm is considered and the analysis was done for a length of 150 cm .Multi rifling is provided with three varying parameters number of rifling, height of rifling, length of pitch of rifling. Figure 1 shows the MLR tube geometry. The boiler tube material is considered as steel. The commercial CFD software employs a control volume based technique to convert the governing equations which are solved numerically using the implicit method. In the segregated formulation the governing equations are solved sequentially, as it is segregated from one another.

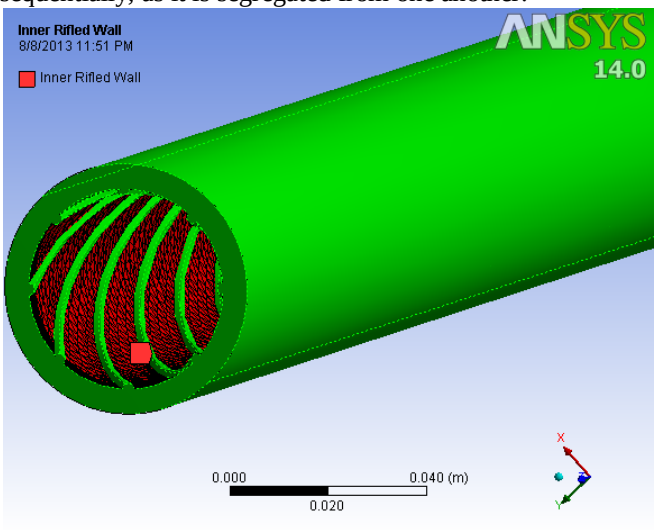

Figure 1 Geometry

A 3D tube geometry with multi lead rifling is considered. The mesh was created using GAMBIT 2.4.6.The tube geometry details and operating conditions are given below. Mesh generation plays an important role in obtaining accurate results. A quadrilateral mesh was created uniformly throughout

the area and analyzed using FLUENT, ANSYS 14.5 package.

Number of rifling : 8
Height of rifling : 0.11cm
Length of pitch : 25.4 cm

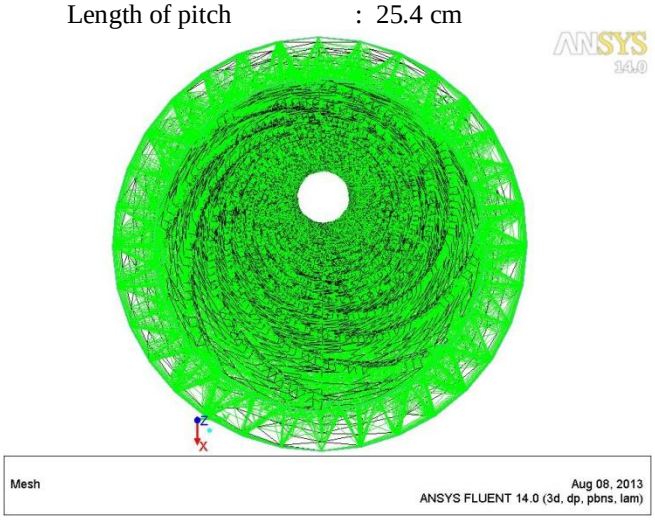

Fig 2 Meshed Geometry

III. SIMULATION OF THERMAL FLOW

3.1 COMPUTATIONAL DOMAIN WITH BOUNDARY CONDITION

The flow and thermal variables are defined by the following boundary conditions.

Working pressure : 22 kg/cm^2
Inlet water Temperature : 450K
Outer wall Temperature : 1000K
Mass flow rate : 0.034 kg/sec
Saturation temperature : 490K

The solution convergence is obtained by monitoring the continuity, momentum, energy, turbulence and species equations separately Figure 4 shows the profile of temperature distribution of water inside the tube. The temperature of the flue gas is 1000 K and heat transfer takes place to the water inside the tubes. The temperature of the water inside the tube reaches approximately 550 K. The temperature distribution in the boiler tube is affected by many variables such as mass flow rate of steam, steam temperature, feed water temperature and pressure. Therefore, effect of these variables is also considered by running a limited number of simulations By using the CFD simulation the result will contains the enhanced heat transfer due to the increased wetted perimeter of the boiler tube and some other effects due to rifling. The main heat transfer enhancement in actual case is due to the increased heat transfer area and the enhanced contact of water to the tube wall. During flow boiling wet steam generated will flow through the water tube, may be in some region steam may in contact with the tube wall, heat absorption capacity of steam is poor when compared with water, so sufficient tube cooling may not take place at that region . In MLR tubes there will be a swirling flow and that centrifugal force will separate steam and water, denser water will be taken away to the wall region by keeping less dense steam at the center region. This effect of MLR boiler tube will make the heat transfer more efficient than ordinary plane boiler tube.

IV. RESULTS AND DISCUSSIONS

Enhancement in the heat transfer in boiler furnace will reflect in the performance of the boiler. A small increase in the heat transfer of the tube will make huge change in the overall performance of the boiler. The boiler which is studied having 332 vertical tubes arranged from its bed coil to the top of the boiler (steam drum) each tube having a height of 11.58 meters .Sample length is analyzed in the software and the resultant temperature, enthalpy contours and plots are shown below

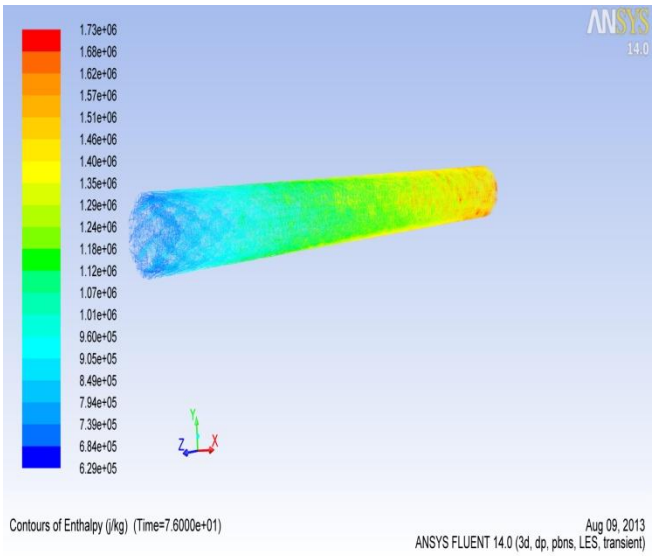

Fig 3: Contours of Enthalpy

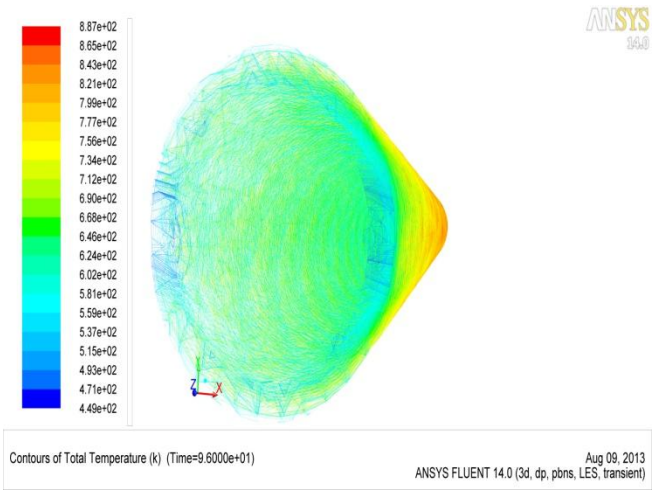

Fig 4: Contours of Temperature

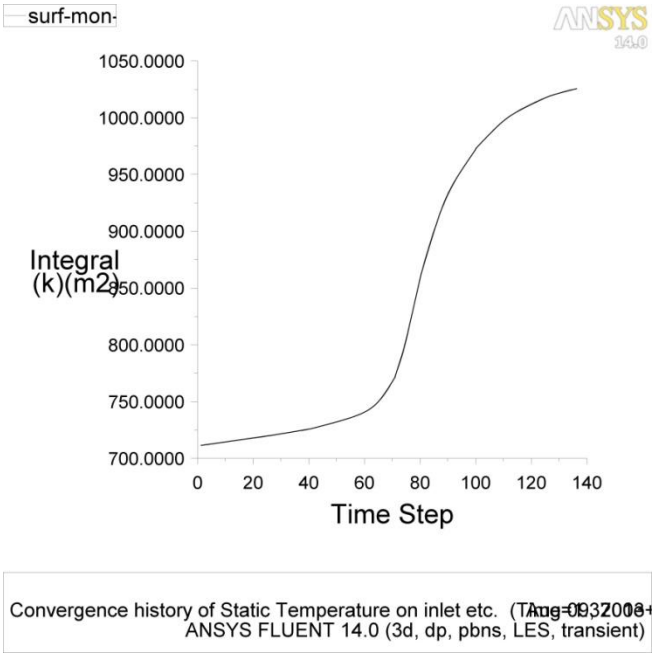

Fig 5: Temperature V/S Time step

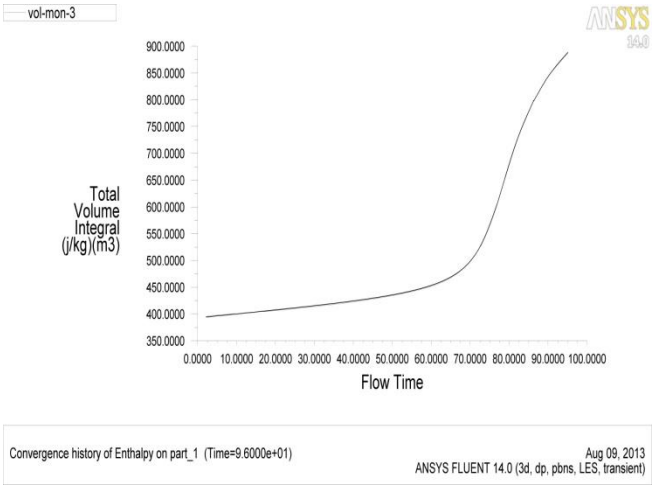

Fig 6: Enthalpy V/S Flow Time

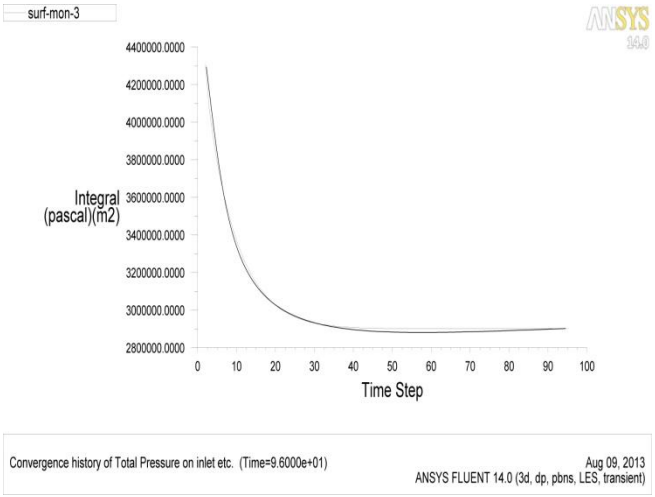

Fig 7: Pressure V/S Time step

The figures shown above are the results that gained after simulation of the geometry using the prescribed inputs and flow conditions. Variation of temperature, enthalpy, and pressure are shown above.

V. CONCLUSION

The model was created using Solid Works 2012 and meshed with Gambit, and the flow analysis is done with Ansys 14. The results showing that the heat transfer is increased. The enthalpy and temperature increase with flow is advancing when compare with normal boiler tube. So the implementation of Optimized Multi Lead Rifled boiler tube in this boiler is advisable. The study show that the improvement in furnace heat transfer can be achieved by changing the internal plane surface to a multi lead rifled tube

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