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Research Article

Enhancement of heat transfer rate of tube and tube Heat exchanger with semispherical hollow baffle of different material for counter flow

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Abstract

An experiment is carried for the measuring the performance of Tube and Tube heat exchanger with insertion of semispherical Hollow baffle for parallel flow and counter flow. A Copper tube of 25 mm internal diameter and 30 mm outer pipe inner diameter. Length of whole test tube is 1000 mm is used. A stainless steel semispherical hollow baffle having diameter 25mm. This paper compare the performance of tube and tube heat exchanger with and without insertion of hollow semispherical baffle for counter flow As well as comparison for parallel flow and counter flow for the insertation of the semispherical hollow baffle tube .experimental results depend on the estimating various heat transfer characteristics. That is nusselt number and the friction factor. Insertion of semispherical Hollow baffle enhances the heat transfer rate with apperatietely increasing friction factor. This experiment also predicts the performance for different Reynold no. range. Heat transfer rate after inserting semispherical hollow baffle tube is higher for the counter flow as compared with the Parallel flow heat exchanger

Keywords: *Heat transfer enhancement, hollow semispherical baffle, heat transfer rate.*

1. Introduction

Heat exchanger is widely used in most of the industrial and general applications. In the present Experimental study, Experiment conducted to enhance the thermal conductivity of Tube and tube heat Exchanger for parallel and counter flow heat exchanger. Various Passive augmentation techniques are generally more popular in practice. Use of various kinds of tube inserts, such as Circular cut twisted tape, snail entrance, Helical coiled wire, louvered twisted strip, and mesh insert and conical rings are the passive technique.

The experimental techniques are based on the swirl formation. Use of augmentation techniques and insertation of the semispherical hollow baffle of different material offer resistance to flow. Which increases friction factor but many researcher show that at high Reynold number and to gives high heat transfer rate of parallel flow and counter flow heat exchanger. Use of the screw tape in tube and tube heat exchanger semispherical hollow baffle gives the better result. Because of holes in baffle gives low resistance to flow in the inner tube and more heat transfer rate. Swirl increases the heat transfer mainly due to decreasing boundary layer and increases resultant velocity. In this paper we have done the experiment with use of semispherical hollow baffle of different material that is of stainless steel and the copper it shows that for copper baffle have higher performance as compared to the stainless steel baffle.

2. Literature Review

Present theories and practices

LI Ya-xia, WU Jian-hua, WANG Hang Presented experimentally, spiral corrugation increases the heat transfer of the smooth helical tube due to the additional swirling motion of the fluid they also predict the Decrease of the pitch of spiral corrugation can enhance heat transfer in the tube but enhancement of flow opposition Due to spiral corrugation can't be neglected.

Pawan A.Sawarkar Conduct experiment with insertion of semispherical cut twisted tape, with the arrangement of this water mixes well at different temperature and velocity thus increases the temperature gradient of the thermal boundary layer and causes uniform fluid temperature. so increases the heat transfer rate. Experimental results show the Friction factor decreases with increase of Reynolds number with increase in cut radius of twisted tape.

P. Sivashanmugam, P.K. Nagarajan Presented experimental investigation on heat transfer from the circular tube fitted with right-left helical screw, they

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shown the right-left helical screw inserts in tube is higher compared with straight helical twist for a given twist ratio heat transfer increases for given twist set is higher than that for predetermined left and right all twist ratio.

Wen Liu, Bofeng Bai investigate the effect of helical vortices due to the insertion of the twisted tape. They found that there are two effects are occur first is vortices formation and another is formation of downstream of twisted tape. The vortices form in the twisted tape.as the Reynolds number increases, the intensity of helical swarl formation is also increases

P.Dubey Perform the experiment with using the snail at the entrance for tube and tube heat exchanger with the arrangement of snail entrance of snail, heat transfer coefficient increases significantly but friction factor also increases. He also predict that friction factor decreases with the increasing the Reynolds number

Sh. Ghadirijafarbeigloo, A. H. Zamzamian, M. Yaghoubi they perform enhancement of convection coefficient in the receiver tube of a solar parabolic concentrator that the absorber tube is assembled with a new perforated louvered twisted tape is studied numerically and they found that heat transfer coefficient and pressure drop increases in comparison with a plain twisted-tape insert in to the tube and a plain tube.

W.H.Azhami show that The heat transfer coefficient of SiO2 water Nano fluid at 3.0% volume concentration is higher than water flow for the same twist ratio. However, the value of heat transfer coefficient of Nanofluid evaluated at the same concentration is greater than water for given twist ratio. After performing the experiment with Nano fluids

Aashique Alam Rezwan, Sarzina Hossain perform the experiment for Air process heater using semispherical baffle and they conclude that The results showed the temperature ratio to be decreased up to significant number where in many electric air heaters the temperature ratio is nearly about one. The designed air process heater Supplies air at respective velocity and temperature nearly up to 150ºC. And the results were also compared with present air process heater for finding out the enhancement of heat transfer

Fahmy Salah Fahmy Abdelhaleem Investigate The insertation of baffles had a significant effect on the hole, which is smaller than the case with use of no baffles, for the baffled tests, the slope angles increase but the downstream slopes are higher than the upstream slopes.

F.P. Incropera, P.D. Witt, T.L.Bergman,A.S. Lavine from Fundamentals of Heat Transfer stated that various heat transfer augmentation techniques and basic concepts regarding the heat exchanger and passive techniques.

From the literature review we can conclude that many researchers have worked on nusselet number, friction factor, and Reynolds no which increases the thermal performance increased with insertion of different specific shape in to tube because these are the passive techniques to increase heat transfer rate. No researcher work on the insertion of hollow semispherical baffle in tube and tube heat exchanger. Most of them work on Screw tape and twisted tape, and other passive techniques. There is no recent work on heat transfer in tube and tube heat exchanger with semispherical hollow baffle for counter flow and no comparison for the parallel flow and counter flow after inserting the semispherical hollow baffle

3. Objective

1) Manufacture the hollow semispherical baffles of materials stainless steel and copper and built up the set up for the counter flow tube and tube heat exchanger
2) To perform on experimental setup and recording the reading with S.S And Cu semispherical hollow baffle behavior of flow for counter flow.
3) Comparative study of proposed arrangement with and without insert of hollow semispherical baffle for counter flow and comparison for the two type baffle material.

The block diagram of the experimental system to be developed hollow semispherical baffles are made up of copper and stainless steel as given below,

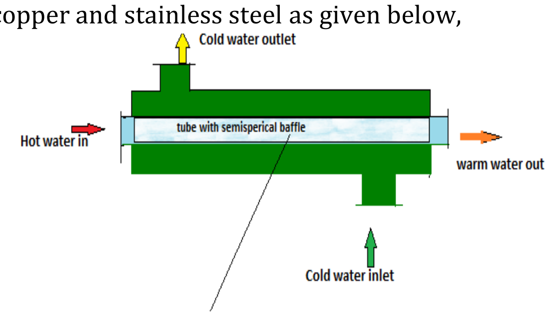

Fig 1 Schematic layout of experimental system

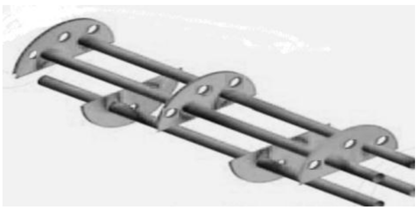

Fig 2 Semispherical hollow baffle

The geometrical shape of the hollow semispherical baffle are shown in Fig. (2).Material used for hollow semispherical baffle is stainless steel. The holes are made to minimize friction factor Fig(1) Shows the arrangement of fluid in tube and tube counter flow heat exchanger. For the comparison of with and without insertion of hollow semispherical baffle we estimate the following Parameters

1) Nusselt Number
2) Prandlt Number
3) Reynold Number
4) Heat transfer coefficient

4. Test Methodology and formulae Used

Heat added to water is calculated by

$Q = mc_p(Tout - Tin)$

Heat transfer coefficient was calculated from,

$h=q/(Tw_i-T_b)$

Heat flux

$q=Q/a$

Where,$a = \pi diL$

Bulk mean temperature = (Tin +Tout)/2

Experimentally Nusselt number was calculated from,

$Nu = hd_i/k$

Theoretically Nusselt number was calculated from Gnielinski 1976 correlation

$Nu_{th} = ((f/8)(Re-1000)Pr)/ 1+12.7(f/8)^{1/2}(Pr^{2/3}-1)$

Theoretically friction factor was calculated from Petukhov 1970,

$f_{th} = (0.790\ln Re - 1.64)^{-2}$

$Re = \rho U_m di/\mu$

$Pr = \mu Cp/ k$

Mean water velocity was obtained from

$Um =m/A_f$

$A_f = 3.14/4(d_i)^2$

$f_{exp} = \Delta p / (L/di)(\rho Um^2)$

Nomenclature

A	Area of the heated region of tube, m^2
Af	Flow area, m^2
Cp	Specific heat of water, J/kgK
d	Tube diameter, m
t	thickness of copper tube, m
h	Heat transfer coefficient, W/m^2K
k	Thermal conductivity of water, W/mK
kw	Thermal conductivity of tube material, W/mK
L	Effective tube length, m
m	Mass flow rate of water, Kg/s
Q	Heat transfer rate, W
q	Heat flux, W/m^2
Nu	Nusselt Number
f	Friction factor
P_r	Prandtl number

5. Results and Discussion

Heat transfer enhancement percentage in percentage for sample calculation,

Convective heat transfer increases as the temperature differences increases as Q=UA(lmtd).

Heat Transfer rate without insertation the semi spherical hollow baffle (w)	Heat Transfer rate with insertation the semi spherical hollow baffle (w)	% Increase in the rate
1622	1823	13%
1720	1924	13.1%
1932	2240	15%

For the logical and systematic comparison, the results are presented in a specific order as described below comparisons are done on the basis of graphs mainly plotting of Reynolds number property versus nusselt number and reynold number versus friction factor due to insertation of hollow baffle tube

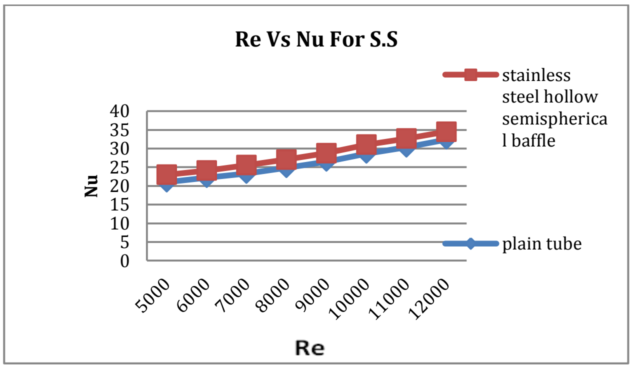

Fig 5.1 Reynold nu vs Nusselt number for stainless steel tube

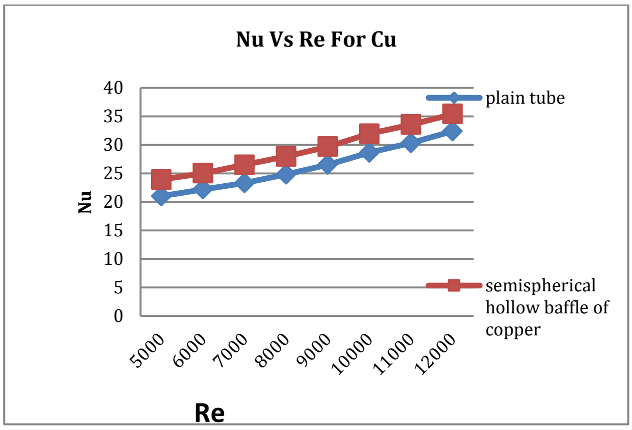

Fig 5.2 Reynold no vs Nusselt number for copper tube

The above graph shows the nusselt number corresponding to Reynolds number for both plain tube and tube inserting with the stainless steel hollow semispherical baffle.it shows that nusselt number is higher for the S.S. Semispherical hollow baffle arrangement than the plain tube.for the both baffles of stainless steel and copper . Nusult number increases slightly up to the significant level.

Fig. 5.3 Shows that nusselt nuber with respect to reynold number for stainless steel and copper hollow semispherical baffle.It shows that copper material has better performance as compared to stainless steel hollow hollow semispherical baffle because of higher nusselt number for same respective Reynolds number.

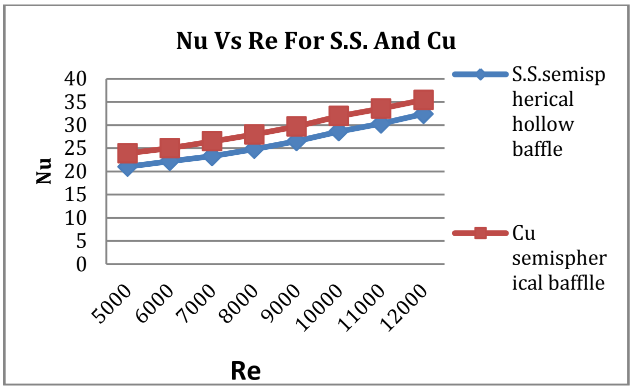

Fig 5.3. Reynold no vs Nusselt number for copper tube And stainless steel hollow semispherical hollow baffle.

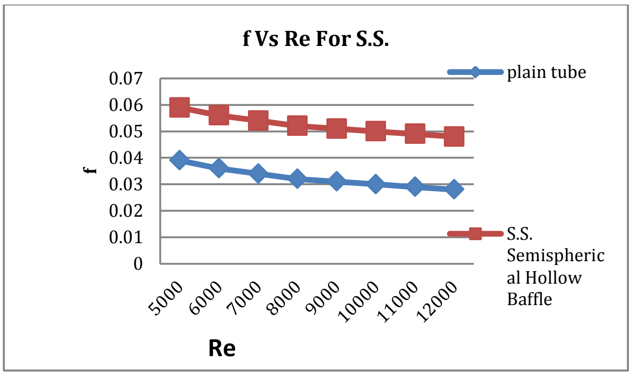

Fig 5.4 Reynold no vs. Friction Factor for S.S semispherical hollow baffle.

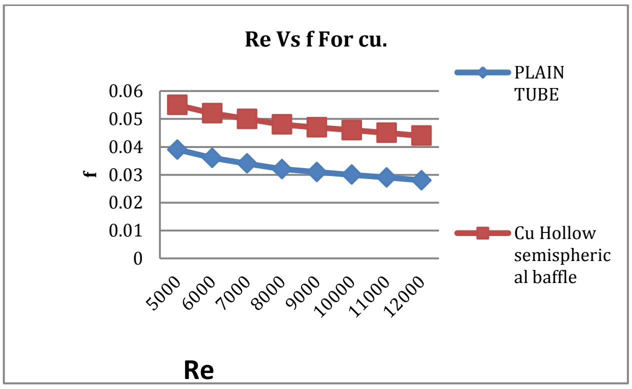

Fig5.5. Reynold no vs. Friction Factor for Cu semispherical hollow baffle

From the fig 5.4 and fig 5.5 shows that use of passive augmentation techniques increases slightly friction factor due to resistance offered by the hollow baffle as compared with the plain tube. Increase of friction factor is somewhat similar for both materials. but the drawbacks of friction factor can be reduced at high Reynolds number

Conclusion

From the experimental work we can conclude that heat transfer rate of tube and tube heat exchanger increases by the insertation of the semispherical hollow baffle, resistance to the flow increases the friction factor but at high Reynolds number it will minimize.

Heat transfer rate of tube and tube heat exchanger is higher for the copper material baffle as compared to the stainless steel material.

Friction factor reduces at high Reynolds number

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