Study of Surface Temperature Distribution of Plain tube and Rifled tube by CFD Analysis

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Abstract: *Computational fluid dynamics were used to simulate and study the heat transfer of both plain tube and helically ribbed tube for fire tube boiler. The surface temperature distribution of plain tube and rifled tube is presented in this paper. The result indicates the helically ribbed tube has higher heat transfer rate than plain tube.*

Keywords- Plain tube, Rifled Tube, Surface Temperature Distribution.

1. INTRODUCTION:

In the present study, the surface temperature distribution of plain tube nd rifled tube is presented using CFD analysis. Smith, J. W. et al. [1] studied the turbulent heat transfer and temperature profiles in a rifled pipe. The rifled pipe was made by fitting snugly the continuous spiral rib inside a smooth brass tube which had the inner diameter of 2.058 inch. The continuous spiral rib was created from 0.25 inch x 0.25 inch copper bar with pitch to diameter ratio of 2.58. Zarnett, G. D. & Charles, M. E. et al. [2] studied the flow patterns of two phase flow in horizontal tubes fitted with internal spiral tubes (rifled tube) which their pitch to diameter ratios is 1.57 and 2.79 respectively. Webb, R. L. et al. [3] studied the heat transfer and friction correlations for turbulent flow in repeated-rib roughness tube. The correlation which was proposed by the authors specifically apply to ribs of rectangular cross-section, whose thickness is small relative to the rib spacing. Iwabuchi, M. et al. [4] studied the heat transfer characteristics of rifled tube in the near critical pressure region. In this experiment, smooth tube and rifled tube were tested to study their heat transfer characteristic. The experiment result shows that when pressure exceeds 20.6MPa, the swirl effect will diminishes and CHF condition appears even in the sub cooled region. However, the wall temperature rise is suppressed to a comparatively lower lever. Dirar, S. et al [5] studied the CFD analysis of normal and rifled tube with a convergence check. As a result of CFD analysis, the maximum outlet temperature in rifled tube is higher than the normal tube.

2. CFD ANALYSIS:

The CAD model is designed in CATIA V5R19. CFD analysis methodology includes grid generation, solver and post processor as following.

2.1 Grid generation:

The meshing is done in ICEM CFD 16.0 after modeling, the total number of elements is 2077644 and the total number of nodes is 467785 for Plain Tube and the total number of elements is 8592287 and total number of nodes is 1802255 for Helically Ribbed Tube. The element type is tetrahedral type. In order to capture both the thermal and velocity boundary layers the entire model is discretized using tetrahedral type mesh elements which are accurate. Fine control on the mesh near the wall surface allows capturing the boundary layer gradient accurately. The entire geometry is divided into two fluid domains i.e. Fluid Flue gases and Fluid Water and remaining i.e. solid thk is considered as solid domain.

2.2 Solver:

The continuity, momentum and energy equations will be used by CFD and convert them to algebraic equations by using Finite volume method and then run the solution by using implicit scheme second order upwind. Flue gases will be used as working fluid. Inside the tube with the thickness (3.6 mm) the helically ribbed tube is consists of four additional parameters, which are Number of ribs, Height of ribs, Width of ribs and lead angle. The CFD simulation is applied on Plain tube and helically ribbed tube under constant mass flow rates. The following boundary conditions are given to the tubes in FLUENT 16.0. In the present study, the flow is considered to be in steady state condition and since there is no uniform heating on the outer wall of the tubes, constant fluid properties such as density and viscosity is used. No slip boundary condition, uw = 0 is imposed.

2.3 Post-Processor:

At the end of this step we obtain the results in the form of contours, velocity vectors and residuals. In the present study, the k-epsilon Realizable model is used with near wall treatment having standard wall functions. The solving is done in FLUENT 16.0 and post processing is done in CFD-Post 16.0. Following figures gives the details of surface temperature distribution of plain tube and rifled tube.

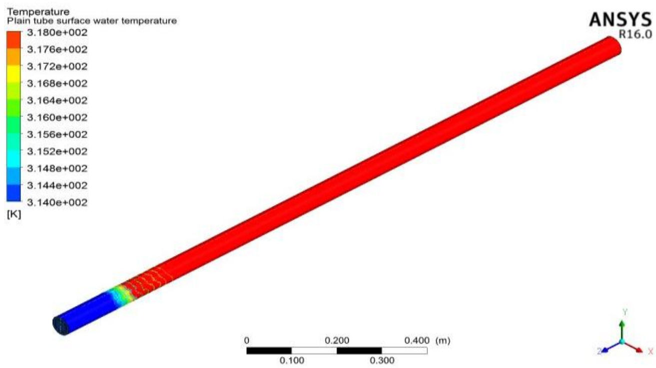

Fig. 1 Plain tube surface water temperature contour at mw=0.079 kg/s and mg=0.004 kg/s.

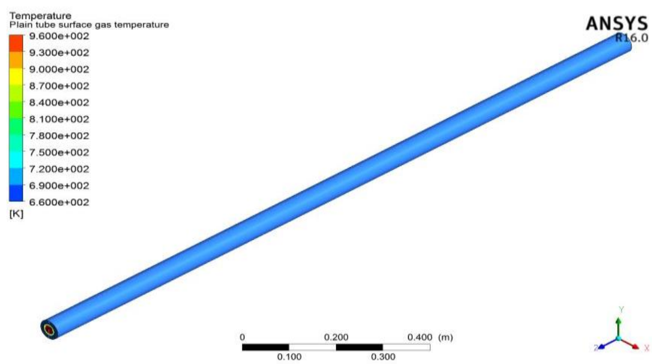

Fig.2 Plain tube surface gas temperature contour at mw=0.079 kg/s and mg=0.004 kg/s.

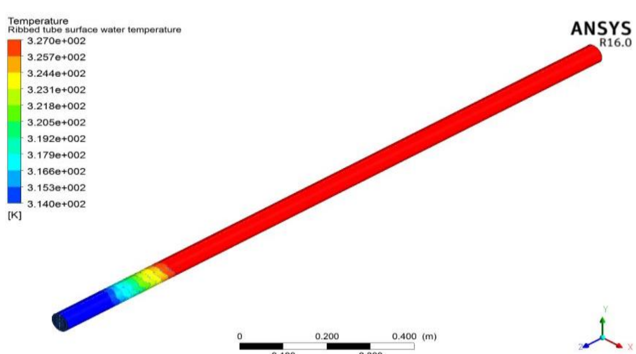

Fig. 3 Rifled tube surface water temperature contour at mw=0.079 kg/s and mg=0.004 kg/s.

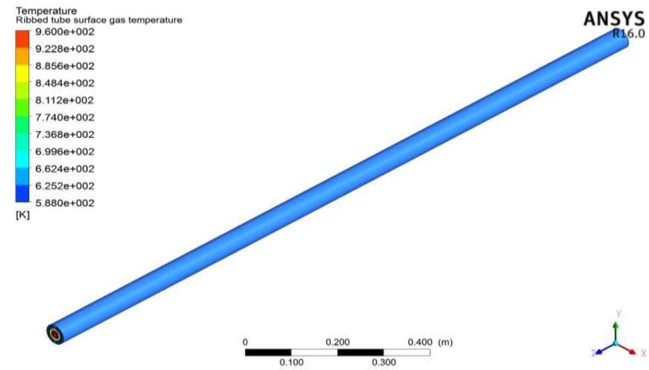

Fig. 3 Rifled tube surface gas temperature contour at mw=0.079 kg/s and mg=0.004 kg/s.

RESULTS AND CONCLUSION:

The surface temperature distribution of plain tube and rifled tube by CFD analysis indicates the surface water temperature of plain tube varies from 314 K to 318 K and surface gas temperature varies from 660 K to 960 K. The surface water temperature of rifled tube varies from 314 K to 327 K and surface gas temperature varies from 588 K to 960 K.

The results proved that use of rifled tube instead of plain tube gives better heat transfer performance.

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