# Review on Heat Transfer Enhancement with the Help of Different type of Inserts in Channel

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*Abstract*— A review paper based on investigation of heat transfer enhancement with the help of using different types of inserts or turbulators used in duct (Square, circular and Rectangular Channel). Set of repeated turbulators used to promote turbulence and enhance convective heat transfer. Which results at various Reynolds number (Re) within the turbulent flow regime the local heat transfer coefficient obtained. Here due to low heat transfer the heat transfer rate also lower level.

***Key words:*** Heat transfer enhancement, Inserts, Thermal Performance

## I. Introduction

There are various technique used to enhance convective type of heat transfer in channels, such as dimple, pin fin, grooves, protrusions, swirl chambers and rib turbulators [1–6]. Turbulators or inserts protruded from the end wall have been commonly used since the introduction of turbulators can interrupt fluid flow, make the thermal boundary layer redevelop, intensify flow mixing by inducing vortices and enlarge heat transfer area. As revealed in [7], on external surface internal turbulators can enhance overall heat transfer effectiveness of the vane by up to 50% compare to the situation without turbulators.

## II. Literature Review

Experimental and numerical investigations have been conducted to explore the effects of various parameters such as configuration of iserts and shape as well as shape of cooling passages on fluid flow and heat transfer [8–10]. According to [8,11–14], both THE geometric parameters of channels and working conditions have significant effects on the thermal performance. Typically, [8,13] it was reported in that the shape of ribs has a more evident effect on pressure drop than that on heat transfer.

Lots of studies focus on the thermal performance in the channel roughened with various shaped ribs. Stephens et al. [15] firstly per- formed computations to investigate the three-dimensional flow field and heat transfer performance in a rectangular channel roughened with five equally spaced square ribs on the bottom wall. Flow separation takes place before the rib and after the rib as well as on top of the ribs. Leonardi et al. [16] using dimple structure an effective heat transfer augmentation approach on coolant channel; this study is to numerically analyze the combination effect of dimples and secondary protrusion. Besides this, the TP of protrusion–dimple channels are comparing with the other typical heat transfer devices, and higher TP can be speculated after a more optimal dimple shape or combination with turbulators and fins. Yonghui Xie et al. [17]

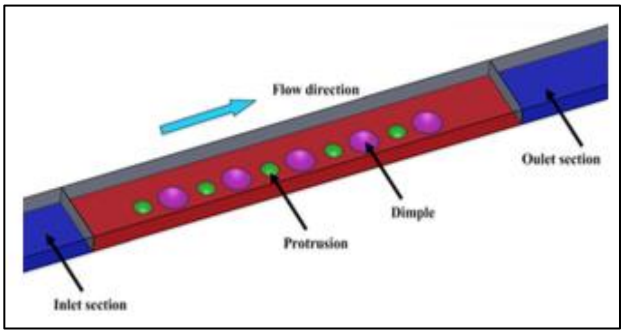


Fig. 1: A schematic diagram of the investigated rectangular channel [17]

Carried out numerical simulations for a fully turbulent flow in a rectangular cavity with square inserts mounted on the bottom surface. For the ratio of distance between the adjacent ribs to the height of rib is more than 7, recirculation zones immediately occur upstream and downstream of each rib while mean streamlines and spatial distributions of the skin frictional drag indicate that each rib is virtually isolated. Murata and Mochizuki [18] conducted experiments for investigate the effects of rib shape, pitch to height ration and angle of attack on the thermal performance in rib-roughened surface. From this research, the rib cross-section has a marked effect on the friction factor and a very modest effect on the heat transfer. Laterally, Han and Park [19] In this article to find the reasons of heat transfer enhancement of a laminar convective heat transfer process in a channel at a uniform heat flux boundary when a pair of longitudinal vortex generators (VGs) is mounted on the bottom wall, According to research show that longitudinal vortices greatly increase the local convection and determine the increased local contribution terms intensify the local convective transport of the heat flux component in the same direction. Liang-Bi Wang et al. [20]

Performed large eddy simulation to observe the effects of transverse ribs on turbulence by changing the rotation number and the aspect ratio. According to the study, the heat transfer enhancement caused by the rotation is larger than that by the higher aspect ratios for the secondary flow induced by the intensified Coriolis. Han et al. [21] studied the combined heat transfer performance in the channels mounted with inclined ribs. Herein, angled ribs (the angle-of- attack is 30–45_) provide about 30% higher heat transfer performance than the transverse ribs does for a constant pumping power. Reported by Yang et al. [22], the increase in heat transfer is accompanied by an increase in friction factor ratio in a channel with angled ribs. During the development of investigations upon the ribs, there are several types of rib occur. Jia et al. [23] Gongnan Xie et al. [24]-This numerical study reports on fluid flow and heat transfer characteristics in a cooling channel with various crescent ribs mounted on one wall. Three kinds of ribs, i.e., the straight rib, the crescent rib concave to the stream-wise direction, the crescent rib convex to the stream-wise direction, are considered to improve thermal performance of the cooling channel.

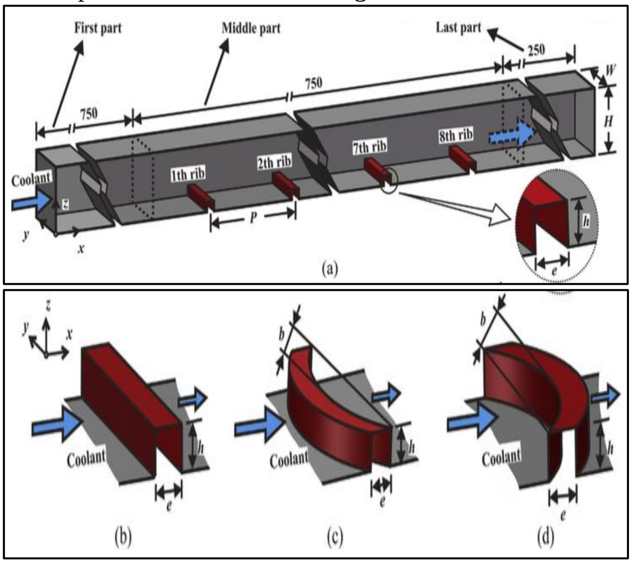


Fig. 2: Computational domain: (a) an overview of the cooling channel; (b-d) schematic illustration of the cooling channel with (b) straight rib (Case A), (c) crescent rib concave to the stream-wise direction (Case B) and (d) crescent rib convex to the stream-wise direction (Case C), respectively. [24]

Numerically investigated the heat transfer and fluid flow phenomena in straight square ducts with V-shaped ribs. According to research found that the V-shaped ribs pointing downstream induce a higher friction factor than the V-shaped ribs pointing upstream does. Tanda [25] using liquid crystal thermography for obtaining detailed distributions of the heat transfer coefficient in the channels with ribs having rectangular or square sections deployed transverse to the main direction of flow or V-shaped with an angle of 45 or 60 relevant to flow direction. In this study, the effect of continuous and broken ribs was considered. Taking pressure drop into account, transverse bro- ken ribs with p/e = 4 and 13.3 have the best thermal performance, while transverse continuous ribs provide a little heat transfer augmentation or even a reduction. Bergmann and Fiebig [26] G. Rau and M. Qakan [27] carried out some experimentation and study the local aerodynamic and heat transfer performance were measured in a rib- roughened square duct as a function of the rib pitch to height ratio. According to research observe that simple correlations derived from the law of the wall similarity and from the Reynolds analogy could not be applied for the present rib height-to-channel hydraulic diameter ratio ($e/D_h$ = 0.1). The strong secondary flows resulted in a three-dimensional flow field with high gradients in the local heat transfer distributions on the smooth side walls.

Compared the local and global turbulent heat transfer in square channel with roughness elements in the form of V-shaped broken ribs attached at two opposite walls. The results showed a symmetric behavior of flow structure and Nusselt number distribution to the middle of the height and span-wise direction. Peng et al. [28] made a comparison of thermo-hydraulic performance in rectangular ducts with five types of ribs. He concluded that the triangular rib has a substantial superiority regarding heat transfer capacity to the other ones. The square rib provides the highest friction factor. Wang et al. [29] experimentally and numerically investigated convective heat transfer in a channel with straight ribs and V-shaped ribs. Compared with a flat wall without ribs, both the straight ribs and V-shaped ribs enhance heat transfer at the cost of higher-pressure drop. Results showed that overall thermal performance of the channel with V-shaped ribs is superior to that with the straight ribs. Ahn [30] Vortex generators in the form of semi circular winglets with punched hole of different diameters at centroid position in-line and staggered manner were used. These vortex generators induced stream wise longitudinal vortices, which cause disruption of the growth of the thermal boundary layer and leads to enhancement of heat transfer between the air and test plate surface. Ravindra F. Dunde et al.[31]

Conducted numerical simulations to predict single-phase turbulent forced convection flow in a channel with triangular ribs, asymmetric arc ribs and compound ribs within the Reynolds number range of 20,000– 60,000. It was found that the compound ribs could improve heat transfer performance and decrease pressure drop concurrently. Zheng et al. [32] Carried out experimental studies to investigate heat transfer in a square duct roughened by ribs having different shapes. They showed that the trapezoidal ribs with decreasing height in the flow direction provide the highest heat transfer enhancement factor. As reported by Yang et al. [33] installed six types of ribs on the bottom wall of a square channel to improve heat transfer in the leeside of the ribs. They reported that ribs with an inclined leeside structure corresponding to an inclination angle of 160_ yield 4.6–6.4% higher heat transfer than rectangular ribs. Furthermore, the rib with an inclined leeside structure corresponding to an inclination angle of 160_ exhibits the highest-pressure drop among the six types of ribs. Wang and Sunden [34], the increase in heat transfer is accompanied by an increase in friction factor ratio in a channel with angled ribs. It is known from the literatures [35,36] that the truncation of ribs can reduce pressure drop penalty but slightly deteriorates heat transfer. Saini et al. [37] carried out an experimental study for heat transfer enhancement in an air duct roughened by arc-shaped insrts. It provides superiority of 3.8 and 1.75 times in Nusselt number and friction factor relative to the smooth channel. The paper investigates (a) thin film formation and (b) falling film heat transfer along a twisted and fluted helix channel on the surface of a vertical tube. It is found from the numerical study that in certain parameter regimes, the flow and temperature fields can be solved in a closed form. It is seen from experimental results that thin films can uniformly cover the surface of the tube and possess relatively higher heat transfer coefficient. Ning Mei et al. [38]

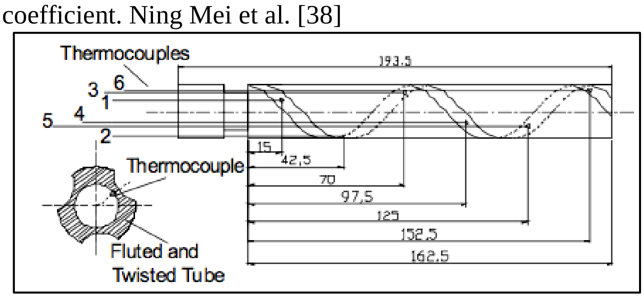


Fig. 4: Sketch of thermocouples embedded scheme. [38]

For investigate the applied performance of the four typical enhanced tubes and parameters such as flow pressure drop, the friction factor, enhanced heat transfer, and anti-fouling performance. On results show that each enhanced tube have certain features. The arc line tube has the greatest friction factor, whereas the corrugated tube has the highest average energy efficiency and the best anti-fouling performance, etc. In addition, these enhanced tubes have better anti-fouling performance in comparison with the corresponding plain tube. Zhi-Ming Xu et al. [39]

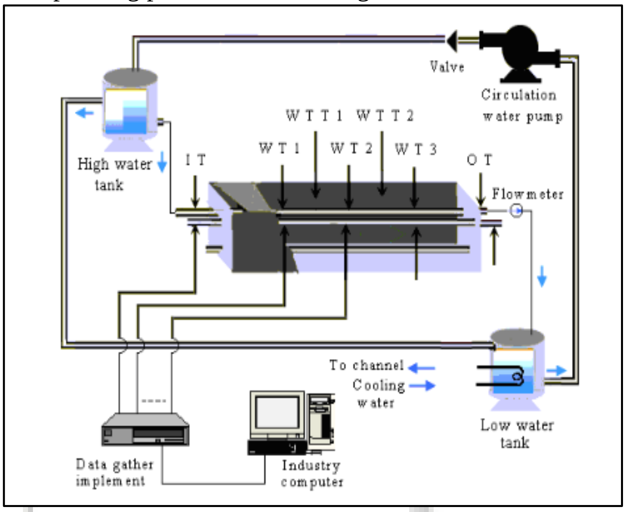


Fig. 5: Experimental system. [39]

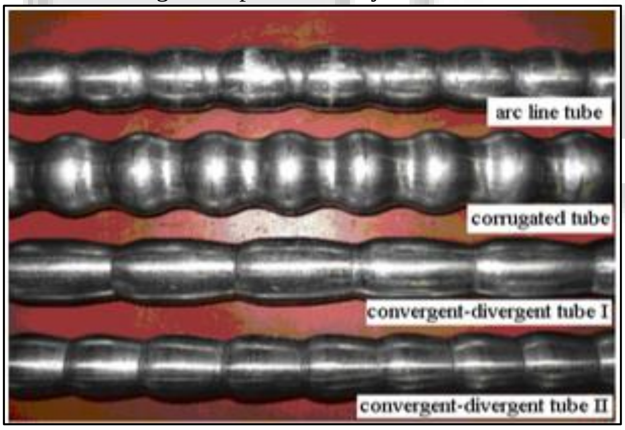


Fig. 6: Picture of enhanced tubes. [39]

In this paper, the heat transfer and fluid flow in a vertical narrow channel with one surface periodically mounted Longitudinal Vortex Generators (LVGs) are investigated by numerical simulation for water. The development of longitudinal vortex along the flow direction and its influence on heat transfer and flow were also presented in detail while keeping the aspect ratio of LVGs constant. The effect of LVGs' flow direction and effective action range were also conducted with Reynolds number ranging from 3000 to $3.5\times10^4$ when the incidence angler of LVGs is equal to $44^0$. It was found that the heat transfer performance in rectangular channel could be greatly enhanced by LVGs. Wang ling et al. [40]

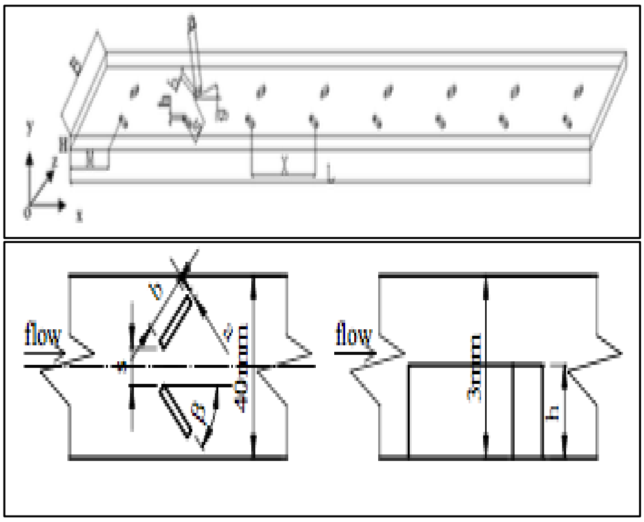


Fig. 7: (a) Schematic of narrow rectangular channel with 8 pairs LVGs, (b) Top view and side view of LVGs[40]

## III. Conclusions

Experimentation on various turbulence models is conducted to find the best heat transfer enhancement. Generating longitudinal vortices, intensify flow mixing. Such vortices also increase the turbulent kinetic energy and reduce thickness of the boundary layer, which lowers local temperature nearby the target surface.

The performance can be improved by using various augmentation techniques such as finned surfaces, integral roughness and insert devices. Devoted to the heat transfer enhancement in a laminar parallel plate flow using rectangular wing vortex generator. It is found that the angle of attack has a direct impact on the heat transfer enhancement. This increase leads to a better enhancement until it reaches an optimal value. In view of the above, the shape of ribs has an important effect on fluid flow and heat transfer in the channel. It is expected that the crescent rib can generate longitudinal vortices, which are cap- able to intensify the disruption of thermal boundary layer to enhance heat transfer in the channel. Specific flow field and heat transfer characteristics in the channel mounted with ribs or different shape of turbulaters is investigated in the present study.

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