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Analysing the Heat Transfer Enhancement of Louvered Strip Inserted Double Pipe Heat Exchanger

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Abstract: Higher rate of heat transfer and higher thermal efficiency are the main goals to improve the efficiency of heat exchanger. The present study investigates the effect of inserting louvered strip attached rod in the inner pipe of the double pipe heat exchanger on heat transfer enhancement and pressure drop in counter flow Double Pipe Heat Exchanger (DPHE). The louvered strip generates turbulent flow in the flow field. The louvered strip of various shapes (rectangular, triangular and trapezoidal), various slant angle ($\theta = 20^o$, 30^o and 40^o) and various pitch (p= 30mm and 40mm) was considered in the analytical process. The analytical results confirmed that use of louvered increase the heat transfer rate compared to the plain double pipe heat exchanger. The louvered strip of trapezoidal shape, slant angle 40^o and pitch 30mm enhance the high heat transfer rate compared to the other type of louvered strip inserted double pipe heat exchanger.

Keywords: Double Pipe Heat exchanger, Louvered strip, Slant angle, Nusselt number, ANSYS FLUENT 15

I. INTRODUCTION

Forced convection heat transfer in a circular tube had been a subject of interest in many research studies over the past decades. In terms of reducing the size and the cost of the heat exchanger devices and saving up the energy, many engineering techniques had been devised to enhance the heat transfer rate from the wall in heat exchanger. These are numerous techniques to embellish the heat transfer. Heat transfer enhancement technology has been widely applied to heat exchanger applications in refrigeration, automobile, process industries etc. The aim of enhanced heat transfer is to encourage high heat fluxes. This result in reduction of heat exchanger size, which generally leads to lower capital cost. So there is need to increase the thermal performance of heat exchangers, thereby effecting energy, material and cost savings have lead to development and use of many techniques termed as heat transfer augmentation. Use of heat transfer augmentation techniques lead to increase in heat transfer coefficient but at the penalty of increase in pressure drop. So while designing a heat transfer using any of these methods, analysis of heat transfer rate, pressure drop and increased pumping power has to be done. Generally heat transfer augmentation techniques are classified in three broad categories. Active method, passive method and compound method. In active method some external power input are required for enhancement of heat transfer for example surface tension, fluid vibration, suction or injection etc. whereas passive method generally uses surface or geometrical modification to the flow channel by incorporating inserts or additional devices for example inserts extra components, rough surfaces, additives for fluid etc. the passive methods are based on this principle, by employing several techniques togenerate swirl in the bulk of the fluids and disturb the actual boundary layer so as to increase the effective surface area, residence time and heat transfer coefficient in existing system. Finally compound method is a combination of both active and passive methods.

II. ANALYTICAL MODEL

Schematic diagram of the double pipe heat exchanger with louvered strip inserted rod are shown in Fig 1, Fig 2, Fig 3. The louvered strips are connected to the central rod of 10mm diameter. The inner diameter of the inner tube and outer tube are 38.1 mm and 63.5mm. the length of the pipe is 500 mm. the dimensions of the rectangular louvered strip are width 10mm, length 16mm and thickness 1mm.

A. The following assumptions are made for the derivation of governing equations

1) The physical properties of fluid are constant.
2) The fluid is incompressible and Newtonian.
3) The effect of gravity is negligible.
4) Heat conduction in the louvered strip and central rod is not considered.

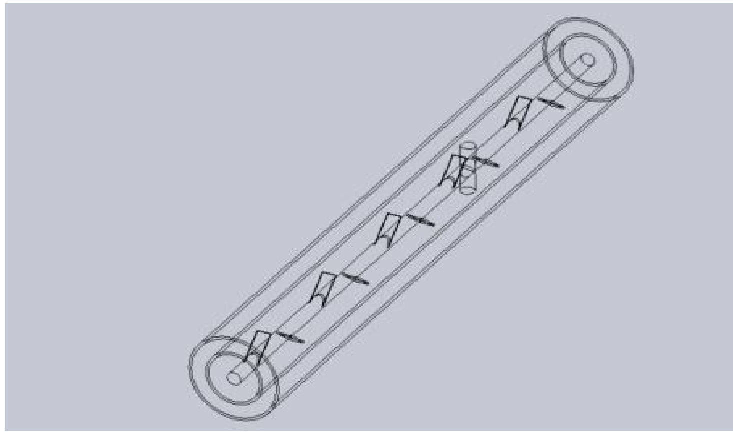


Fig. 1. Rectangular shaped louvered strips inserted double pipe heat exchanger.

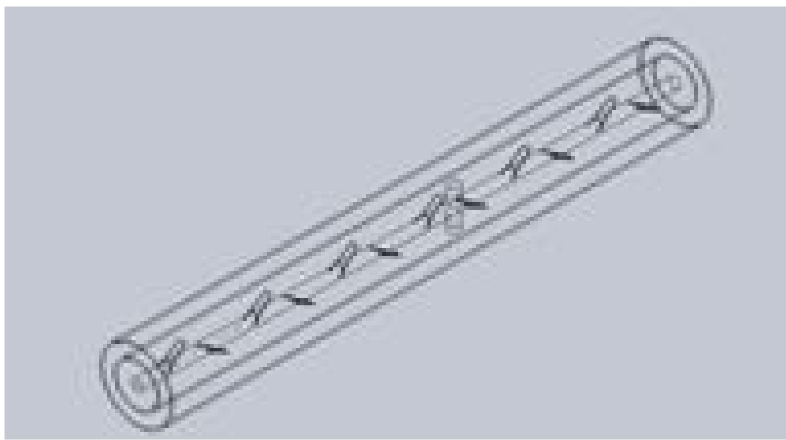


Fig. 2. Trapezoidal shaped louvered strips inserted double pipe heat exchanger.

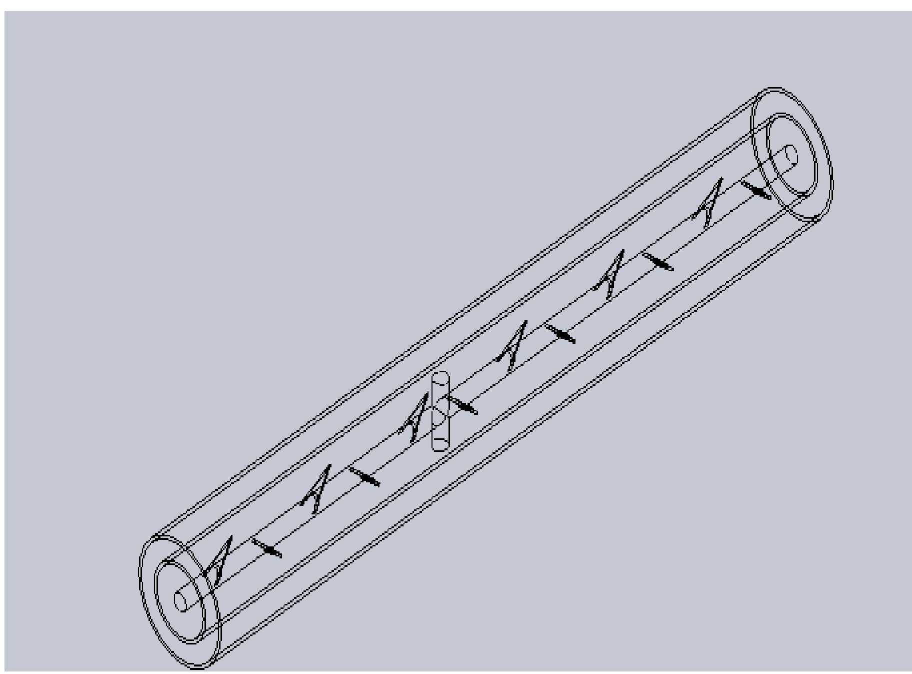


Fig.3 Triangular shaped louvered strips inserted double pipe heat exchanger

B. Parameter and Range

In this project slant angle used in the louvered strip are $\theta = 20^o$, 30^o and 40^o and different pitch length 30mm and 40mm are taken for analysis. Also strips of varying shapes were considered and details are tabulated below

Table 1 louvered Strip Slant angle $\Theta = 20^o$

Shape of the strip	Pitch 1 (mm)	Pitch 2 (mm)
Triangular	30	40
Trapezoidal	30	40
Rectangular	30	40

Table 2 louvered Strip Slant angle $\Theta = 30^o$

Shape of the strip	Pitch 1 (mm)	Pitch 2 (mm)
Triangular	30	40
Trapezoidal	30	40
Rectangular	30	40

C. Theoretical Calculations

The average Nusselt number and the friction factor are based on the inner diameter of the test tube. Heat absorbed by the cold water in the annulus $Q_{w,c}$ can be written by

$$Q_c = m_c C_{Pw}(T_{c,out}-T_{c,in})$$

Where,

m_h- is the mass flow rate of cold water;

$C_{p,w}$ - is the specific heat of water;

$T_{c,in}$ and $T_{c,out}$ are the inlet and outlet cold water temperatures respectively.

The heat supplied from the hot water, Q_h can be determined by

$$Q_h = m_h C_{p,w}(T_{h,out} - T_{h,in})$$

Where,

$m^{\cdot}_c$ - is the hot water mass flow rate;

$T_{h,in}$ and $T_{h,out}$ are the inlet and outlet hot water Temperatures, respectively.

The heat supplied by the hot fluid into the test tube is found to be 3% to 8% higher than the heat absorbed by the cold fluid for thermal equilibrium due to convection and radiation heat losses from the test section to surroundings. Thus, the average value of heat transfer rate, supplied and absorbed by both fluids, is taken for internal convective heat transfer coefficient calculation.

$$Q_{avg} = \frac{Qc+Qh}{2}$$

For fluid flows in a concentric tube heat exchanger, the heat transfer coefficient, h_i is calculated from

$$Q_{ave} = U A_i \Delta T_{LMTD}$$

where

$A_i = \pi D_i L$

The tube-side heat transfer coefficient h_i is then determined (by neglecting the thermal resistance in the copper-tube wall) using

$$\frac{1}{U} = \frac{1}{hi} + \frac{1}{ho}$$

Where the annulus side heat transfer coefficient h_o was estimated by using the correlation of Dittus–Boelter

$$Nu = \frac{hoD}{K} = 0.023Re^{0.8}Pr^{0.3}$$

Where,

$D=D_0-D_i$

The local thermal conductivity k of the fluid is calculated from the fluid properties at the local mean bulk fluid temperature. The Reynolds number is based on the different flow rate at the

$$Re = (\rho VD)/\mu$$

where μ is the dynamic viscosity of the working fluid.

III. RESULTS AND DISCUSSION

The effect of different shapes, different slant angle and different pitch of the louvered strip inserted in the double pipe heat exchanger are analysed and discussed in this section. The analysis was carried out in the ANSYS FLUENT 15.

A. *Rectangular Shaped Louvered Strip*

Result for amount of heat transfer from hot fluid to cold fluid in rectangular shaped louvered strip with slant angle 20º,30º,40º and varying pitch from 30mm to 40 mm. In this case increasing slant angle from 20º to 40º turbulence level in the flow field is increased thereby increasing the heat transfer rate. From the above analysis rectangular shaped louvered strip with slant angle 40 and pitch 30mm enhance more heat transfer rate compared to the other slant angle and pitches of the rectangular shaped louvered shaped inserted double pipe heat exchanger.

Table.3.Heat Transfer Analysis Date for Rectangular louvered Strip

Slant angle(in degree)	Pitch (in mm)	Heat transfer rate (kW)
40	30	8.820
40	40	8.734
30	30	8.665
30	40	8.561
20	30	8.213
20	40	8.079

B. *Triangular Shaped Louvered Strip*

Result for amount of heat transfer from hot fluid to cold fluid in triangular shaped louvered strip with slant angle 20º,30º,40º and varying pitch from 30mm to 40 mm. In this case increasing slant angle from 20º to 40º turbulence level in the flow field is increased thereby increasing the heat transfer rate. From the above analysis triangular shaped louvered strip with slant angle 40 and pitch 30mm enhance more heat transfer rate compared to the other slant angle and pitches of the triangular shaped louvered shaped inserted double pipe heat exchanger

Table 4 Heat Transfer Analysis Date for Triangular Louvered Strip

Slant angle (in degree)	Pitch (in mm)	Heat transfer rate (kW)
40	30	7.938
40	40	7.759
30	30	7.712
30	40	7.697
20	30	7.678
20	40	7.697

C. Trapezoidal Shaped Louvered Strip

Result for amount of heat transfer from hot fluid to cold fluid in trapezoidal shaped louvered strip with slant angle 20º,30º,40º and varying pitch from 30mm to 40 mm. In this case increasing slant angle from 20º to 40º turbulence level in the flow field is increased thereby increasing the heat transfer rate. From the above analysis trapezoidal shaped louvered strip with slant angle 40 and pitch 30mm enhance more heat transfer rate compared to the other slant angle and pitches of the trapezoidal shaped louvered shaped inserted double pipe heat exchanger

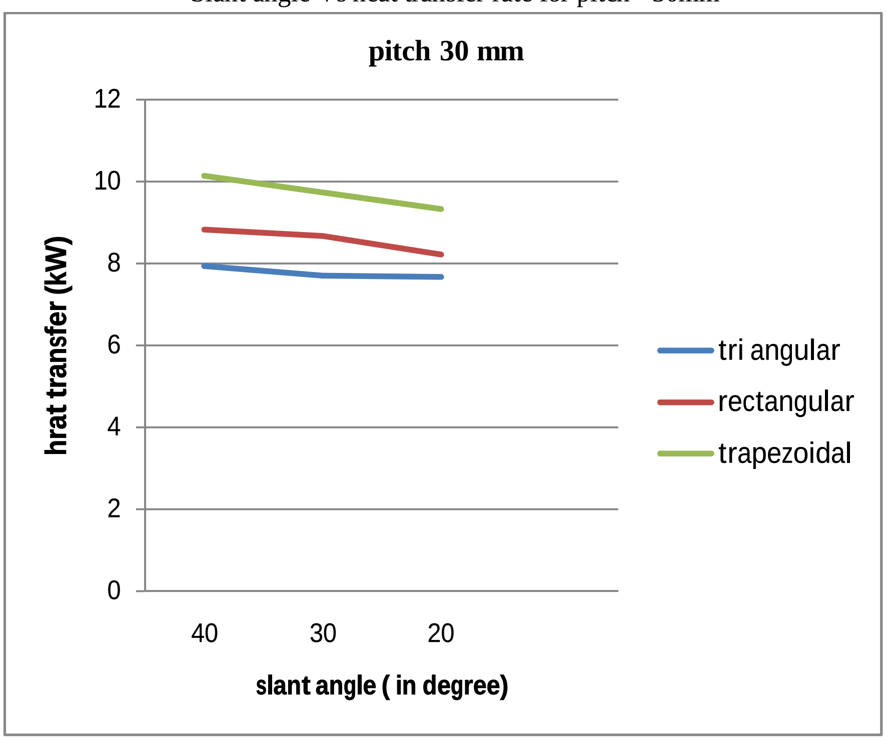
Table 5 Heat Transfer Analysis Date for Trapezoidal Louvered Strip

Slant angle (in degree)	Pitch (in mm)	Heat transfer rate (kW)
40	30	10.144
40	40	9.985
30	30	9.730
30	40	9.463
20	30	9.327
20	40	9.240

D. Graphs

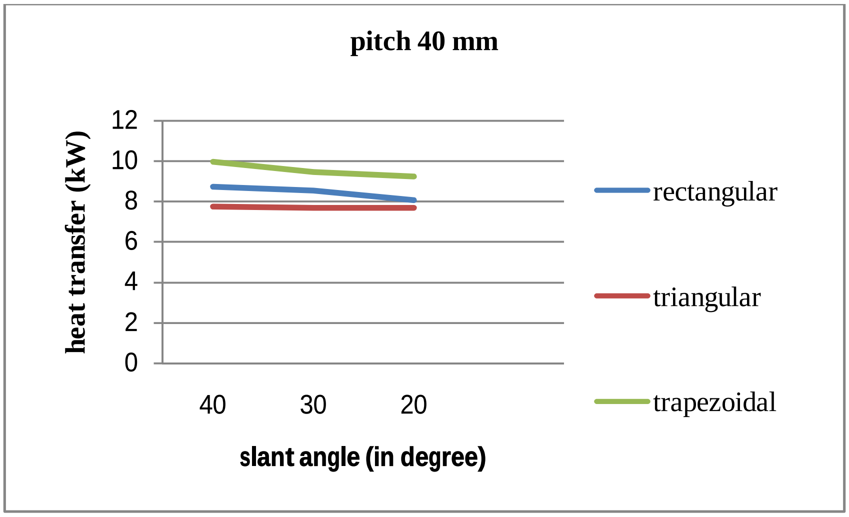
From the above analysis the variation of heat transfer for various shape, various slant angle and various pitches are presented in the graph

Slant angle Vs heat transfer rate for pitch= 30mm



It is observed that heat transfer increased in trapezoidal shape louvered strip with slant angle 40º and pitch 30mm enhance the high heat transfer rate compare to the rectangular and triangular shape of all the slant angles.

Slant angle Vs heat transfer rate for pitch= 40 mm



It is observed that heat transfer increased in trapezoidal shape louvered strip with slant angle 40º and pitch 40mm enhance the high heat transfer rate compare to the rectangular and triangular shape of all the slant angles.

E. Effect of Louvered Strip Arrangement

From the above results all inclined louvered strip arrangement would significantly enhance the heat transfer in comparison with the plain tube. It should be mentioned that the use of louvered strip provides.

Strong mixing or turbulence flow in front of the louvered strip leading to destruction of thermal boundary layer. Strong vortices of flow creating better flow mixing between the fluid at the core and tube wall.

IV. CONCLUSION

The heat transfer rate by inserting louvered strip in double pipe heat exchanger is investigated using ANSYS FLUENT 15 software. His analysis is executed to examine detailed heat transfer characteristics and flow characteristics. As a result of present study, the following conclusions were derived: It was found that the increase of 1 to 3% in heat transfer rate in tri angular shaped louvered strip inserted heat exchanger compared to the plain tube heat exchanger. Similarly, Heat transfer is augmented by 5 to 15.46% in rectangular shaped louvered strip inserted heat exchanger compared to the plain tube heat exchanger. And 21 to 32.7% of increase in heat transfer rate for trapezoidal shaped louvered strip inserted heat exchanger compared to the plain tube heat exchanger.

The trapezoidal shaped louvered strip with slant angle 40ºand 30 mm pitch enhance the high heat transfer rate in the double pipe heat exchanger.

REFERENCES

[1] H.A. Mohammed, Husam A. Hasan, M.A. Wahid.Heat transfer enhancement of nanofluids in a double pipe heat exchanger with louvered strip inserts(2012).
[2] A .W. Fan a, J.J. Deng , A. Nakayama, W. Liu. Parametric study on turbulent heat transfer and flow characteristics in a circular tube fitted with louvered strip inserts (2012).
[3] Smith Eiamsa-ard, SomsakPethkoolChinarukThianpong , PongjetPromvonge.Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with louvered strip inserts(2007).
[4] SomsakPethkoo, Smith Eiamsa-ard, ArtitRidluan and PongjetPromvong.Effect of Louvered Strips on Heat Transfer in a Concentric Pipe Heat Exchanger (2006).
[5] Jagpreet Singh, Ashwani Kumar, Satbir Singh Sehgal.Experimental Studies on Heat Transfer Augmentation of a Heat Exchanger with Swirl Generators Inserts (2014).
[6] HamedSadighiDizaji, SamadJafarmadar, FarokhMobadersani.Experimental studies on heat transfer and pressure drop characteristics for new arrangements of corrugated tubes in a double pipe heat exchanger.
[7] Snehal S. Pachegaonkar, Santosh G. Taji, Narayan Sane.Performance Analysis of Double Pipe Heat Exchanger with Annular Twisted Tape Insert (2014)
[8] Seong-YeonYoo, Dong-Seong Park, Min-Ho Chung.Heat Transfer Enhancement for Fin-Tube Heat Exchanger Using Vortex Generators (2002).
[9] Kamlesh R. Raut1, Prof. H.S. Farkade. Convective heat transfer enhancement in tube using louvered strip insert (2014).
[10] DeepaliGaikwad 1, Kundlik Mali. Heat Transfer Enhancement for Double Pipe Heat Exchanger Using Twisted Wire Brush Inserts (2014).

[11] HamedSadighiDizaji, SamadJafarmadar ,MajidAbbasalizadeh, SalehKhorasani.Experiments on air bubbles injection into a vertical shell and coiled tube. heat exchanger; exergy and NTU analysis (2015
[12] H. Mroue, J.B. Ramos, L.C. Wrobel , H. Jouhara.Experimental and numerica investigation of an air-to-water heat pipe-based heat exchanger (2015)
[13] Adnan seozen, H. Ibrahim Variyenli, M. BahadırOzdemir , MetinGürü,IpekAytaç Heat transfer enhancement using alumina and fly ash nanofluids in parallel and cross-flow concentric tube heat exchangers (2015)
[14] Jian Wen, Huizhu Yang , Simin Wang , YulanXue, Xin Tong Experimental investigation on performance comparison for shell-and-tube heat exchangers with different baffles(2015).