International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 08 | August -2020 ISSN: 2582-3930

Experimental study for heat transfer enhancement using different section rib with and without and without dimple

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***ABSTRACT*:**

**Experimental and therotical study reports on fluid flow and heat transfer characteristics in a rectangular channel with C-Type ,W type rib with and without dimple Based on available experimental data, a series of Experiment with 4 type turbulence models are conducted to compare Heat performance
i.e., C type rib, the Reynolds number varies from 10000 to 26,000. It is found that the W-shape ribs evidently enhance local heat transfer and increase the turbulent kinetic energy and reduce thickness of the boundary layer, which lowers local temperature Numerical results show that the cases with W ribs significantly outperform the case with no ribs with respect to heat transfer performance. The C type and W type ribbed channels provide 6% higher normalized average Nusselt number relative the plain channel, Overall the case with W shape ribs provides the best thermal performance.**

INTRODUCTION

The heat transfer rate in flow passage is increased by three techniques such as passive, active techniques and compound technique. Passive techniques are more preferable because of its simplicity in design and fabrication also the cost for fabrication is low in comparison with active and compound techniques. It includes the surface roughening or geometrical modifications in the flow channel which alters flow distribution and promotes more heat transfer. Another technique used is active technique, these techniques are complex to design and implement because it requires external input to disturb the flow. It includes mechanical aids, surface vibration, fluid vibration, electrostatic fields, and injection, suction and jet impingement. A number of experimental investigations have done additional rib with rectangular channel. The flow disturbance is maximum for inline arrangement. The C W shape RIB are more efficient geometry for heat transfer , with the peak end at upstream and round end at downstream produces more mixing of fluid which promotes the heat transfer rate. Analytically analysed convective heat transfer in turbulised flow.

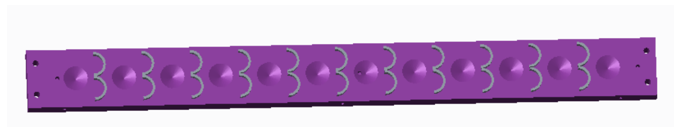

Fig 1: Plate design with Dimple and W section

A parametric study is performed with k-ε turbulence model to determine the effects of Reynolds number, and Nusselt number on heat transfer enhancement, and have computed heat transfer coefficients in a channel with one side C, W shape rib added surface. The Reynolds number based on the channel hydraulic diameter was varied from 10000 to 25000.They showed that more heat transfer was occurred downstream of the turbulators due to flow reattachment. Due to the flow recirculation on the upstream side in the turbulators, the heat transfer coefficient was very low. As the Reynolds number increased, the overall heat transfer coefficient was also increased. This experiment includes study of heat transfer rate from rectangular plain channel and channel C-Type dia 20 mm , W-Type dia 10 mm inline arrangement The heat transfer rate is given by the Nusselt number ratio i.e. ratio of practical Nusselt number and theoretical Nusselt number. The friction factor is calculated with help pressure drop across test section and compared with theoretical friction factor which is given by Dittus-Boelter equation. The obtained results are compared with plain plate results.

2. EXPERIMENTAL INVESTIGATIONS

2.1 Test specimen

The baseline rectangular channel in this experiment and the indication/pattern of protrusion and dimple as shown below Fig

The investigated part which is the middle heated section of the domain has a length of L0 520 mm,

The inlet and outlet of the channel are composed by a rectangular cross section with a channel aspect ratio (W/H) of 4:1. The hydraulic diameter of the inlet cross section is Dh¼ 48mm, According to the value of W and H. C section W section rib added on plain Channel with and without dimple

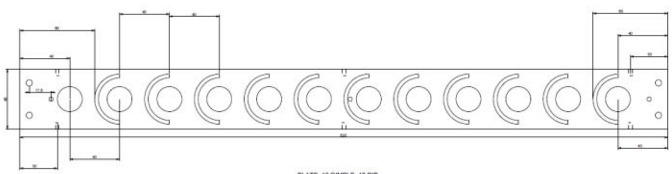

Fig-2

EXPERIMENTAL PROCEDURE

The test section is kept in duct /chamberEnsured all thermocouple to be assemble on test specimen to Measure surface temp.

Chamber made closed and ensure leak proof with masking tapeThe blower switched on and rotated at constant RPM Blower deliver predetermined rate of airflow through the duct at constant RPM.A constant heat flux/Input is applied to the heater, Heater will maintain the test specimen surface temp through out of specimenU-tube manometer connected to in and out of orifice meter, Air flow will determine using shown, difference on manometerSystem was allowed to attain a steady state before the reading were recorded. The pressure drops were measured when steady state is reached.

During experimentation the following parameters were measured:

i) Pressure difference across the orifice meter.

ii) Temperature of the heated surface and temperatures of air at inlet and outlet of the test section.

iii) Pressure drop across the test section

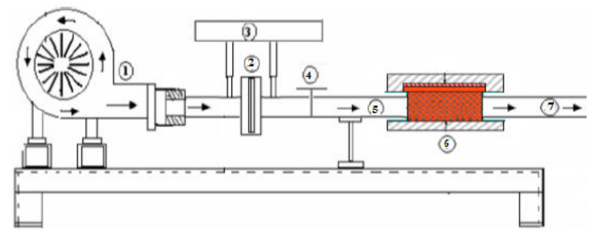

Fig-3 Test set up

TEST SPECIMEN

The figures below shows the schematics of rib section used, these test plate are having Plain plate, C section Rib, W section Rib with and out dimple

Fig-4 Plain Channel

Fig 5 Channel with C-section

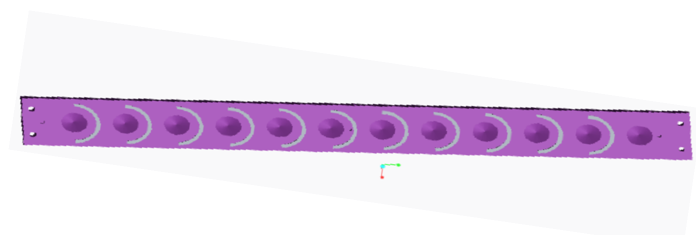

Fig.6 Channel with C Section Rib with Dimple

Fig.7 Channel with W shape rib

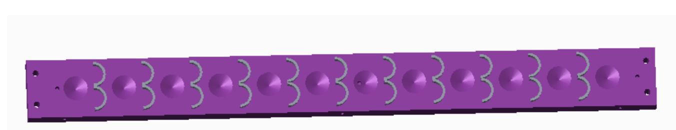

Fig 8 Channel W-Shape rib with dimple

Data collection and Calculation

The values of performance parameter, mass flow rate of air at given heat flux can be calculated with steady state values of plate and air temperature.

Q = h A (Ts- Ta)

ΔTs = ($T1$+$T2$+$T3$+$T4$+$T5$+-----+ $T6$)/6-----Average surface

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Temp

ΔTa = (T9+T10)/2--------------Average Air In, Air out temp

A-Area of plate

Q=Heat flux/Heat input

h = Q/ [A*(Ts−Ta)] --------------Heat transfer coefficient

Reynolds No

$$Reynolds = \frac{\text{Densityx VelocityxDh}}{\text{Dynamic Viscosity}}$$

Dittus-Boelter equation

$$Nu = 0.023 Re^{0.8} Pr^{0.4}$$

Nusselt No

Nu=hD/K

Hydraulic Diameter Dh=4A/P

❖ **Friction Factor**

Friction factor for channel with diff section is calculated is calculated as

Darcy friction factor,
hf=fLV^2/2gd

f=h2gdh/LV^2

❖ **Thermal performance factor**

The Thermal performance factor is defined as the ratio of the heat transfer enhancement ratio to the friction factor ratio. This parameter is also used to compare different passive techniques and enables a comparison of two different methods for the same pressure drop.

The Thermal performance factor is defined as

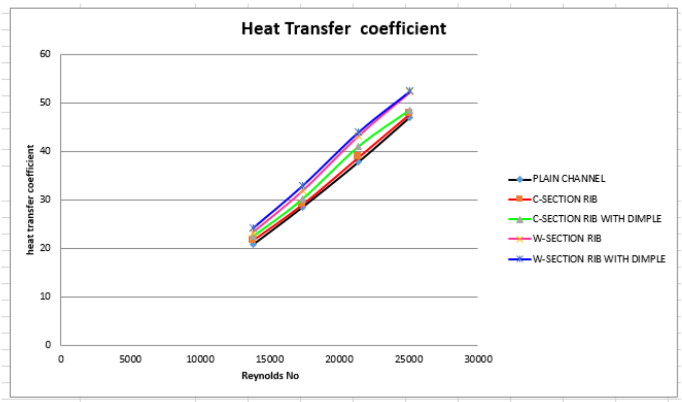
$$Thermal\ performance\ factor = \frac{\frac{Nu}{Nu_0}}{(\frac{f}{f_0})^{1/3}}$$

3 Results and Discussions

The boundary layer of the mainstream was separated by the turbulators and recirculation zone is created in the upstream side of the turbulators. The separated mainstream flow reattaches in the downstream surface and the reattached flow forms a twin vortex. As the flow comes out of the turbulators, it reattaches again at the downstream of the turbulators. These complex flow phenomena induce high and low heat transfer in and near the turbulators. The heat transfer, thermal performance and friction factor characteristics of duct has given which is obtained from experimental data.

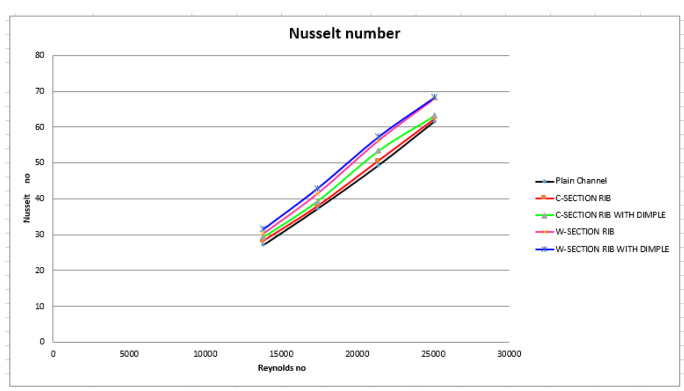
Reynolds number

Variations in Convective Heat Transfer Coefficient with Reynolds Number for Plain and Channel, Channel with C section, W Section Rib, with and without dimple with different Reynolds no



Nusselt number

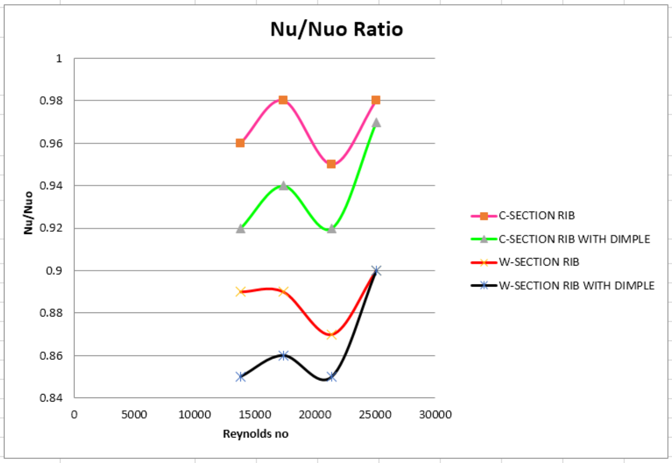
It is observed that baseline Nusselt number increase with increase in Reynolds number and the rate of increase for plate is higher than for smooth plate. The measured Nusselt numbers are compared with theoretical value of plain plate Nusselt no Nusselt number and Different rib section plate Nusselt no The maximum value of Nusselt number obtained with W section rib with dimple .



Nu/Nuo Ratio

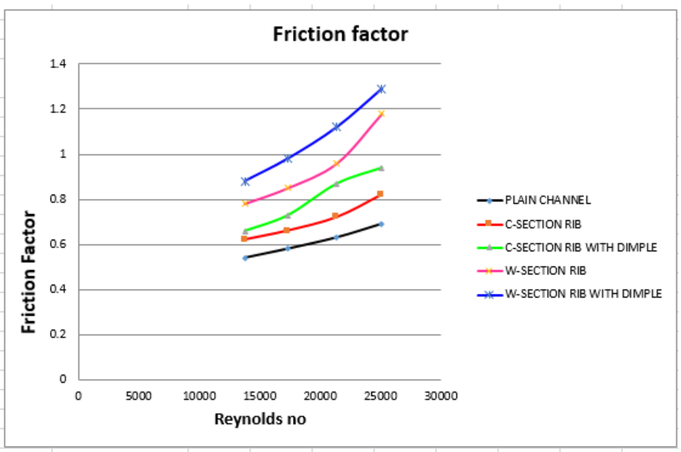
Variations in Nu/Nuo ratio with Reynolds Number for Plain and Channel, Channel with C section, W Section Rib, with and without dimple

The experimental Nusselt numbers are compared with theoretical Nusselt number. Effect of different section rib can be found by the Nusselt number ratio



FRICTION FACTOR

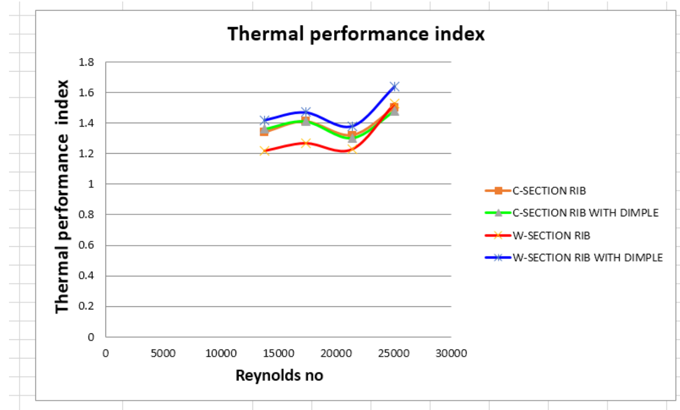
From results it is observed that friction factor increases with increase in Reynolds number.



THERMAL PERFORMANCE INDEX

The thermal performance index parameter provides the quality of heat transfer augmentation (Nu/Nuo) and friction factor augmentation (f/fo)^(1/3). It increases with W section rib and dimple

Variations in Thermal performance index with Reynolds Number for Plain and Channel, Channel with C section, W Section Rib, with and without dimple



4 Conclusions

In this study forced convection heat transfer characteristics Plain channel, Channel with C Section, Channel with W section, Channel with C section and Dimple, Channel with W section and Dimple has been investigated experimentally.

The effect of variation in Channel with C section and Channel with W section with and without dimple has been investigated with variation in mass flow rate of air and heat input. Across test section has also been investigated with variation in mass flow rate of air and heat input.

The whole experimentation has been carried out under turbulent flow condition.

This investigation was carried out to observe if the use of dimples C-Section OR W Section Channel can enhance heat transfer characteristics without severe penalties associated with pressure drops for turbulent flow.

The following conclusions were drawn from this study.

- Heat transfer enhancement under forced convection can be achieved by Channel with C, With W Section, C Section with Dimple, and W Section with dimple. It is also observed that W Section with dimple facilitates higher heat transfer augmentation when compared to the Plain channel.
- The enhancement in convective heat transfer coefficient is observed as 8% and in Nusselt number as 10 % as compared with Plain channel for same mass flow rate of air and same heat input.
- The W section with dimple shows enhancement of 6 % as compared with C section and dimple arrangement for same heat input and mass flow rate of air.

The thermal performance factors were plotted for all the geometries. The thermal performance factor values for the W Section with dimple geometry were more than corresponding plain channel in the Reynolds number range studied.

Thus, the W-section rib with dimple dimpled surface on the Channel was found to enhance heat transfer over a plain channel surface for turbulent airflows.

5.REFERENCES:

1)Yonghui Xie, Zhongyang Shen, Di Zhang, Phillip Ligrani Numerical Analysis of Flow Structure and Heat Transfer Characteristics in Dimpled Channels With Secondary Protrusions, Journal of Heat Transfer, MARCH 2016, Vol. 138 / 031901-1

2) Gongnan Xie , Jian Liu Phillip M. Ligrani , Bengt Sunden Flow structure and heat transfer in a square passage with offset mid-truncated ribs

3)Gongnan Xie , Xueting Liu Hongbin Yan Jiang Qin Turbulent flow characteristics and heat transfer enhancement in a square channel with various crescent ribs on one wall

4) Yu Rao1 Chaoyi Wan Shusheng Zang An Experimental and Numerical Study of Flow and
Heat Transfer in Channels With Pin Fin-Dimple Combined Arrays of Different Configurations

5) S.A. Isaev A.V. Schelchkov A.I. Leontiev , Yu F. Gortyshov P.A. Baranov , I.A. Popov Vortex heat transfer enhancement in the narrow plane-parallel channelwith the oval-trench dimple of fixed depth and spot area

6) Lu Zheng , Yonghui Xie , Di Zhang Numerical investigation on heat transfer performance and flowcharacteristics in a rectangular air cooling channel (AR = 2) with ridged Dimples

7) Gongnan Xie , Jian Liu , Phillip M. Ligrani , Weihong Zhang a Numerical analysis of flow structure and heat transfer characteristics in square channels with different internal-protruded dimple geometrics

8) S. Caliskan S. Baskaya b Velocity field and turbulence effects on heat transfer characteristics from surfaces with V-shaped ribs

9) R.K. Ali Heat transfer enhancement from protruding heat sources using perforated zone between the heat sources

10) Abdelkader Korichi a, Lounes Oufer ,∗Numerical heat transfer in a rectangular channel with mounted obstacles on upper and lower walls

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