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Analysis of Convective Heat Transfer Coefficient by using Internal Threads of varying Pitch through a Tube

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Abstract

Under turbulent flow conditions, the increase in heat transfer rate is more significant than that under laminar flow conditions. The turbulent effects become a dominant factor over secondary flow at higher Reynolds number. The turbulent flow can be produced by inserting different geometries in the circular tube. The heat transfer rate to a fluid flowing through the tube can be enhanced by the use of internal threads. This paper is concerned with experimental study of tube with and without internal threads. Internal threads of varying pitch are used to enhance their heat transfer performance subjected to forced convection heat transfer. In this experimentation analysis on convectiveheat transfer carried out in a plain circular tube and with internal threads of different pitches in the tube and results are compared.Aluminum material is used for tube and air is taken as fluid flowing through the tube.Reynolds number between 7000 to 15000 is assumed for the analysis.Number of parameters can be studied to improve heat transfer rate.

Keywords: *Heat transfer rate, Internal threads, Heat transfer co-efficient, Forced convection, Turbulent Flow*

1. Introduction

Extensive research effort has been focused on reducing the consumption of nonrenewable energy. Improving the efficiency of the universal process of heat is one such area which to attracts lot of attraction. Enhancing the efficiency of heat transfer is useful in variety of practical applications such as macro and micro scale heat exchangers, gas turbine internal aerofoil cooling, fuel elements of nuclear power plants, powerful semiconductor devices, electronic cooling, combustion chambers liners, biomedical devices etc. compact heat exchangers and gas turbine aerofoil cooling are two applications which have been the subject of study for a number of researchers over the recent years.

Air-side resistance to heat transfer in heat exchangers comprises between 70-80% of the total resistance & hence any improvement in the efficiency of a compact heat exchangers is focused on augmenting the air side convective heat transfer.

As the pitch of internal threads decreases it is found that there is increase in heat transfer rate but increases in friction factor is observed. So it can be concluded that minimum the pitch of internal threads maximum the heat transfer rate but more frictional losses will occur (PradipRamdasBodade,*et al* 2013). The effect on heat transfer rate and outlet temperature of air is calculated and observed respectively for threaded pipes and the results are compared with plain pipe. The variations are plotted for heat transfer rates Vs area and Reynolds number. In addition to that the moisture holding capacity of the air which is applicable in onion drying system is analyzed. Heat transfer rate for the threaded pipes is higher as compared to plain pipe for the given conditions and the highest performance is observed for the pipe with pitch= 4mm means with the highest internal surface area(Vijay D. Shejwalkar*et al* 2014).To produce the turbulent flow through the pipe for good heat transfer characteristics one of the method used is to use a pipe with internal threads. Experimental investigations on enhancement of turbulent flow heat transfer with internal threads of varying depth in a horizontal duct under forced convection with air flowing inside arecarried out (ShubhamDambiwal, *et al* 2014).As the pitch of internal threads decreases it is found that there is increase in heat transfer rate but increases in friction factor is observed. So it can be concluded that minimum the pitch of internal threads maximum the heat transfer rate but more frictional losses will occur (PradipBodade*et al* 2015). This work deals with experimental investigation of the forced convection heat transfer through a Circular channel. The various heat transfer parameters considered for study are Nusselt number, heat transfer coefficient, heat transfer rate and Reynolds Number. (Pradip R. Bodade*et al*2015).

The effects of internal threads of varying depth on heat transfer and friction factor were presented. Based on the same pumping power consumption, the duct with internal threads possesses the highest performance factors for turbulent flow. The heat transfer coefficient enhancement for internal threads is higher than that for plain duct for a given Reynolds number. The use ofinternal threads improved the performance of circular duct (AsmaQureshi, *et al* 2016).The heat transfer rate increases in a test tube having internal threads as compared to smooth tube. The result shows that the heat transfer rate increases with increasing in Reynold number (KundanGunwant More, *et al* 2017).

The present experimental study investigates the increase in the heat transfer rate between a tubes heated at constant heat flux with a air flowing inside it using internal thread a of varying pitch. As per available literature, the enhancement of heat transfer using internal threads in turbulent region is limited. So the present work has been carried out with turbulent flow(Re number range of 7000-14000) as most of the flow problems in industrial heat exchangers involve turbulent flow region.

2. Experimental Set Up

The apparatus consists of a blower unit fitted with a circular duct, which is connected to the test section located in horizontal orientation. Nichromeplate heater encloses the test section. Three thermocouples T2, T3 and T4 are placed on the walls of the tube and two thermocouples are placed in the air stream, one at the entrance (T1) and the other at the exit (T5) of the test section to measure the temperature of flowing air as shown in Fig. 1.

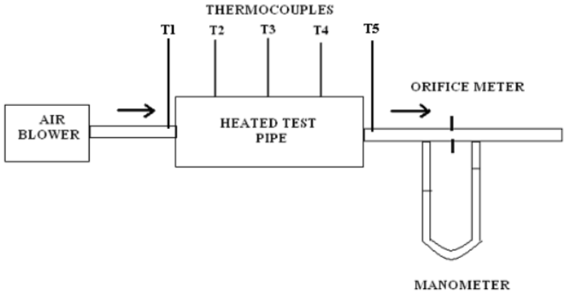

Fig. 1 Experimental Setup Layout

The duct system consists of a valve, which controls the air flow rate through it and an orifice meter to find the volume flow rate of air through the system. The diameter of the orifice is 14 mm and coefficient of discharge is 0.64. The two pressure tapings of the orifice meter are connected to a water U-tube manometer to indicate the pressure difference between them. Input to heater is given through dimmer stat. The test tube of 50 mm length is used for experimentation. Display unit consists of voltmeter, ammeter and temperature indicator.

3. Data Reduction

The data reduction of the measured results is summarized in the following procedures:
The duct surface and in/out temperature:-
$T_S = (T2 + T3 + T4)/3$(1)
$T_b = (T1 + T5)/2$ (2)
Discharge of air:-
$Q = Cd * A_1 * A_2 \sqrt{2gh_{air}} / \sqrt{(A_{12} - A_{22})}$ (3)

Equivalent height of air column:-
$h_{air} = (\dot{\rho}_w * h_w) / \dot{\rho}_w$(4)
Velocity of air flow:-
$V = (Q/A)$ (5)
Where A =convective heat transfer area (π*D*L)
$Re = (\dot{\rho} * V * D) / \mu$ (6)
Where D = inner diameter of duct and L= Length of duct
Experimental Nusselt number:-
$Nu = h^* (D/ K)$ (7)

Nusselt numbers calculated from the experimental data for plain tube were compared with the correlation recommended by Dittus-Boelter.
Theoretical Nusselt number:-
$Nu=0.023 Re^{0.8} Pr^{0.4}$ (8)

4. Result and Discussion

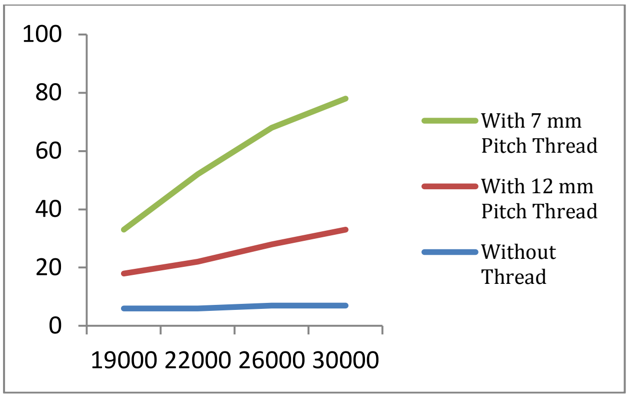

Fig.2 Nusselt NumberVs Reynolds Number

From Fig.2 it is observed that there is increase in Nusselt number as increase in Reynolds number .As Reynolds number increases the air flow will cause more turbulence due to which heat transfer rate will increase in heat transfer coefficient (h) and Nu=hDh/k i.e. increase in heat transfer coefficient increases the Nusselt number.

Conclusions

Laminar flow shows less heat transfer through performance characteristics than that of through turbulent flow. To produce this turbulent flow, various techniques and design strategies are used. Experimental investigations have been carried out to study the effects of the internal threads of different pitches in a Circular tube. Heat transfer coefficient and Nusselt number are analyzed with using passive heat transfer enhancement methods. From the graph plotted above following conclusions are made.

1) The heat transfer rate increases in tube with the internal threads as compared to without internal threads. The result shows that the heat transfer rate increases as the Reynolds number increases.

2) The performance of horizontal duct can be improved by the use of internal threads. The cost involved for making internal threads is minimal compared to energy efficiency improvement provided by this technique.

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