Review of Heat Transfer Enhancement Using Different Types of Inserts and Their Orientations Using Passive Techniques

Sitender Dahiya[1] Sunil Dhingra[2]
[1]Student [2]Assistant Professor
[1,2]Department Of Mechanical Engineering
[1,2]UIET Kurukshetra University, Kurukshetra, India

Abstract— Heat transfer enhancement techniques are used to increase rate of heat transfer. Many industries are utilizing thermal systems wherein overheating can damage the system components and lead to failure of the system . The excessive heat so generated must be dissipated to surroundings to avoid such problems for smooth functioning of system. In order to overcome this problem, thermal systems with effective emitters such as ribs, fins, baffle etc. are desirable. This review paper based on different types of baffles and their different orientation or arrangements. According to recent studies these are known to be economic heat transfer augmentation tools.

Keywords: Heat transfer enhancement, baffle, ducts, passive techniques.

I. INTRODUCTION

The process of involving the performance of a heat transfer system is referred as the heat transfer enhancement technique. The major difficulty to design a heat transfer equipment is compact and to achieve a high transfer rate. Augmentation techniques convective heat transfer by reducing thermal resistance in a heat exchanger. The heat transfer can be increased by the following different augmentation techniques. They are classified as

- Passive Technique
- Active Technique
- Compound Techniques

Passive Technique: These techniques do not require any external power input rather they use it from the system which leads to an increase in fluid pressure drop.
Active Technique: The technique require an external power input for enhancement of heat transfer . Ex. Use of magnetic field to disturb the seeded light particle in a following stream.
Compound Technique: The combination of above two techniques is the compound techniques.
In this paper we studied about passive techniques only.

A. PASSIVE TECHNIQUE :-

Passive technique is widely used to intensify the heat transfer as no external power is required. In this method or technique, modification of surface and the geometry of the duct is used. This method is used in designing of nuclear reactors, heat exchanger, industries.

II. DIFFERENT METHOD OF INTENSIFICICATION

Following are the methods used to enhance the heat transfer:-

A. SURFACE ROUGHNESS

Shivani T. Gajusingh, Nasiruddin Shaikh, Kamran Siddiqui [1] the impact of a rectangular baffle inside a square channel. The literature review shows that significant research work has been done to investigate the impact of vortex generator on the flow behavior and heat transfer augmentation. The present study is aimed at quantifying the flow modifications by a vortex generator through a systematic comparison of the flow structure in the presence and absence of a vortex generator. Two experimental cases were considered at the Reynolds numbers of 4190 and 3420, using baffle they are considered as cases I and II, respectively. The Reynolds numbers for cases I and II in the absence of baffle are 4350 and 3550, respectively. Comparison of the Reynolds numbers in the presence and absence of baffle shows that for each case, the Reynolds number in the presence of baffle is 3.7% lower than that in the absence of baffle. The results have shown that the flow characteristics are significantly modified due to the insertion of a baffle inside the channel. Comparison of the turbulent characteristics in the presence and absence of the baffle has demonstrated that turbulent velocities and other turbulent properties are enhanced significantly. The most significant turbulence enhancement was observed in the region within a distance of two baffle heights from the bottom wall just downstream of the baffle which increased to three baffle heights at further downstream locations. The turbulence in this region was several times higher than that without a baffle.

B. DECREASED/GRADED BAFFLE

DJAMEL SAHEL, REDOUANCE BENZEGUR[2] found that present a novel design of baffled channel, which is called decreased/graded baffle design. The baffle are decreased or graded according to the channel length decreased baffle ratio varied from 0 to 0.08. the result shows that the decreased or graded baffle design can significantly reduce friction factors, for the channel at dbr = 0.08, the friction factor decrease from 4-8%, this reduction of friction factors decreased the thermal transfer by 5% at maximum value compared with simple baffle.

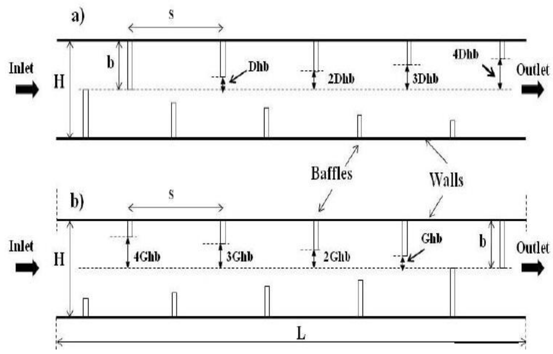

Fig. 2: Channel and baffle geometry

C. PERFORATED BAFFLE

K. DAVID HAUNG, SHENG CHUNG TZENG[3] work performed a measurement of local heat transfer co-efficient in a square channel with a perforation baffle using the transient liquid crystal thermography. The heat transfer enhancement in case of a baffle with hole is greater than that without holes. When there are more holes, the heat transfer enhancement is more average and the peak of nusselt number on the downstream of step baffle appears and the position moves further to downstream. If the Reynolds number become bigger the higher peak of nusselt number occurs at the downstream of step baffle.

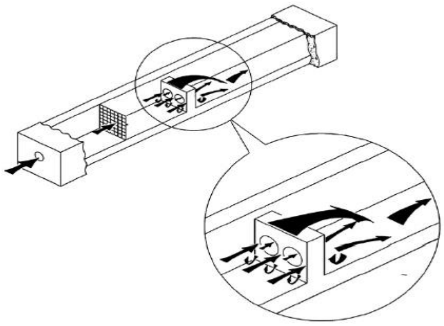

Fig. 3: test section and flow mechanism

D. DIAMOND SHAPE BAFFLE

SOMCHI SRIPATTANAPIPAT, PONGJET[4] found that laminar periodic flow and heat transfer in 2-D horizontal channel with isothermal walls and with staggered diamond shapped baffles is investigated. Effects of different baffle tip angle on heat transfer and pressure loss in the channel are studied. The order of enhancement is about 200-680% for using the diamond baffles. However the augmentation is associated with enlarged friction loss ranging from 20 to 220 times greater the smooth channel. The enhancement of heat transfer for the 5^{o} diamond baffle is around 6% higher than that for flat baffle.

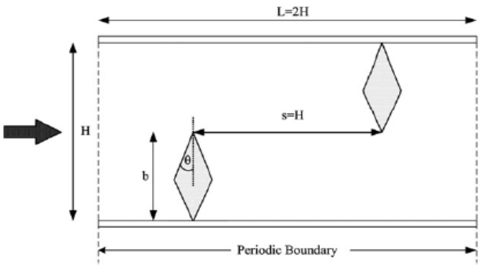

Fig. 4: channel geometry

E. INCLINED BAFFLE

AHMET TANDIROGLU[5] found that effect of flow geometry parameters on transient forced convection heat transfer for turbulent flow in a circular tube with baffle insert. The characteristics parameters of the tubes are pitch to tube inlet diameter ratio H/D = 1, 2and 3 baffle orientation angle $\beta = 45^{o}$, 90^{o} , 180^{o} . Air prandtl number of which is 0.71 was used as a working fluid. The proposed empirical correlations were considered to be applicable with in range of Reynolds number $3000 \leq Re \leq 20000$ for the case of constant heat flux. It is observed that the maximum heat loss did not exceed 5% all through test runs. The highest time averaged nusselt number was achieved with baffle inserted tube of the type 9031. In this type, increase in the time averaged nusselt number was obtained atleast 786% as compared to smooth tube. Nusselt number increase with increase of Reynolds number for transient flow conditions but decreases with increasing Reynolds number for the steady state flow conditions.

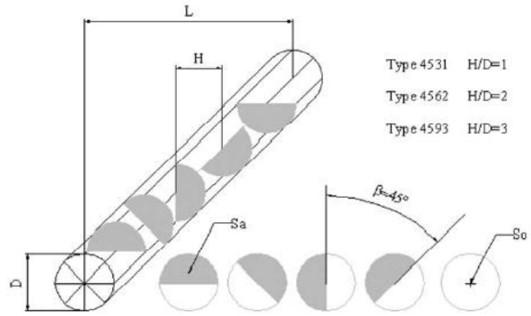

Fig. 5: schematic of 45^{o} half circle baffled tubes

F. VERTICLE AND INCLINED BAFFLES

NASIRUDDIN, M. H. KAMRAN SIDDIQUE[6] found that effect of three different baffle arrangement on heat transfer enhancement. The result show that for the vertical baffle , an increase in the baffle height Causes a substantial increase in the nusselt number but the pressure loss is also very significant. For inclined baffles , the nusselt number enhancement is almost independent of the baffle inclination angle, with maximum and average nusselt number 120% and 70% higher than that for no baffle case . For a given baffle geometry, the nusselt number enhancement is increased by more than a factor of two as the Reynolds number decreased from 20000 to 5000. Average nusselt number for two baffle case is 20% higher than the one baffle case and 82% higher than the no baffle case. The above result suggest that a significant heat transfer in a heat exchanger tube can be achieved by introducing a baffle inclined towards downstream side, with minimum pressure loss.

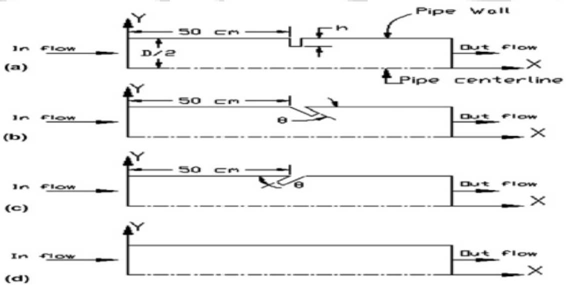

Fig. 6: Test section with different types of baffles

G. TWISTED TAPE

Pongjet Promvonge,Somsak Pethkool, Monsak Pimsarn, Chinaruk Thianpong[7] the experiment was carried out in a double tube heat exchanger using the helical-ribbed tube having a single rib-height to tube-diameter ratio, e/DH=0.06 and rib-pitch to diameter ratio, P/DH=0.27 as the tested section. The experimental results reveal that the co-swirling inserted tube performs much better than the ribbed/smooth tube alone at a similar operating condition. The work has been conducted in the turbulent flow regime, Reynolds number from 6000 to 60,000 using water as the test fluid. For the inserted ribbed tube, the Nusselt number(Nu) tends to increase with the rise in Reynolds number. The compound enhancement devices of the helical-ribbed tube and the twin twisted tapes show a considerable improvement of heat transfer rate and thermal performance relative to the smooth tube and the helical-ribbed tube acting alone, depending on twist ratios. The co-swirl tube yields higher

Nu and f than the ribbed tube at higher twist ratio. The maximum TEF is obtained for the co-swirl tube at Y≈8.

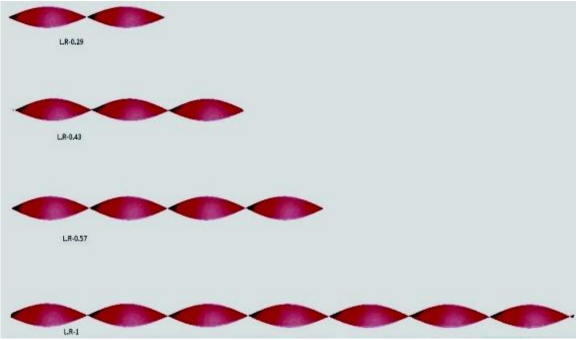

Fig. 7: Twisted tape inserts

III. CONCLUSION

In this paper, the following heat transfer intensifiers are described and reviewed :- (a) surface roughnes and ribs (b) decreased/graded baffle (c) perforated baffle (d) diamond shaped baffles (e) inclined baffle (f) vertical and inclined baffle (g) twisted tape inserts. Different researchers works about each one have been reviewed and many methods that assist their augmentation effects have been extracted from the literature. These methods presented in the literature are graded baffle and diamond shaped baffle found that more efficient. Many researchers work related to passive enhancement technique.

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