Thermal Analysis of Heat Exchanger with Vortex Generator

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ABSTRACT

A type of plate-fin channel with circular wings as a transverse vortex-generator channel was considered. As the first part of project, a precise and reliable experimental setup was designed and fabricated to generate heat flow. In the second part of the project, the influences effective geometrical parameters. As the third part of the project, general correlations were derived for Nusselt number, Heat transfer Coefficient, Heat coefficient, Reynolds Number, the plate-fin heat exchangers with vortex-generator channels.

Keyword : - *Vortex generator, Heat Exchanger and Convection*

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1. INTRODUCTION

Heat transfer is a discipline of thermal engineering that concerns with generation, use, conversion, and exchange of thermal energy and heat between physical systems as well as chemical system. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Plate-fin heat exchangers (PFHEs) are widely used in many industrial areas such as chemical and food engineering, radiator of car, power system, heating and air conditioning, refrigeration, aerospace, and other engineering applications In this study, attempt is made to study the effect of various parameters related to semicircular vortex generator on heat transfer rate and frictional losses

1.1 Heat transfer enhancement technique

1. Passive Techniques: These techniques generally use surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior (except for extended surfaces) which also leads to increase in the pressure drop. In case of extended surfaces, effective heat transfer area on the side of the extended surface is increased. Passive techniques hold the advantage over the active techniques as they do not require any direct input of external power. Heat transfer augmentation by these techniques can be achieved

2. Active Techniques
This method involves some external power input for the enhancement of heat transfer and has not shown much potential owing to complexity in design. Furthermore, external power is not easy to provide in several applications. In comparison to the passive techniques, these techniques have not shown much potential as it is difficult to provide external power input in many cases Some examples of active methods are induced pulsation by cams and reciprocating plungers, the use of a magnetic field to disturb the seeded light particles in a flowing stream, etc.

2 LITERATURE REVIEW

Ashwin Kannan Iyengar & Gautam Biswas evaluated performance parameters in terms of Nusselt number, vorticity and quality factor (a ratio between the Colburn factor to apparent friction factor, also refer to as area goodness factor with slight modification). The results show significant improvement in the heat transfer performance due to the nozzle-like flow passages created by the winglet pair and the region behind the circular tube which promote accelerating flow [1]. K. Torii & K. M. Kwak proposes a novel technique that can augment heat transfer but nevertheless can reduce pressure-loss in a fin-tube heat exchanger with circular tubes in a relatively low Reynolds number flow, by deploying delta winglet-type vortex generators [2]. Paisarn Naphon et al., studied experimentally heat transfer and pressure drop in the different angles of corrugated upper and lower plates. The experimentation was carried out for Reynolds number in the range of 2000 to 9000 and heat flux 0.5 to 1.2w/m2K. Experiments were conducted with various heat flux as well as flow rate of air. It was concluded that the heat transfer rate was higher as the air mass flow rate increases. Heat transfer obtained with the corrugated channel was 3.5 times higher than smooth channel, and pressure drop was 5 to 6 times greater than smooth channel. [3].

3. EXPERIMENTATION & METHODLOGY

Fig 1shows the schematic diagram of the experimental setup from top view. The without vortex different position and same thickness is as shown in fig 3.2 The rectangular channel is used for this investigation and made up of EN8 material . All the geometrical dimensions are in term of channel height while the heat transfer coefficient are presented in term of channel. A suction mode fan is used to draw the air from entrance to exit section.

In present study, vortex generator of different height of same thickness and height (t=1mm, h=10mm) are used. The systematic view of vortex used in this investigation is given in fig 2. These vortex are attached in test section by providing screwing arrangement in front and back portion of the duct. These vortex are in contact with the heated top surface Test sections are prepared for experimentation purpose. In experimental procedure, one test section validated by running through the rectangular duct without using any vortex. In second phase the experimentation is carried out by using vortex inside the duct. their performance is compared with each other.

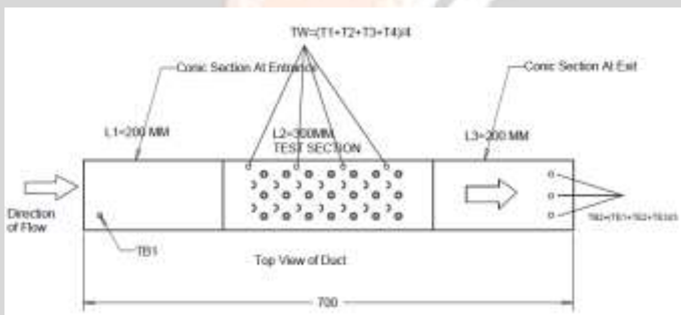

Fig 1 Shows the schematic diagram of the experimental setup from top view

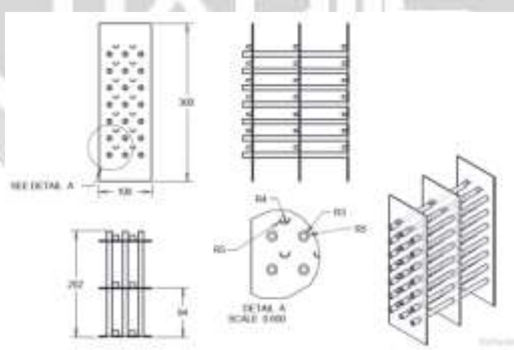

Fig 2 Shows the schematic diagram of Test Section with vortex generator

4. RESULTS & DISCUSSION

The experiments were carried out on the test rig initially smooth channel without using any vortex and the different heat transfer characteristics were calculated and then the same is done using with vortex. Based on the above calculations following graphs are plotted for interpretation of performance:

4.1 Heat transfer coefficient Vs mass flow rate

From the chart - 1, it is observed that the heat transfer coefficient increases with increase in mass flow rate. As mass flow rate increases, the air flow will cause more turbulence so definitely the heat transfer rate will increase. It is observed that the rectangular channel without any vortex gives least heat transfer coefficient. Use of semicircular vortex increases the heat transfer coefficient. value of heat transfer coefficient because it create more turbulence in a duct as compare to without vortex which creates less turbulence.

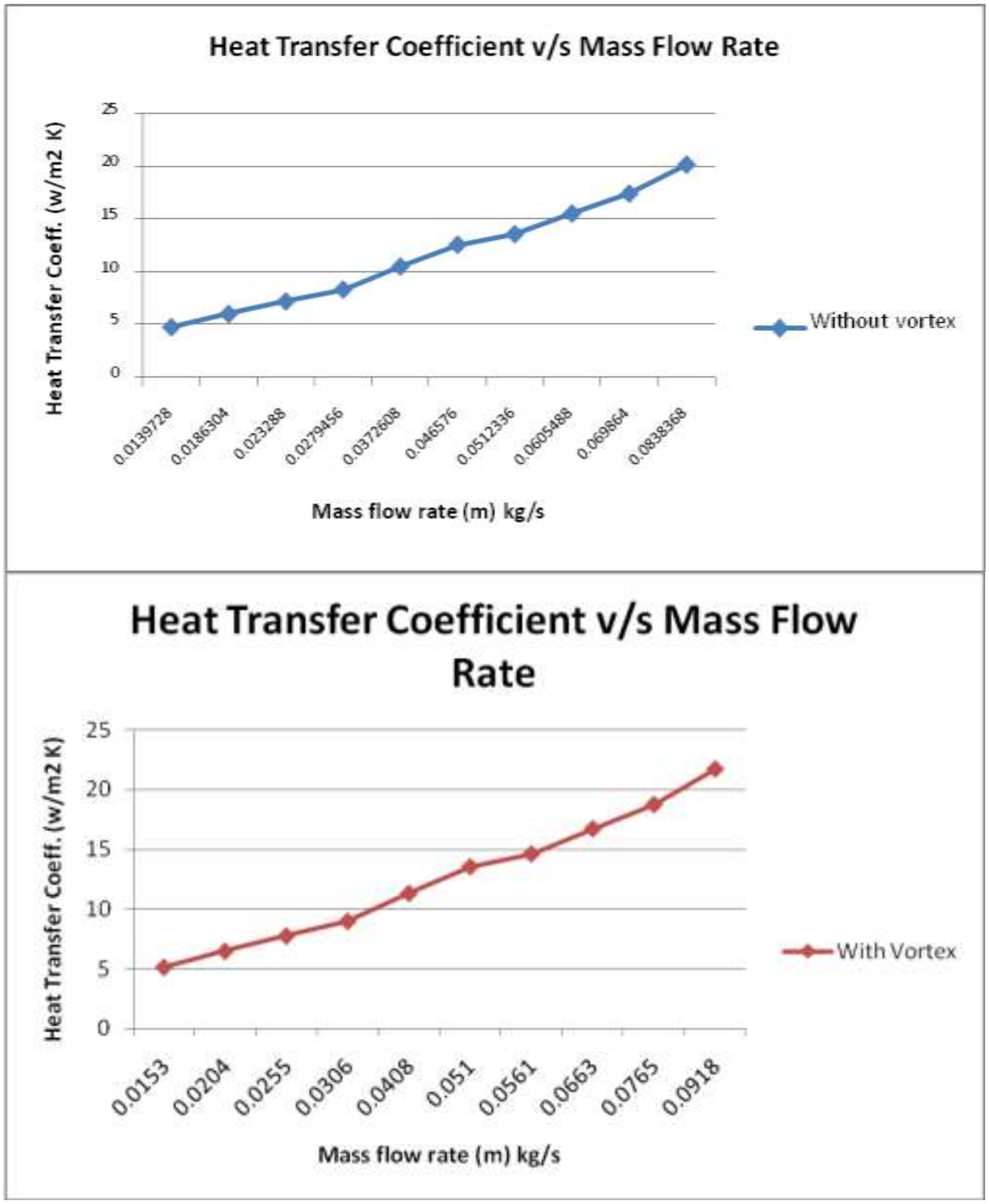

Chart -1 Heat Transfer Coefficient v/s Mass Flow Rate

Heat transfer coefficient Vs Reynolds No

From chart-2., it is observed that the heat transfer coefficient increases with increase in Reynolds no. As Reynolds no. increases, the air flow will cause more turbulence, so due to which the heat transfer rate will increase. It is also observed that, the rectangular duct without using vortex gives less heat transfer coefficient than with the use of vortex generator gives maximum value of heat transfer coefficient because it create more turbulence in a duct as compared to vortex which is create less turbulence than with vortex generator.. It is observed that, least heat transfer coefficient obtained in without vortex

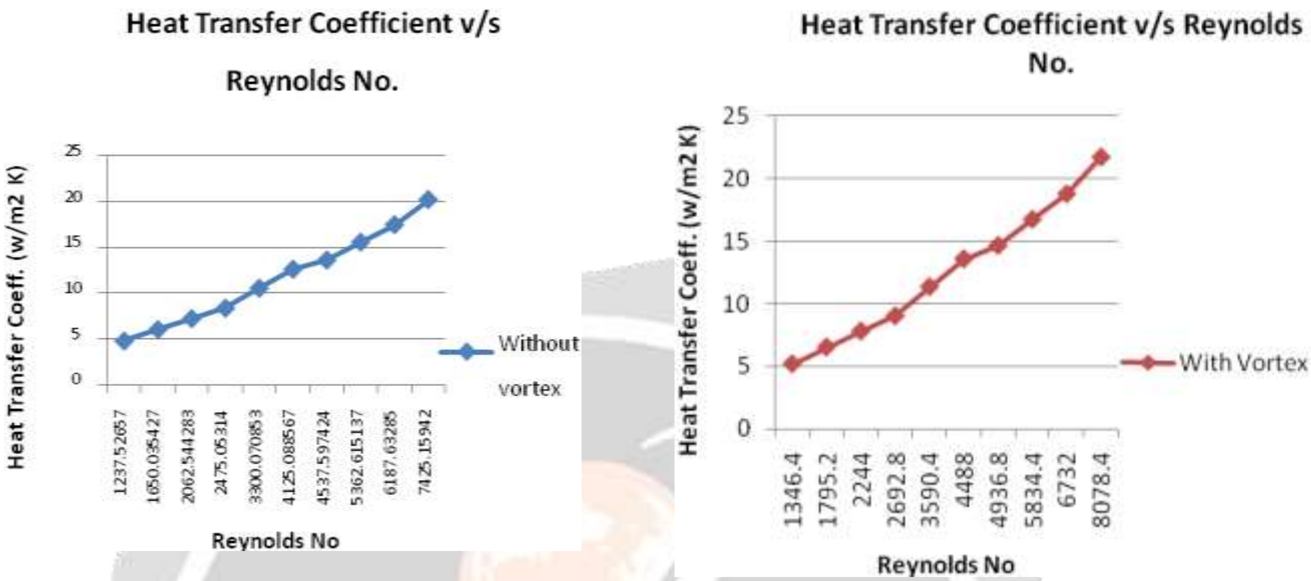

Chart -2 Heat Transfer Coefficient v/s Reynolds Number

Friction factor ratio Vs Reynolds Number.

From chart 3 it is observed that as Reynolds number increases there is decrease in friction factor is observed. This is because friction factor is inversely proportional to the velocity. So as velocity increases (i.e. Reynolds no. increases) friction factor will decrease. It is also observed that, minimum friction factor is obtained in duct with vortex and maximum friction factor is observed in without vortex

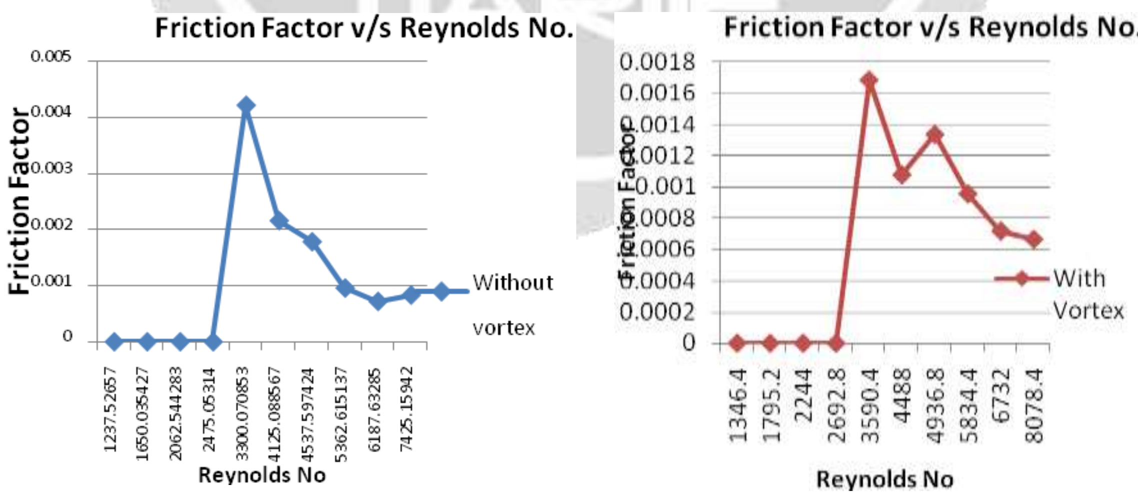

Chart-3 Friction Factor v/s Reynold Number

5. CONCLUSIONS

The various characteristic are studied for the different cases viz. without vortex, with vortex. These characteristics are compared to each other and the following conclusions are made.

The heat transfer in rectangular duct with vortex generator is found to be more efficient as compared to without ribs. The increase in heat transfer rate of air is 50.00% more for with vortex generator and 35.52% with Vortex over when no vortex in duct. The increase in heat transfer occurs due to more turbulence is generated within the duct by using vortex in a duct.

Friction factor reduces, as the Reynolds number increases. This is because with increase in Reynolds number, velocity increases. This friction factor is found to be more in with vortex.

As the velocity increases friction factor decreases because friction factor is inversely proportional to velocity of air

6. REFERENCES

[1]. C.P. Khotandaraman, S. Subramanyan, "Heat and Mass Transfer Data book", 7th Edition, pp.1-185, 2010.

[2]. Giovanni Tanda, "Heat transfer in rectangular channels with transverse andV-shaped broken ribs", International Journal of Heat and Mass Transfer 47 (2004), pp.229–243.

[3] Kenichiro Takeishiet,Yoshiaki Miyake,Yusuke Motoda,Yutaka Oda, "Convective Heat Transfer and Pressure Loss in Rectangular Ducts With Inclined Pin-Fin on a Wavy Endwall", Journal of Engineering for Gas Turbines and Power. JUNE 2013, Vol. 135 , pp.061902-1—061902-10.

[4].Mohammad Mashud, "Experimental Investigation of Heat Transfer Characteristics of Cylindrical Fin with Different Grooves" International Journal of Mechanical and Mechatronics Engineering IJMME Vol:9 No.10.

[5] M. Khoshvaght-Aliabadi a, *, S. Zangouei a, F. Hormozi'Performance of a plate-fin heat exchanger with vortex-generator channels: 3D-CFD simulation and experimental validation'", International journal of thermal engineering research, Department of Chemical Engineering, Shahrood Branch, Islamic Azad University, Shahrood, Iran

[6] K. Torii *, K.M. Kwak, K. Nishino "Heat transfer enhancement accompanying pressure-loss reduction with winglet-type vortex generators for fin-tube heat exchangers' Received 5 September 2001; received in revised form 6 February 2002

[7] Anupam Sinha a, Himadri Chattopadhyay b, Ashwin Kannan Iyengar c, Gautam Biswas "Enhancement of heat transfer in a fin-tube heat exchanger using rectangular winglet type vortex generators" Indian Institute of Technology Guwahati, Guwahati 781039, India