EXPERIMENTAL INVESTIGATION OFTHERMAL PERFORMANCE IN HEAT EXCHANGERTUBE FOR DOUBLE SIDED DELTA WING WITH BOTH SIDE SERRATIONINSERT

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Abstract

In the present study the experimental investigation of heat transfer properties for double sided delta wing with both side serration(backward arrangement) insertin heat exchanger tube. The heat transfer, friction factor and thermal performance of the heat exchanger tube isinvestigated at constant heat flux and steady state conditions.The various parameters pitch width ratio,serration depth ratioand serration width ratio have been considered for the study. The Reynolds number is varies from 10000 to 35000 and air is taken as a working fluid.The thermal performance factor achieved is greater than unity at Reynolds number ranging from 25000-30000.

KEYWORDS:

Heat exchanger, Heat transfer coefficient, Reynolds Number,friction factor,Thermal performance and pressure drop.

1.Introduction

Heat exchanger play an important role in heat storage and recovery. Heat transfer augmentation techniques are widely at different places for example, industries, heat and cooling in evaporator, thermal power plant, AC, refrigerator and radiators for space vehicles, automobiles. Surface area, roughnessand variation in the boundary conditions are the factors which affect the heat transfer rate.

The different types of methods are used to enhance the heat transfer rate namely: *1).Active Method*: This method requires the external power source and includes mechanical aids.In this method we used Nano-sized, high thermal conductivity, metallic powder to the base fluid in order to increase the heattransfer rate and *2)Passive Method*: these methods don't require any external power source. In this method we used various types of inserts such as twisted tapes, wire coil, vortex rings etc. are used to enhance the heat transfer rate without the any help of external power. Inserts create the swirl flow in the path of working fluid which disturbs the actual boundary layers results increase in effective surface in the existing systems.*3)Compound Method*:When two or more techniques i.e. active and passive are used to enhance the heat transfer rate of any device, which is greater than that of produced by any of those technique separately.

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Nomenclature	
	l Length of wing, (m)
A Heat transfer surface area, (m^2)	*M* Mass flow rate, (kgs^{-1})
$c_{p,air}$ Specific heat capacity of hot air, ($jkg^{-1}K^{-1}$)	*Nu* Nusselt number
D Diameter of test tube, (m)	*Re* Reynolds number
e_p Wing pitch ratio (P/W)	*Pr* Prandtl number
e_w Wing width ratio (w/W)	*P* Pitch length of wing, (m)
f Friction factor	*ΔP* Pressure drop, (Pa)
h Heat transfer coefficient, ($W\ m^{-2}K^{-1}$)	*Q* Heat transfer rate, (W)
I Current, (A)	*W* Tape width, (m)
k_{air} Thermal conductivity of air, ($Wm^{-1}k^{-1}$)	*w* Wing width, (m)
L Length of test section, (m)	*x* Serration width,(m)
V Voltage,(V)	*d* Serration depth,(m)
η Thermal performance factor	T_{wm} Wall meantemperature, (K)
μ Dynamic viscosity, (Nsm^{-2})	T_i Inlet temperature, (K)
ν Kinematic viscosity, (m^2s^{-1})	T_o Outlet temperature, (K)
	T_{fm} Fluid mean temperature

In the present work double sided delta wings with both side serration(With forward arrangement) used as insert geometry. The rectangular and delta wings are widely used to enhance the heat transfer and the selection of the double sided delta wings and serration is based on the previousresearches[1,2]. They investigate the heat transfer coefficient and friction factor for double side delta winglet with alternate axis and serrated twisted tape (STT) in turbulent tube flow straight pipe presented and found better performance in forward arrangement as compare to backward arrangement using delta winglets[1]. At low Reynolds number, STT have maximum thermal performance factor [2].The investigation using conical-nozzle as turbulators with diverging and converging arrangement is shown[3] and reveals that there is a significant effect on heat transfer enhancement using nozzle turbulators.

Behavioural fluid flow characteristics investigation for circular heat exchanger tube using solid hollow circular ring and circular perforated ring (CPR)respectively carried out by [4,5]. They found thermal performance factor increases with increase in diameter ratio and perforation index respectively. Modified heat exchanger tube by using protruded surface of sheet metal,attached to the tube surface presented [6]. The study behaviour of heat transfer and flow friction in twisted tape swirl generator is presented in [7] which isplaced separately from the tube wall. The counter twisted tapes used as counter-swirl flow generator is shown [8] and concluded that the thermal performance factor achieved greater than unityby this insert. Investigation of heat transfer characteristics of roughened tube is carried out and found that Nusselt number and friction factor increase with co-twisted tapes[9].

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2.Experimental Facility

Experimental facility mainly comprised of inlet section also called as calming section, testing section, heating arrangement and air supply system (blower).Schematic diagram of Experimental setup is shown in Fig.1.

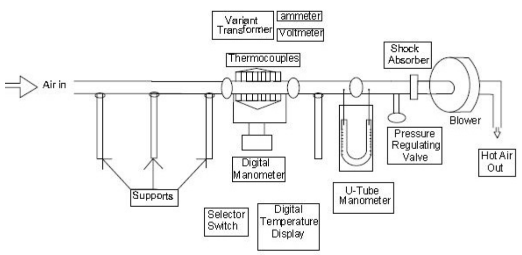

Fig.1.SchematicDiagramofSetup.

3.Methodology and Mathematical Calculations

During experimentation the air is taken as working fluid.It is assumed that there is uniform heat flux conditions.The pipe having length of 1.5 metre and diameter is 68.1 mm. A 3-phase centrifugal blower of 3-phase power supply is used to generate the turbulent fluid flow. It is assumed that the amount of heat loss given by the test section is equal to the heat carried by the air at steady state conditions [10].

$Q_{con}=Q_{air}$.......(1)

$hA_s(T_{wm}-T_{fm}) = Mc_{p,air}(T_o-T_i)$

Where, $Q_{air}=Mc_{p,air}(T_o-T_i)$ ....(2)

$Q_{con}=hA_s(T_{wm}-T_{fm})$ ....(3)

$T_o=(T_{21}+T_{22}+T_{23})/3$

(Outlet temperature of fluid)

$T_i = T_{24}$ (Inlet temperature of fluid)

Nusselt number (*Nu*), Reynold number (*Re*) and Prandtlnumber (*Pr*) arecalculated by the standard equations which are:

$Nu =hD/k_{air}$..........(4)

$Re = DU/\nu$ ....(5)

$Pr=mc_{p,air}/k_{air}$..........(6)

The friction factor is determined from the formula:

$f = 2\Delta P/[(L/D)(\rho U^2)]$.........(7) U is the mean velocity of the fluid. Thermal performance factor is calculatedby the equation:

$\eta=(Nu/Nu_s)/(f/f_s)^{1/3}$............(8)

Nu_s= Standard Nusselt Number

f_s=Standard Friction Factor

4.Results and Discussion

The experimental investigation carried out using double sided delta wings with both side serration in heat exchanger tube. The main focus on to determine the heat transfer and friction factor for different geometrical and flow parameters.In this study constant parameters such as pitch width ratio, serration depth ratioand serration width ratio are considered.

The study is based on constant heat flux and steady state conditions. The different view of geometry of insert used in the study is shown in Fig.2(a),2(b).

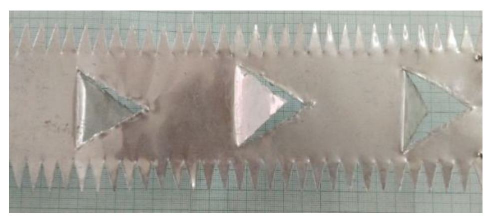

Fig.2(a)

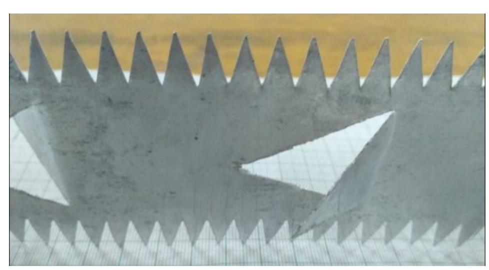

Fig.2(b) Photographic view of double sided delta wings with both side serration insert

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The experimentally obtained data are further used to determine the nusselt number, friction factor and thermal performance factor to study the behaviour of thermal properties of heat exchanger and discussed belowwith the variation of Reynolds number.

4.1 Effect on Heat Transfer

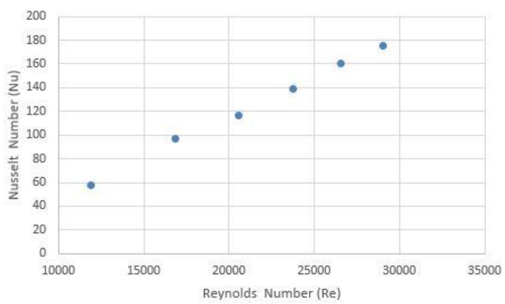

Fig.3. Variation ofNusselt number with Reynolds number.

The variation betweenNusselt number and Reynolds number is shown in Fig.3. It is noted from the figure that the variation depict approximately linear in nature. The Nusselt number increases with the increase of Reynolds numberand it increases the thermal performance factor (η).

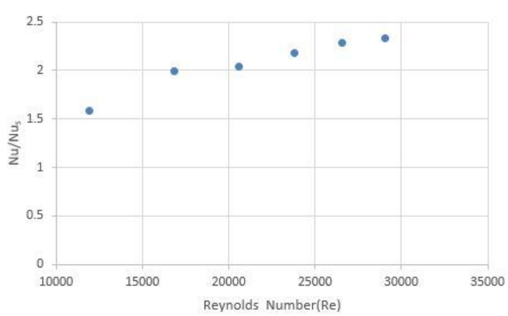

Fig.4. Variation of Nu/Nu_s with respect to Reynolds number

$Nu/Nu_s$is the ratio of the enhancement in the heat transfer when inserts are placed to heat transfer when inserts are not placed. The variation of $Nu/Nu_s$with respect to Reynolds number is shown in Fig. 4. Itis observed that with the increase in Reynolds number there is an enhancement in the thermal performance by using this insert.

4.2 Effect on Friction Factor

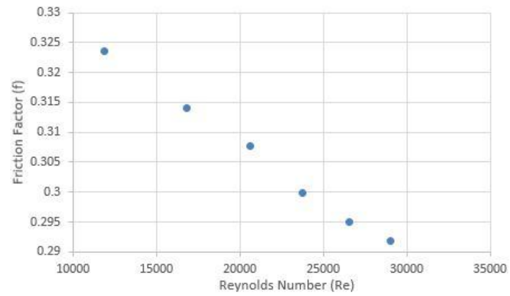

Fig.5. Variation offriction factor with Reynolds number.

The variation in Friction factor with the Reynolds number is presented in Fig.5.It is observed that the friction factor decreases with the increase in Reynolds number.The result reveals that the thermal performance factor increases or enhance due to decrease in friction factor.

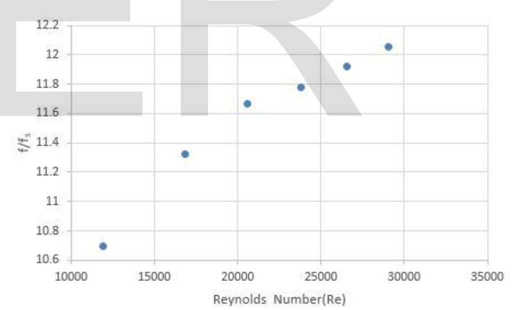

Fig.6. Variation of $f/f_s$with respect to Reynolds number

The ratioof $f/f_s$with the variationof Reynolds number is depicted in Fig.6. The f/f_sincreases when increasing the Reynolds number.The term f/f_s inversely affect the thermal performance factor.

4.3 Effect on Thermal Performance Factor

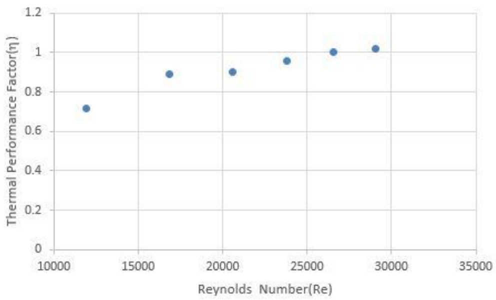

Fig.7. Variation in thermal performance factor with Reynolds number

The thermal performance factor (η) with the variation of Reynolds number is shown in Fig.7.The small changes in thermal performance factor with variation of Reynolds Number is noted. The variation of η beyond 21000 is very slight with Reynolds number. It is resulted from the study that the effectiveness depends on the various factors such as Re, Nu and friction factor etc.

Conclusion

Thermal properties study of circular heat exchanger tube using double sided delta wing with both side serration is done experimentally at Reynolds number in between 10000 to 35000. From the results obtained, it is concluded:

- High thermal performance factor is achieved at highest Reynolds number and the thermal performance factor is greater than unity at Reynolds number ranging from 25000-30000.
- As the Reynolds number increase,Nusselt number also increase while friction factor decreases.
- Friction factor in thermal system reduced due to reduction in pressure drop at high Reynolds number.

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