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Review Article

A Review on Dimple Tube Heat Exchanger

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Abstract

A heat exchanger is a device that is used for thermal energy exchange. It may be within the solid or solid fluid interface or within the gas itself having temperature gradient. Heat exchanger are vital from industry point of view having good efficiency and also having an economic running cost. Study is been conducting on enhancing the heat transfer rate. The paper proposes the research and practical work done on dimple tube heat exchanger which is a heat transfer augmentation technique.

Keywords: *Thermal energy exchange, Temperature gradient, Heat transfer augmentation.*

1. Introduction

From industry point of view it is important to increase the efficiency of the heat transfer equipment which are been installed, not only for the heat transfer augmentation but it is also important to remove the excessive heat generated to avoid the damaging effects of the burning and overheating. The temperature levels are dependent on the application, the one thing which can be varied is the surface area per unit volume. There are various methods for heat transfer augmentation such as geometric modification of the existing structure or to increase the turbulence. Turbulence is required to suppress the growth of the thermal boundary layer or to reduce its thickness. It is commonly observed that implementing these techniques may often lead to pressure drops, thus an optimum design is always helpful. The design should be also adequate enough to tackle the problems like scaling and fouling of the surfaces which often tend to degrade the heat transfer rate in case of systems using low grade fuel. There are various techniques for heat transfer augmentation like pin fins, louvered fins, twisted tape inserts, slit fins, ribs, protrusions and dimple tube. Out of the method listed, dimple tube provides maximum enhancement of the heat transfer rates with lower pressure drops compared to others in the chart. Geometric variations mainly include providing extended surfaces, but owing to demand for light, compact and economical find, many studies are been conducted, also this technology would be very helpful in many of the petrochemical heat transfer processes as it provides minimum pressure drop penalty and potential to reduce the fouling rate.

2. Literature Survey

It is the only quest to increase the efficiency which has encouraged the people to take up the study in this direction. Study has been conducted to analyze the varies types of dimple tube heat exchanger varying the shape of the dimple may it be hemispherical, almond shape or square shape dimples also varying the conditions to analyze the performance of the system and comparing the result with the usual system.

Idario. P. Nascimento and Ezio. C. Garcia performed experiments to enhance the heat transfer rate in compact heat exchangers by using shallow square dimples in flat plate tubes. By using dimple flat tubes it enhanced the heat transfer augmentation factor. A good correlation was found among the experimental and the predicted internal coefficient of friction. The method is a passive way of heat transfer enhancement technique. It was noticed that the setup provided a heat transfer augmentation factor between 1.37 and 2.28.

Chi-Chuan Wang, Kuan-Yu Chen, Yur-Tsai Lin investigated the semi dimple vortex generator. The setup is applicable to fin and tube heat exchanger. The study examines the air side performance of the fin and tube heat exchangers having simple dimple vortex generator. Many samples were been taken, out of the many conclusions one of the conclusions is that the experimental setup is 10% more efficient than the plain fin geometry.

Ming Li, Tariq. S. Khan, Ebrahim Al Hajri and Zahid. H. Ayub worked on the geometric optimization for thermal hydraulic performance of dimpled tubes for single phase flow. Enhanced surfaces have larger heat transfer surface area and offer increased turbulence level hence allowing higher heat exchange performance. In this study, numerical simulations are

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conducted to simulate geometric design optimization of enhanced tubes for optimal thermal–hydraulic performance. The simulations are validated with experimental data.

3. Case Study

In this paper we will study about development and field testing of dimpled tube heat exchanger for chemical process applications like heating. The experiment was been conducted by Gas Technology Institute to develop and field test a cost effective Dimpled tube heat exchanger to improve the energy efficiency of chemical industry gas fired process heaters. A collection of data base don the earlier studies was been collected from the University of Utah also the results of in house CFD modeling were been studied. Simultaneously six test sections were under observation, which included bundles of tubes, one section consisted of smooth tubes likewise other consisted of the finned tubes and other with dimpled tube. Air flowing outside the tube would analyze the hot medium that is the flue gases and the water flowing inside the tube would analyze the cold medium that is the chemical product. A data acquisition system was been used to record the data like temperature, pressure, mass flow rate etc.

4. CFD Modeling

One of the important objective is to increase the turbulence so as to restrict the growth of thermal boundary layer.

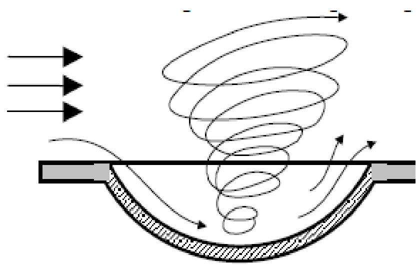

Fig 1. Mechanism of Vortices Formation (Yaroslav Chudnovsky)

Vortices are been created, a bunch of such vortices are been created at each dimple.

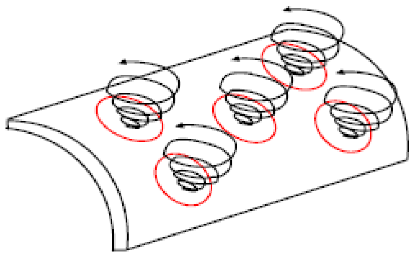

Fig 2. Cluster of Vortices on the Surface (Yaroslav Chudnovsky)

For the purpose of CFD modeling FLUENT software was been used. Gas Technology Institute also used GAMBIT for mesh generation code. The validation was based on comparing the results of smooth tubes with the dimpled tubes. To decide the geometric parameters the conditions prevailing were been altered so that the changes in heat transfer parameters could be understood and optimum dimensions could be selected.

The computational work was been done in two stages, in first a 2D geometry was been examined.

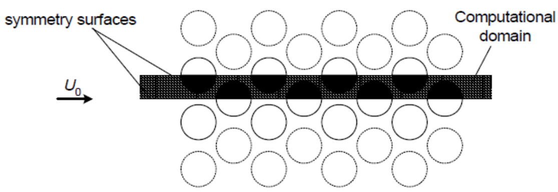

Fig 3. 2D Model of Smooth Tube (Yaroslav Chudnovsky)

A 3D model was choose for dimpled tube. A uniform incoming velocity was been maintained at a distance 5 times the tube diameter.

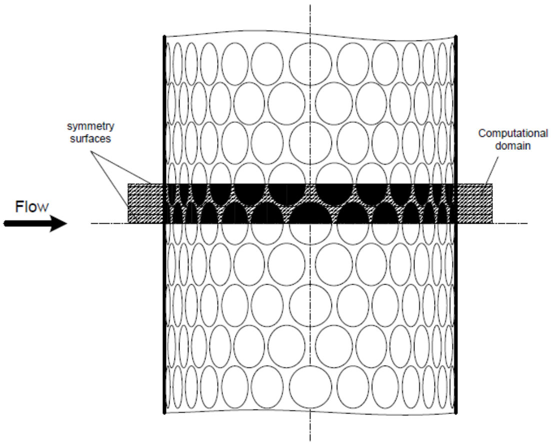

Fig 4. 3D Model of Dimpled Tube (Yaroslav Chudnovsky)

5. Results of CFD Model

Basically the CFD results are the solution to the general differential equation developed for the transport of mass, momentum, energy etc.

The calculation domain is been subdivide into number of many non-overlapping control volume spaces. These general equations are been balanced over the control spaces. The residual errors are been monitored and are been suppressed. The converging result are the solutions to these governing equations. These are been expressed in form of self-explanatory diagrams.

The surfaces for smooth tube and dimpled tube used for the analysis is shown in the following figures.

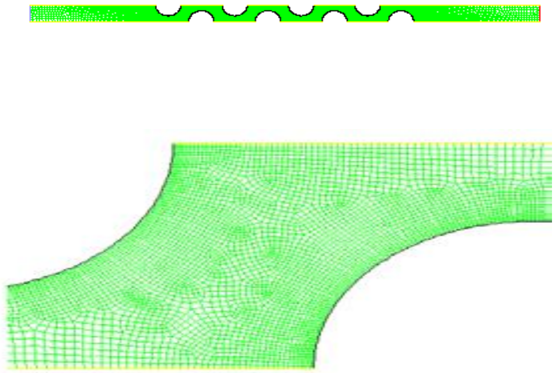

Fig 5. Bare Tube (smooth tube) (Yaroslav Chudnovsky)

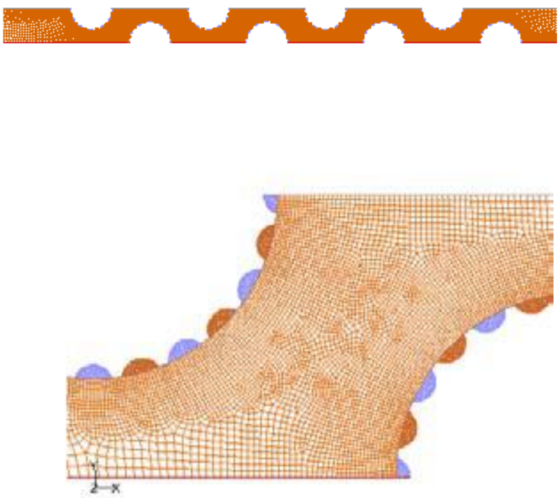

Fig 6. Dimpled Tube (Yaroslav Chudnovsky)

The dimples present on the tube causes increase in the turbulence intensity as the gas flows in and out of the dimples causing a recirculation of the gas.

From FLUENT software pressure drop analysis were made. Figure showing pressure drop in case of smooth tube and dimple tube are shown in figure.

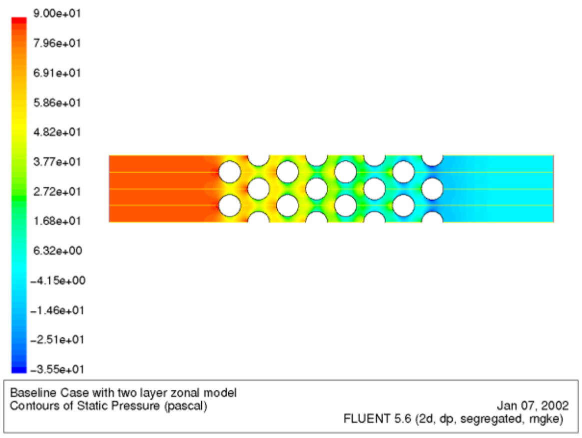

Fig 7. Static pressure Variation for Smooth Tube (Yaroslav Chudnovsky)

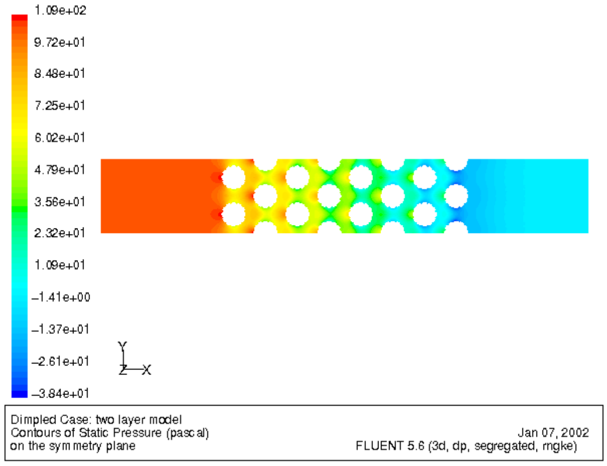

Fig 8. Static Pressure Variation for Dimpled Tube (Yaroslav Chudnovsky)

Lower pressure drop was been obtained in case of dimples tube.

Similarly static temperature distribution plot were been obtained.

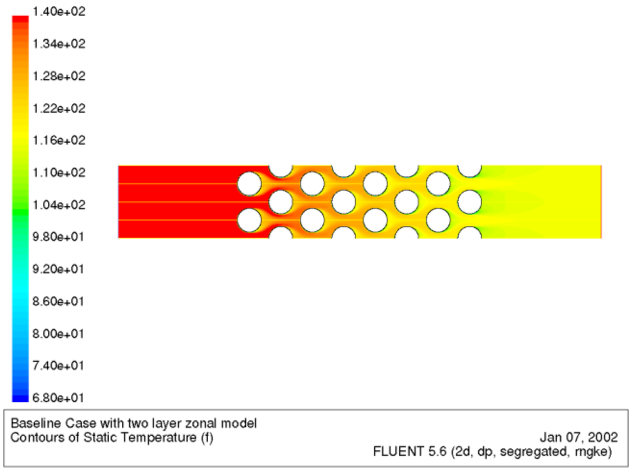

Fig 9. Static Temperature Plot for Smooth Tube (Yaroslav Chudnovsky)

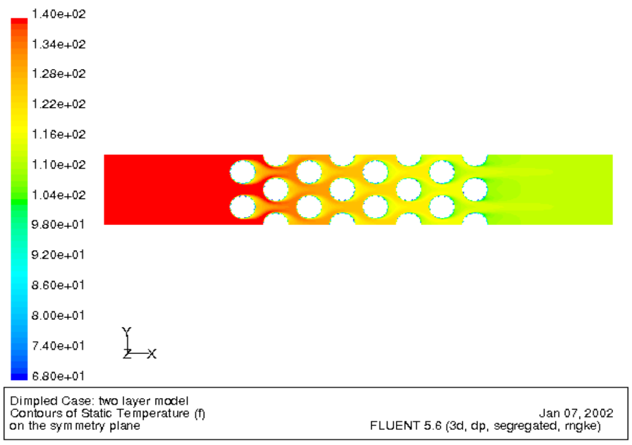

Fig 10. Static Temperature Plot for Dimpled Tube (Yaroslav Chudnovsky)

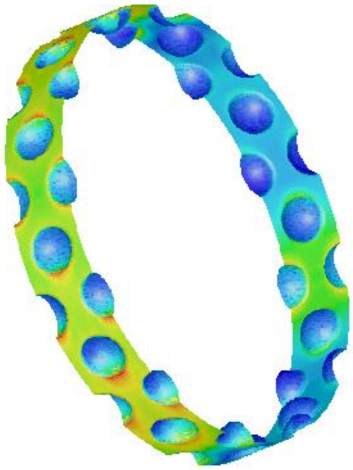

Fig 11. Heat Transfer Enhancement in Dimple Tube (Yaroslav Chudnovsky)

The above figure shows result of enhanced heat transfer on dimpled tube.

Conclusions

- Pressure drop in case of smooth tube is more compared to that of dimpled tube for low Reynolds number.
- The temperature of the flue gases at the end of the heat exchanger is more in case of smooth tube when compare with the dimpled tube.

References

Vilas Apte, Dr Prof S. L. Borse (2015), International Journal for Scientific Research and Development, Heat Transfer Enhancement in Dimple Tube, Vol. 3 Issue. 03.

Padmakar Deshmukh,(2014), IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),

An Experimental Study of Heat Transfer Enhancement in the Circular Channel with Almond Shape Dimples, Volume 11, Issue 5 Ver. I (Sep- Oct. 2014), PP 48-57.

Yaroslav Chudnovsky, Project Report on Development and Field Trial of Dimpled Tube Heat Exchanger for Chemical Process Heater,

Gas Technology Institute.

Idario P. Nascimento et al, Applied Thermal Engineering, Heat transfer performance enhancement in compact heat exchangers by using shallow square dimples in flat tubes, Elsevier.

Chi-Chuan Wang et al,(2014), Applied Thermal Engineering, Investigation of the Semi-dimple Vortex Generator Applicable to Fin-and-Tube Heat

Exchangers.