INVESTIGATION OF TURBULENT EFFECT IN FORCED CONVECTION BY USING VARIOUS INSERTS-A Review

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ABSTRACT

The present work shows the result obtained from investigation of turbulent flow heat transfer in circular and rectangular tube by using various inserts like Fins, Ribs and Twisted tapes. The effect on heat transfer rate and outlet temperature of air is calculated and observed. The turbulent flow was created by inserting the twisted tape inserts into the test pipe creating high rate of turbulence in pipe, which results in increasing heat transfer enhancement and pressure drop. In this review increasing the surface area of the object increases the heat transfer by adding a fin toan object. Rib is a popular heat transfer enhancement device used in various heat exchanging channels. The flow blockage suchas ribs increases the pressure drop and leads to increase the viscous effect because of reduced fluid flow area this results in increasing heat transfer coefficient.

Keywords : Forced convection, Heat transfer, Turbulence flow.

1.INTRODUCTION

Now a days, efforts have been made to produce more efficient ways of heat transfer by employing various method of heat transfer enhancement. The heat transfer rate can be improved by introducing a disturbance in the fluid flow. Among many techniques used for investigation of heat transfer rates inside circular tubes, a wide range of inserts have been utilize, particularly when turbulent flow is considered Included twisted tapes inserts, fins, ribs.Heat transfer rate can be increased by using various inserts because inserts increases the turbulence of the flow. Heat transfer characteristics are mainly depends upon turbulent effect.The rate of heat transfer Q due to force convection is expressed through the average heat transfer coefficient h by,

$Q= hA_s (T_s–T_\infty)$ ------(i)

Where, A_s is the surface area at which convective heat transfer occurs in m^2, $T_s$the surface temperature and T_∞ is the temperature of fluid.‘h’ is neither the property of surface nor that of fluid but it is dependent on type of fluid flow, thermal properties of fluid and vital dimensions of surface or pipe i.e.

$h = (\rho, V, D/L, \mu, C_p, k)$ ------(ii)

The rate of heat transfer is depends upon mixing of fluid particles and the rate of mixing of fluid particles depends on the Reynolds number. Thus, higher Reynolds number higher will be mixing of fluid particles resulting into higher value of rate of heat transfer it results into increased heat transfer coefficient ‘h’.

The Nusselt number Nu is depends on Reynolds number Re and Prandtl number Pr

$Nu = f(Re.Pr)$, These dimensionless numbers are defined by

Nusselt number, $Nu = hD/k$,

Reynolds number, $Re = U_\infty D/\nu$,

Prandtl number, $Pr = \nu/\alpha$

Here k is thermal conductivity, ν is kinematic viscosity and $\alpha = k/(\rho c_p)$ is the thermal diffusivity with ρ and C_p the density and the specific heat at constant pressure, respectively. All these fluids properties are based here on tabulated values.Reynolds number is mainly depends on the velocity of turbulent flow. If the turbulent flow is increased in the tube, the heat transfer rate is also increase. And as Nusselt number increased the heat transfer coefficient is increases.

2.LITRATURE REVIEW

Aniruddh Gupta, Pramod Bhatt [1], In this research paper they studied average convective heat transfer experiments were conducted using heater in experimental setup with rectangular duct. The result of experiment is, the heat transfer through the plane fin is moderated. The blockages with circular protrusions enhance the heat transfer on the segment of rectangular channel wall downstream of the blockages, whereas they also cause pressure drops across two consecutive blockages. They also conclude that the heat transfer through plane fin is lesser than protruded fin. As flow just passed over the surface and extract the heat from fin. The maximum heat transfer takes place from the protrusion fin due to the turbulence created by the geometrical blockages. The heat transfer rate also depends on the pitch and density of the protrusion.

C Nithiyesh Kumar, P Murugesan [2], In this research paper the numerically predicted characteristics of laminar flow and heat transfer through square duct with twisted tape inserts. The heat transfer characteristics are predicted under axially and peripherally constant wall heat flux conditions. Correlations for friction factor and Nusselt number are developed from the predicted data. The agreement between the correlation and experimental data for friction factor is found to be excellent. Carried out an experimental investigation of heat transfer in rectangular channels with transverse and v-shaped broken ribs. The ribs, having rectangular or square sections, were deployed transvers to the main direction of flow or v-shaped with an angle of 45 & 60 degree relative flow direction. The effect of continuous and broken ribs was also considered. Local heat transfer coefficients were obtained at various Reynolds number, within the turbulent flow regime. Maximum heat transfer is attained for 60 degree v-shaped ribs. They studied experimentally the heat transfer and the pressure drop characteristic of laminar flow of viscous oil through rectangular and square ducts with internal transvers rib turbulators on two opposite surfaces of the ducts and with wire coil inserts. The transvers ribs in combination with wire coil inserts have been found to perform better than either ribs or wire coil inserts acting alone.

Naga Sarda S, et al. [3], In this research paper they studied an experimental investigation of the potential of mesh inserts to enhance the rate of heat transfer occurring between the surface of pipe heated with constant and uniform heat flux and the air flowing inside. For a constant diameter, further enhancement in heat transfer can be attained by using a porous inserts with smaller porosity. The maximum increase in Nusselt number of approximately two times was obtained by fully filling the pipe at the expense of highest pressure drop of 8.6 pa.

H V Chavan, et al. [4], In this research paper they concluded that by using twisted tape inserts the highest heat transfer rate was achieved for twist ratio 3.78. In comparison with plain tube all twisted tape inserts would significantly enhance the heat transfer rate.From experimental study the results For Reynold number range 5000 to 25000the Nusselt number for twisted tape inserts with twist ratio 3.78, 3.89 and 4.22, increased as twisted ratio 4.22 respectively.

Joseph N Momanyi, et al. [5], In this research paper the governing equations with boundary conditions were described using three point central difference approximations for known uniform mesh. The results were presented on the graphs to show velocity profiles and temperature distribution in a room. Temperature decreased with increase in a room height. Also temperature was directly proportional to pressure. Decrease in pressure lead to decrease in temperature this was due to influence of the fan.

K Amghar, et al. [6], In this article they presents numerical modeling of dynamic and thermal behavior of turbulent forced convection in horizontal channel by using baffles as an obstacle for cooling of hot walls. The numerical simulations are tested by varying the number of elements of mesh and the results shows the stability of convergence of the model is achieved for all meshes. They studied the effect of spacing between baffles on the heat exchange between hot solid wall and the flow. They concluded that the spacing between the baffles improves the heat transfer rate.

Suvanjan Bhattacharyya, et al.[7], They studied the friction factor and Nusselt number data for turbulent flow through a circular pipe having and fitted with spring tape. They found that with and without spring tape with different twist ratio. It is seen that spring tape can significantly enhance heat transfer. The Nusselt number increases with increase of Reynolds number shows the maximum Nusselt number in the range of present study. This research finding is useful in designing tubes carrying solar thermal air preheater mass of air in parabolic through solar connector used in environmentally sound and increasingly cost effective solar thermal electric power plants.

Adam Neale, et al. [8], In this research paper they evaluate the turbulent flow field and heat transfer for forced convection over a smooth flat plate and the performance of most commonly used turbulence model by using computational fluid dynamics (CFD) software fluent. The heat transfer coefficients calculated from the forced convection simulations are consistent for all of the turbulence models studied, and also coincide closely with selected correlations from literature. Two simulations of natural convection were performed to investigate the validity of wall functions for natural convection simulations. It is concluded that the standard wall functions are not valid for cases involving natural convection and that instead low Reynold number modelling should be used.

Kanika Joshi, et al. [9], In this research paper they investigate heat transfer rate in concentric tube heat exchanger using Pentagonal shape inserts in ANSYS FLUENT 14.5 with varying mass flow rate for parallel flow. According to this the heat transfer effect is primarily due to induced turbulence which gives higher heat transfer rate. In this research they determine after all investigation regarding heat transfer characteristics of various parameter for different geometrical linear spacing between two inserts with varying mass flow rate that as the spacing increase the quality of heat transfer characteristics for various parameters like Nusselt number, Raynolds number, friction factor and pressure drop will also decreased.

3. PROPOSED WORK

It is proposed to carry out "experimental investigation of turbulence effect in forced convection by using by various inserts fins, ribsand twisted tapes.

1. Detailed information of existing techniques available for turbulence effect in forced convection for heat transfer.
2. Determining the effect of parameters like density, velocity, viscosity, specific heat and thermal conductivityon the heat transfer rate in forced convection.
3. Determining the impact of Reynolds, Prandtl and Nusselt number on temperature and rate of heat transfer in forced convection.
4. Fabrications of experimental setups.
5. Comparison of result obtained from different inserts with the reference data.
6. Completion of project and prepare a project report.

3.1 PROPOSED EXPERIMENTAL SETUP

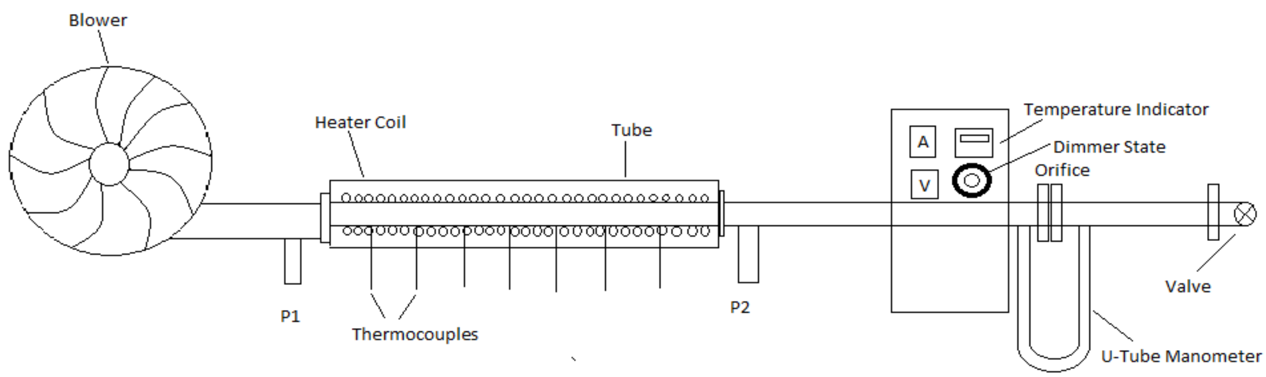

Fig.1:Proposed experimental setup

An experimental setup is proposed to investigation of turbulent effect in forced convection by using various inserts like fins, ribs and twisted tapes. This setup consist of centrifugal blower, flow control valve, circular tube, heater coil, pressure sensor and temperature indicator, thermocouples, orifice meter and control panel.

NOMENCLATURE

Q Rate of heat transfer (W)

h Convective heat transfer coefficient (W/m^2K)

A_s Surface area at which heat transfer occurs (m^2)

T_s Surface temperature (°C or K)

T_∞ Temperature of fluid (°C or K)

Re Reynolds number

Nu Nusselt number

PrPrandtl number

C_p Specific heat of air (J/kg K)

ν Kinematic viscosity (m^2/s)

ρ Density of fluid (kg/m^3)

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