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Comparative Study of Heat Exchangers Using CFD

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ABSTRACT
A parallel flow heat exchanger and a corresponding ribbed tube heat exchanger is modeled and numerically analysed using a commercial finite volume CFD package. Pro-E & ANSYS 14.5 softwares are used for the designing and the analysis. CFD predictions of effectiveness of the two heat exchangers are obtained and compared. After selecting the best modeling approach, the sensitivity of the results to particular flow rate is investigated. It is observed that the flow and the temperature fields obtained from CFD simulations provide valuable information about the parts of the heat exchanger design that need improvement. Correlation based approaches may indicate the existence of the weakness but CFD simulations can also pin point the source and the location of it. Using CFD may speed up the design process and may improve the final design.
Keywords: *CFD, Ribbed tubes, k-ε model.*

I. Introduction

A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another. In ordinary heat exchanger there is simple tubes are used.Ribbed tube heat exchangers make the use of internal ribs .While comparison with ordinary heat exchanger it is quite efficient due to the increased internal surface area. Pro-E & ANSYS FLUENT softwares are used for the designing and the analysis [1]. This type of analysis is based on the different methods used for analyzing using this CFD technology.ANSYS FLUENT 14.5 software contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial applications ranging from air flow over an aircraft wing to combustion in a furnace. The effectiveness from both the analysis are found out and then compared. The comparison helps us realize the fact that the effectiveness of the heat exchanger can be increased significantly with the use of the ribbed tubes.

II. Computational procedure

The model is modeled using Pro-E wildfire 2.0.Then the model is discretized into several parts i.e. meshing of the model is done using ANSYS ICEM. After the model is created and analysed using the ANSYS FLUENT software, here the two standard input temperatures are inputted and the analysis of it is done and the corresponding outlet temperature is obtained for both parallel as well as ribbed tube. Using the temperature obtained the effectiveness of both are calculated using the general effectiveness equation and then compared.

III. Model definition and meshing

The software Pro-E Wildfire 2.0 is used for model creation and ANSYS ICEM CFD is used for meshing. Mesh generation plays an important role in obtaining accurate results. For simple tube a mesh was created and a total of 165252 nodes and 120855 elements were obtained. The specification of the obtained model was as following:

Inner tube Material of tube: Copper
Inner diameter of inner tube: 9.5 mm
Outer diameter of inner tube: 12.5 mm
Outer tube Material of tube: G.I
Inner diameter of outer tube: 28.5 mm
Outer diameter of outer tube: 32.5 mm
Length of heat exchanger: 1500 mm

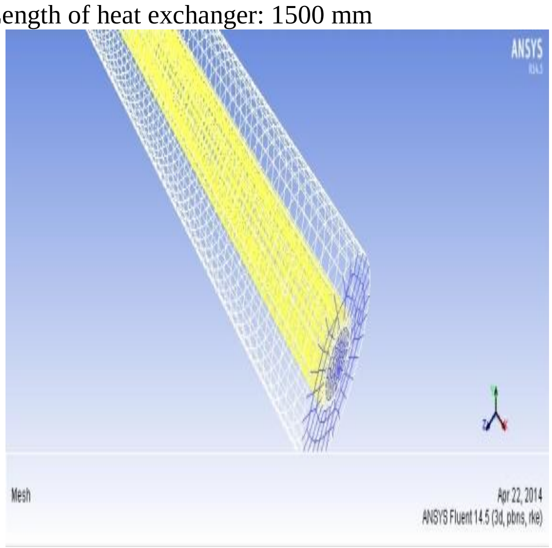

Fig.1. Simple heat exchanger meshing

The total number of nodes and elements for ribbed tube case are 231786 & 175860.

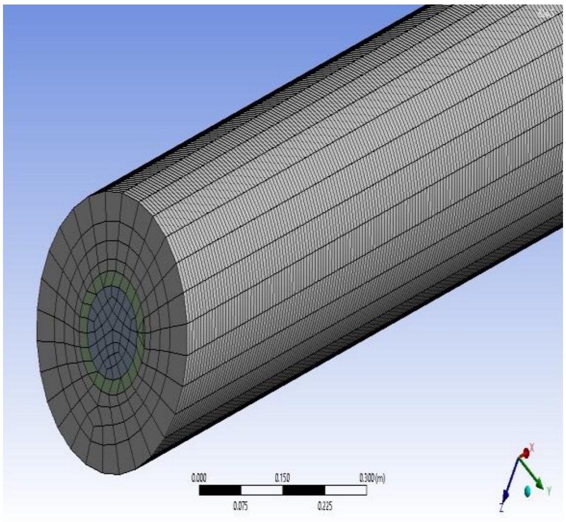

Fig.2. Ribbed heat exchanger meshing

IV. Governing equations and model

For flows involving species mixing or reactions, a species conservation equation is solved. Additional transport equations are also solved when the flow is turbulent.

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho \vec{v}) = S_m$$

It is the general form of the mass conservation equation and is valid for incompressible as well as compressible flows.
The turbulent (or eddy) viscosity, μ_t is computed by combining k and ε as follows:

$$\mu_{t=}\rho C_\mu \frac{k^2}{\varepsilon}$$

V. Methodology and boundary conditions

After modeling the geometry for analysis viscous standard k-e model is enabled for considering eddy dissipation. Then some standard values are inputted including the two input temperatures also the density, hydraulic diameter. Hot temperature inlet=75ºc and cold temperature inlet=27.3ºc and also the flow rate as .07571 and .0641 respectively.

VI. Result and discussion

Two heat exchangers having same dimensions were analysed and their corresponding temperature contours and graphs were obtained. From the temperature contours we can obtain the corresponding outlet temperatures.

6.1. Simple tube heat exchanger

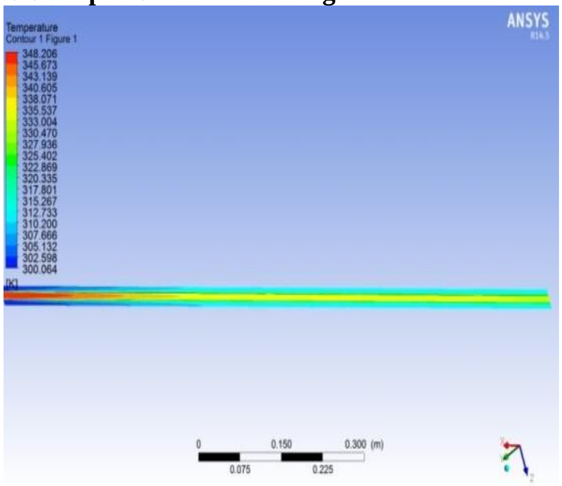

Fig.3.Temperature Contour for simple heat exchanger

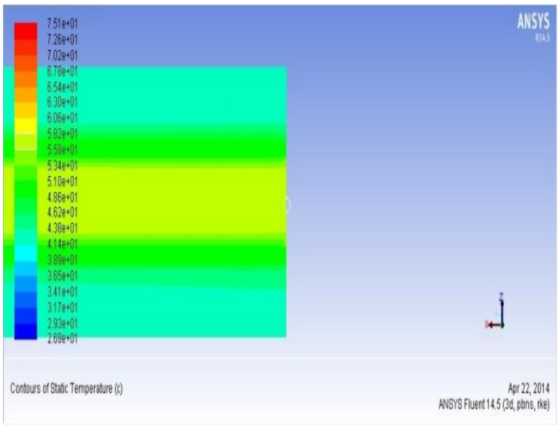

Fig.4. Temperature Contour for simple heat exchanger outlet

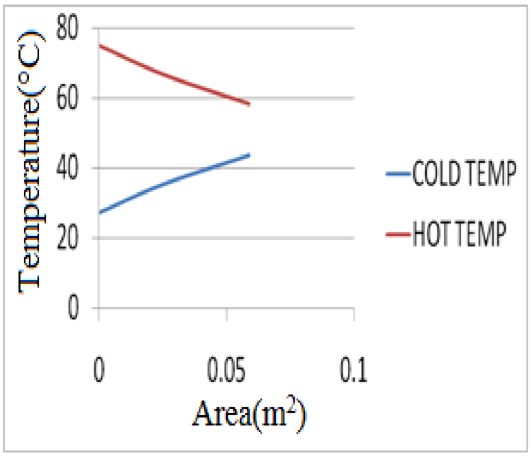

Fig.5. Temp. v/s Area for simple heat exchanger

The outlet temperature for hot water is near 58.2°C and for cold is water 43.7°C (Fig.4).

The effectiveness obtained:

$$\varepsilon = (c_h/c_{min})*((T_{hi}-T_{ho})/(T_{hi}-T_{ci}))$$

$$\varepsilon = ((75-58.2)/(75-27.3)) = 0.3522$$

6.2. Ribbed tube heat exchanger

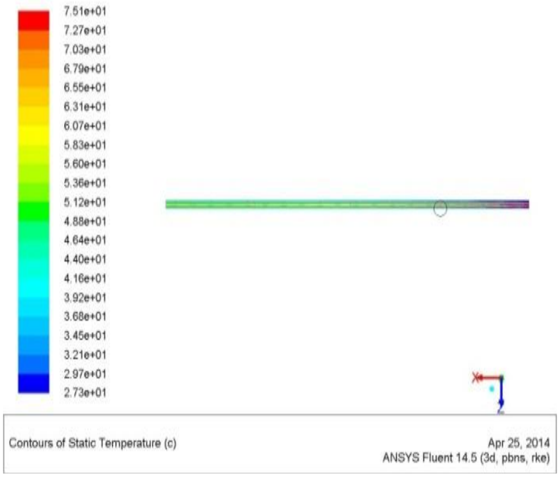

Fig.6. Temperature contour for ribbed heat exchanger

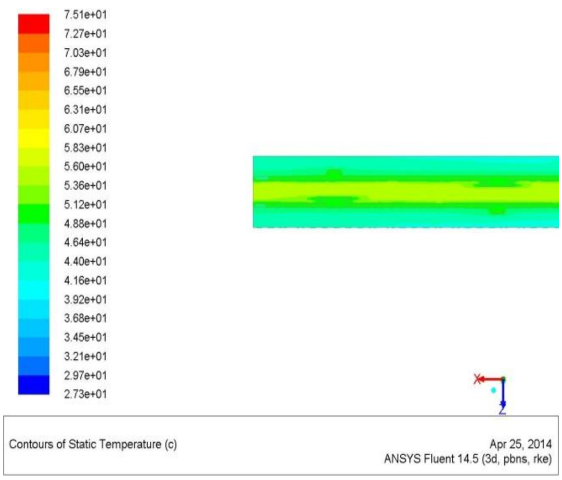

Fig. 7. Temperature contour for ribbed heat exchanger outlet

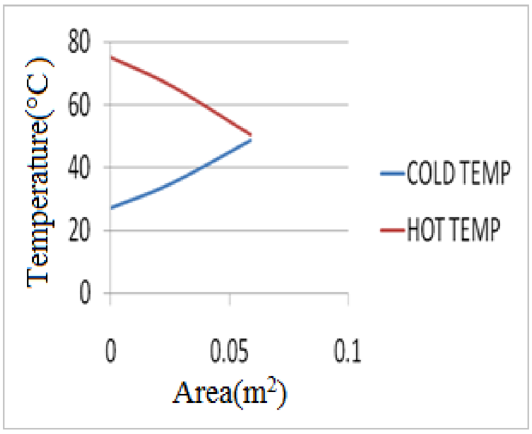

Fig. 8. Temp v/s Area for ribbed heat exchanger

The outlet temperature for hot water was near 50.51°C and for cold water 48.5°C (Fig.7).

The effectiveness obtained:

$$\varepsilon = (c_h/c_{min})*((T_{hi}-T_{ho})/(T_{hi}-T_{ci}))$$

$$\varepsilon = ((75-50.51)/(75-27.3)) = 0.5134$$

VII. Conclusion

By doing the analysis we reach at the following conclusions:

1) The effectiveness of the ribbed heat exchanger is more than that of simple heat exchanger.
2) Due to the ribbed helical shape of the tube the flow of fluid is not parallel but in swirls, which increases turbulence and thereby increasing the effectiveness.
3) Ribbed tubes increase the surface area of the tube and thereby increasing the effectiveness.

VIII. Acknowledgement

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