Experimental Analysis of Heat Transfer Enhancement through Pipe using Baffles: A Review

J. M. Lanjewar
Student,IV semester M.Tech
(Heat Power Engineering)

Mr. S. A. Borikar
Asst.Professor

Mechanical Engineering Department,
Kavikulguru
Institute of Technology and Science,
Ramtek.(India)
Corresponding Author

Abstract:

Energy saving plays a important role in industrial development as well as reducing environmental impact.The necessity of energy saving is growing because of the current energy prices. Reducing energy cost can be achieved by producing more efficient equipments. Heat exchangers are the most important components in the refrigeration, automotives, chemical and process industries.So there is a need for the cost effective, more efficient and compact heat exchanger in the industrial market.In passive heat transfer enhancement strategy the use of inserts in channel is commonly used. Considering the increase in energy demand, effective heat transfer enhancement techniques have become important task . The present paper is a review of different types of inserts and its arrangement. According to recent studies inserts are known to be economic heat transfer augmentation tools.

Index Term - Baffle, heat transfer enhancement, Inserts, Augmentation.

I. INTRODUCTION

Heat transfer augmentation techniques refer to different methods used to increase rate of heat transfer without affecting much the overall performance of the system. These techniques broadly divided in two groups viz. passive, and active. Active techniques involves some external power input for the enhancement of heat transfer, some examples of active techniques include induced vibrations in the setup, the use of a magnetic field to disturb the seeded light particles in a flowing stream etc. Passive techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices, for example, inserts, use of rough surfaces etc. In present work passive technique of augmentation is used.

The following are the some of the types of inserts generally used.

1.1 Ribs:

Ribs are placed periodically on the heat transfer surface increases the turbulence and since these ribs are small they do not disturb the core flow hence a high heat transfer performing surface could be achieved without incurring the penalties of frication and pressure drop .

1.2 Baffles:

Inserting baffles into the channel promote heat transfer rate by creating the turbulence into the flow. These baffles can significantly disturb the bulk flow and increases the heat transfer rate.

1.3 Extended surfaces:

Use of heat sink such as fins increases the surface area in contact with the flow channel. These extended dissipation area are widely used to improve the heat transfer. Various examples are plain fin, wavy fin, louvered fin, offset-strip fin, rectangular fins etc.

1.4 Twisted tapes and wire coils:

Twisted tapes are metallic strips twisted in some ratio known as twist ratio, inserted in the flow channel. Wire coil inserts are made by tightly wrapping a coil of spring wire on a rod. When the coil spring is pulled up the wires forms a helical roughness which after insertion increases heat transfer rate.

1.5 Surface modification:

This section includes such surface which has fin scales or coating which may be continuous or discontinuous. It also includes rough surfaces which promotes turbulence in the flow field

II. REVIEW OF WORK CARRIED OUT

Kang-Hoon Ko, N.K. Anan[1]

Experimentally investigated the average heat transfer coefficient in a rectangular channel which was heated from all the four sides and porous baffles were mounted alternately on the top and bottom walls in staggered manner. Aluminum foam material was used for baffles. The experiment was conducted using three different pore densities (viz.: 10 PPI, 20 PPI, and 40 PPI) and two different thickness (viz.: 1and 0.25in.). An experiment was also conducted with solid baffles for the sake of comparison. Reynolds number was varied between 20,000 and 50,000. From the study following conclusion can be made.

• Heat transfer enhancement in straight channel using baffles was 300% more compared with heat transfer in straight channel with no baffle.

• With increase in Reynolds number Heat transfer enhancement ratio decreases and increases with increase in pore density, thickness and height of the baffle.

• With increase in Reynolds number the frictional factor decreases and increases with increase in pore density, thickness and height of the baffle.

• Porous baffle with 40PPI has the highest friction factor and gives the best performance.

Sheng-Chung Tzeng et al.[2]

Had studied experimentally the local and average heat transfer characteristic in an asymmetrically heated porous channel. This channel was made up of sintered bronze bead with two diameters 0.704mm and 1.163mm. Using WEDM (wire electronic discharge machine) periodic cavities were made in it into which solid copper baffles were inserted . An experiment was carried out using following modes of baffles.

Mode A (without baffle);

Mode B (with baffles periodically inserted into the top portion);

Mode C (with baffles periodically inserted into the bottom portion), and

Mode D (with baffles inserted periodically and in a staggered fashion into both the top and the bottom portions).

For various bead diameters Relationship between the average Nusselt number and Reynolds number was investigated. The following conclusions have been made.

- As the bead diameter was declined at high Reynolds number the heat transfer by convection in all modes was increased .
- Mode D was had an excellent heat transfer for a Reynolds number of around 1000.
- In Mode D Heat transfer enhancement was around 20~30%, in mode C it was around 0~12% and in mode B it was around 10~20%.

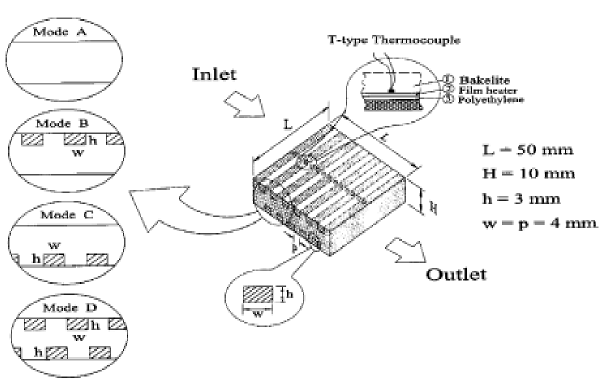

Fig.2.1. Experimental model

Irfan Kurtbas[3]:

Experimentally investigated the heat transfer coefficient for a rectangular channel with 450 and 900 turned flow. Inside the channel of variable height single baffle was used. Seven different flow channels has been manufactured i.e. one straight channel, three channel with different entry height (hc) (named as the ratio of the height of entry channel to the height of test section (Hc= hc/H)) and the remaining three with different baffle height (named as ratio of the baffle height to the channel height (Hb = hb/H)).The Reynolds number was varied between 2800 and 30,000. The following points has been concluded from this experiment.

- Heat transfer enhancement in a straight channel using baffles is 350% more than heat transfer in straight channel without baffles.
- For Hb = 0:75, Nu is higher (approximately 280%) than that of no baffle case.
- The effect of Hb is,with the lower value of Re,Nu is also decreases.This is because the increasing in the baffle height results in an increase in the height, length and strength of the vortex.

Monsak Pimsarn,et al, [4]:

This paper deals with the design of the suitable ribs used for enhancing heat transfer in a rectangular duct heat exchanger by using wall heat transfer (Nusselt number), friction loss (friction factor) and thermal performance (thermal enhancement factor) data. In this experimentation, on the rectangular duct the Z-shaped ribs were set at 30°,45° and 60° and flat rib was set at 90° relative to the air flow direction. In the test section Reynolds numbers studied ranging from 5000 to 25,000. Aspect ratio(ratio of width to height)of the rectangular duct was AR = 10 and height, H = 30 mm with the Z rib height (e), elH = 0.2 and the rib pitch (P),PIH = 3. On the whole area of the upper plate the ribs were fitted in Z-shape (Z-rib) aligned in series.Over the smooth channel Z-ribs showed the significant increase in heat transfer rate and friction loss.The highest increase in the heat transfer rate and the best thermal performance was provided by the 45° Z-rib.

R.M. Majumdar, V.M. Kriplani[5]:

In this paper they had experimentally studied the local heat transfer characteristic and the associated frictional head losses in a rectangular channel.This channel is fitted with solid and perforated baffle with different orientation. Baffle was perforated with the Diameter of hole as Φ4, Φ6, Φ8 (mm). Reynolds number was varied from 7600 to 54000. Following conclusion had been drawn.

•With the increase in the Reynolds number the heat transfer coefficient increases, as the increase in Reynolds number causes more turbulence. By the use of perforated baffles the overall heat transfer coefficient increases. When the baffles of 9 hole (Φ8) was used, it gave maximum value as compared to 6 hole (Φ6) baffle and 3 hole (Φ4) baffle. The reason behind this is that more number of hole and large diameter provides more air flow area and jet impingement toward heat transfer surface.

• At the same Reynolds number by changing the baffle orientation, heat transfer coefficient is increased by 28% as compared to with no baffle, Optimum angle of inclination selected was 30^0

•As the Reynolds number increases more friction occurs to the fluid which may lead more pumping power and hence reduce life of component. It was also observed that with the increase in inclination of baffle more obstruction to flow causes and hence lead to frictional losses.

Ahmet Tandiroglu [6]:

In this paper he studied the effect of the flow geometry parameters on transient forced convection heat transfer for turbulent flow in circular tube with baffle as inserts. Experimentation was done by changing the different parameters of the tube such as different ranges of pitch to inlet diameter ratio H/D=1, 2, 3. Baffle orientation angle β was also changed, such as $\beta=45^0$, 90^0 and 180^0. Air was used as working fluid. Reynolds's number was varied from 3000 to 20,000.

From his experimentation the following conclusions has been drawn

- Heat transfer rate in case of tube with baffle insert is higher than the tube without baffles.
- With the increasing Reynolds number the time averaged Nusselt number was increases.
- For transient flow conditions, with increasing Reynolds number the rate of pressure drop increases whereas for the steady state flow conditions, with increasing Reynolds number the rate of pressure drop decreases.

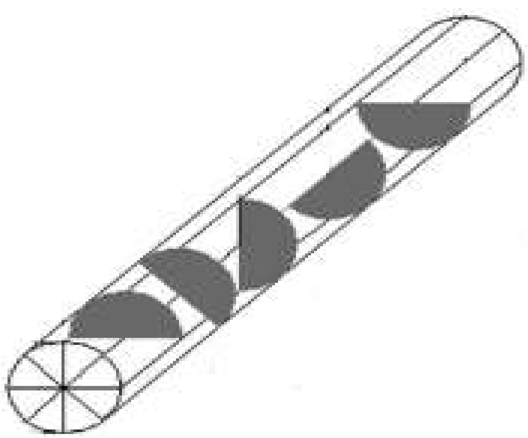

Fig 2.2: 45^0 half circle baffled tubes.

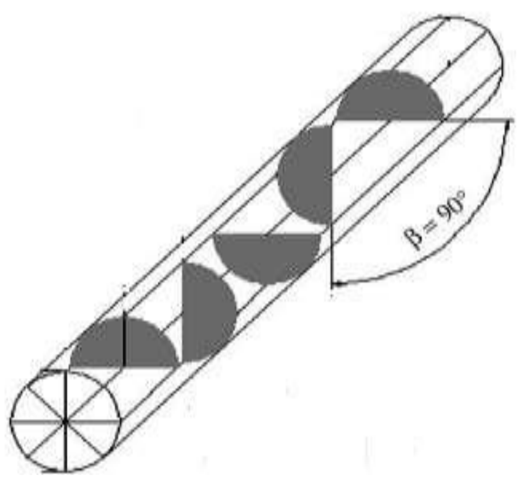

Fig 2.3: 90^0 half circle baffled tubes.

Sutapat Kwankaomeng,et al,[7]

In this paper they had done an experimental investigation in a square channel inserted with staggered inclined baffles. Baffles are placed at an attack angle $\alpha=45^0$ on the lower and upper walls of the test channel. Changes in heat transfer and pressure loss were investigated for different baffle to channel height ratio (e/H=0.1, 0.2, 0.3, 0.4). Reynolds number was varied from 4000 to 25,000.

From this experimentation following conclusions have been drawn.

• Heat transfer was increases with rise in Reynolds number; this is because the inclined baffles interrupt the development of boundary layer and increases the degree of turbulence of flow.

• For baffle-to-channel height ratio, e/H=0.4, the heat transfer coefficient is considerably higher than those for e/H = 0.3, 0.2, and 0.1.

•There was a substantial increase in friction factor over the smooth channel because of the use of baffle turbulators; this was because of flow blockage, higher surface area and the act caused by the reverse flow.

REFERENCES

[1] Kang-Hoon Ko, N.K. Anand "Use of porous baffles to enhance heat transfer in a rectangular channel", International Journal of Heat and Mass Transfer 46 (2003) 4191–4199.

[2] Sheng-Chung Tzeng , Tzer-Ming Jeng , Yen-Chan Wang "Experimental study of forced convection in asymmetrically heated sintered porous channels with/without periodic baffles" International Journal of Heat and Mass Transfer 49 (2006) 78–88.

[3] Irfan Kurtbas "The effect of different inlet conditions of air in a rectangular channel on convection heat transfer: Turbulence flow", Experimental Thermal and Fluid Science 33 (2008) 140–152.

[4] Monsak Pimsarn, Parkpoom Sriromreun, and Pongjet Promvonge,"Augmented Heat Transfer in Rectangular Duct with Angled Z-Shaped Ribs" PEA-AIT International Conference on Energy and Sustainable Development: Issues and Strategies (ESD 2010) The Empress Hotel, Chiang Mai, Thailand. 2-4 June 2010. 249

[5] R.M. Majumdar, V.M. Kriplani "Internal cooling augmentation using inclined perforated baffles in rectangular channel", International Journal of mechanics and Thermodynamics. Volume 2, Number 2 (2011), pp. 113-126.

[6] Ahmet Tandiroglu , ―Effect of flow geometry parameters on transient heat transfer for turbulent flow in circular tube with baffle inserts‖. International Journal of Heat and Mass Transfer 49(2006) 1559-1567.

[7] Sutapat Kwankaomeng, Sompol Skullong, Thavee Teschareon and Pongjet Promvonge "Thermal Characteristics in Square Channel with 45° Staggered Baffle inserts", PEA-AIT International Conference on Energy and Sustainable Development: Issues and Strategies (ESD 2010) The Empress Hotel, Chiang Mai, Thailand. 2-4 June 2010.