Investigation of Heat Transfer Enhancement of Flow over the dimples (triangular shape) using in Divergent Duct.

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Abstract- *The Effective fluid mixing is one of the requirements in food processing and chemical industry. The effect of divergent Duct is a good way to promote the flow mixing in Duct flow. When using divergent Duct then we get flow difference means low pressure drop it is also called pressure recovery. By using Triangular shape as an extended surface in the divergent Duct it can help us to increase the heat transfer enhancement and Triangular surface present the highest performance of the heat transfer enhancement. The Triangular surface act as extended surface (fin surface) and the main purpose of extended surface to increase the heat transfer rate. The advantages of the divergent Duct with internal Triangular surface are fluid mixing is more as compared to cylindrical pipe, pressure drop is less and boundary layer separation occurs as well as the heat transfer coefficient increases 40 to 50% as compare to plain divergent Duct .*

Keywords- Heat transfer enhancement, Divergent Duct, Extended Surface (Triangular), Heat transfer rate, Heat transfer coefficient.

I. INTRODUCTION

Heat transfer enhancement is the practice of modifying a heat transfer surface or the flow cross section to either increase the heat transfer coefficient between the surface and a fluid or the surface area so as to effectively sustain higher heat loads with a smaller temperature difference. Some practical examples of heat transfer enhancement. i.e fins, surface roughness, twisted tape inserts and coiled tube, which are generally referred to as passive technique. Heat transfer enhancement may also be achieved by surface or fluid vibration, electrostatic fields or mechanical stirrers. These latter methods are often referred to as active techniques because they required the application of external power. Although active techniques have received attention in the research literature their practical applications have been very limited. In this section therefore we focus on some specific example of passive techniques Increases in heat transfer due to surface treatment can be brought about by increased turbulence, increased surface area, and improved mixing or flow swirl. These effects generally result in an increase in pressure drop along with the increase in heat transfer. However, with appropriate performance evaluation and concomitant optimization, significant heat transfer improvement relative to a smooth (untreated) heat transfer surface of the same nominal (base) heat transfer area can be achieved for a variety of applications.

Effective fluid mixing - requirements in food processing and chemical industry. The effect of divergent channels - to promote the flow mixing in channel flow. When if we use divergent channel then we get flow difference means low pressure drop it is also called pressure recovery. By using Triangular shape dimples in the divergent channel it can help us to increase the heat transfer enhancement and triangular surface present the highest performance of the heat transfer enhancement. The Triangular surface act as extended surface (Artificial surface) and the main purpose of extended surface to increase the heat transfer rate. The advantages of the divergent channel with internal Triangles are fluid mixing is more as compared to cylindrical pipe, pressure drop is less and boundary layer separation occurs in divergent channel which will help in heat transfer.

Following are some Literature Survey show that how extended surface useful to increase heat transfer rate.

C. Bi, G.H. Tang*, W.Q. Tao, et al.- [1] They concluded that The dimple surface presents the highest performance of the heat transfer enhancement, the performance of cylindrical groove surface is slightly lower than that of the dimple surface, and the low fin surface presents the lowest performance. The study on the independent geometry size effects of the dimple suggests that the deep dimple with large diameter can enhance heat transfer more easily.

HONG Mengna**, DENG Xianhe, HUANG Kuo and LI Zhiwu, et al. - [2] They investigated that the pressure drop and compound heat transfer characteristics of converging-diverging tube with evenly spaced twisted tapes experimentally. In this paper they made comparison of experiment between smooth circular tube and converging diverging tube without carrying the twisted tapes.

Kirti Chandra Sahu, Rama Govindarajan, et al. - [3] although the critical Reynolds number for linear instability of the laminar flow in a straight pipe is infinite. They show that the critical Reynolds number for linear instability of laminar flow is finite in case of divergent Duct and it approaches to infinity as the inverse of the divergence angle.

A Dewan, P Mahanta, K Sumithra Raju and P Suresh Kumar, et al. - [4] In this paper it is shown that heat transfer can be enhanced by the use of passive techniques that is by modifying the geometrical shape of the pipe or duct and by insertion of twisted tapes, ribs, fins, dimples. They also stated that insertion of twisted tapes performs better in laminar flow and insertion of ribs, dimples performs better in turbulent flow.

Dr. Anirudh Gupta, Mayank Uniyal, et al. - [5] The researchers are taking interest in enhancing heat transfer rate with passive methods. Dimple, protrude and rough surfaces etc. passive methods are used in heat exchangers, air heaters and heat sinks to enhance heat transfer. Passive methods can easily manufacture and applicable too.

Dr. Mohammed Najm Abdullah, et al. - [6] they performed the experimental study on fully developed turbulent flow in a eccentric converging-diverging tube (ECDT) with twisted tapes. The influences of twist ratio on the heat transfer rate and friction factor characteristics have also been investigated.

Pradip Ramdas Bodade, Dinesh Kumar Koli, et al. - [7] in this paper the following heat transfer intensifiers are described and reviewed. Surface roughness, plate baffle and wave baffle, perforated baffle, twisted tape inserts etc. in heat transfer application if area of tube is changes then heat transfer rate also changes.

Vijay D. Shejwalkar, M.D. Nadar, et al. – [8] Found that in the experiment which was carried out for three heater input & with three different flow rates of air. The effect on heat flow rate and outlet temperature for air is calculated and observed respectively threaded part and these results are compared with plain pipe. They also found that more number of threads increases the swirl (turbulence) formation which improves the contact surface of air with the heated pipe which results in heat transfer enhancement. Kumbhar D.G, Dr. Sane N.K, et al. – [9] Found that insertion of twisted tapes increases the performance in laminar flow. They also found that if pressure drop is not considered twisted tape insert is more effective method. But in turbulence flow it is not effective for wide range of Reynolds number. Because it blocks the flow and pressure drop increases hence performance of twisted tape is not good in turbulence flow. David j kukulka, Rick smith, et al. – [10] they stated that the improving of heat transfer rate and modifications of tube are necessary. The flow optimization study of the character that is used to build the enhanced surface using computational fluid dynamics method was performed.

Wang.L.H, Tao.W.Q, Wang.Q.W, Wong.T.T, et al.- [11] Many heat augmentation techniques has been reviewed, these are (a) surface roughness, (b) plate baffle and wave baffle, (c) perforated baffle, (d) inclined baffle, (e) porous baffle, (f) corrugated Duct, (g) twisted tape inserts, (h) discontinuous Crossed Ribs and Grooves. Most of these enhancement techniques are based on the baffle arrangement. Use of Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop.

Soo Wban Abn and Kang Pil Son, et al.-[12] found that the heat transfer can be enhanced by the use of rough surfaces. Four different shapes such as semicircle, sine wave, trapezoid, and arc were suggested to investigate the heat transfer enhancement and friction factor on rectangular duct. They measured the friction factor and heat transfer enhancement on smooth duct and compared it with the results. Square shape geometry gave the highest value because of its strongest turbulence mixing caused by rib. Non circular ducts such as equilateral triangle, Square and rectangular ducts have lower frictional factors and heat transfer as compared to circular ducts this increase in the friction factor and heat transfer depends upon properties and size of the fluid molecules.

Sivakumar, K., Natarajan, E., Kulasekharan, N, et al.- [13] Thermal characteristics were tested by measuring wall temperature at selected locations, fluid temperature at the inlet and the outlet and wall static pressures at the Duct inlet and the outlets. Ribbed Ducts show larger pressure drops than the smooth Ducts and the value of pressure drop increases with increase in rib height. This can be attributed to the recirculation zones in the downstream side of each rib.

TuqaAbdulrazzaq, et al.-[14] the results show that the Nusselt number increases with the increase of Reynolds number for all cases at constant surface temperature. According to the profile of local Nusselt number on ribs walled of Duct, the peak is at the midpoint between the two ribs. The maximum value of average Nusselt number is obtained for triangular ribs of angel 60° and at Reynolds number of 60000 compared to the Nusselt number for the ribs of angel 90° and 45° and at same Reynolds number. The recirculation regions generated by the ribs corresponding to the velocity streamline show the largest recirculation region at triangular ribs of angle 60° which also provides the highest enhancement of heat transfer.

Francisco Oviedo-Tolentino a, Ricardo Romero-Méndez a,* Abel Hernandez-Guerrero b, Benjamin Girón-Palomares b, et al.-[15] the results of this investigation are important since they illustrate that promotion of mixing is possible by using a divergence of the sinusoidal wavy Duct. As may be hinted from other investigations, this mixing promotion might lead to an augmentation of the heat transfer, but also to an increase in the pressure drop. It is desirable to do further research to determine the feasibility and advantages of this chaotic mixing promotion technique. To address this issue numerical and experimental techniques might be used. The results presented here could be used as a starting point.

II. RELATED CONCEPT, RESEARCH, WORK

In this work we are using divergent Duct with the Triangular surface.

Figure 1. Experimental set up

Figure shows the Experimental set up of forced convection using divergent duct instead of cylindrical pipe. Divergent channel are used where pressure difference required is relatively small. The main advantage of divergent tube over cylindrical pipe is that the divergent tube has greater area than the cylindrical pipe and in divergent tube fluid mixing is proper between the flow passages. Divergent channel is suitable for wide range of Reynolds number because it posses greater amount of turbulence. And to improve the heat transfer rate we can apply the passive techniques i.e., by inserting triangle, ribs, bumps, fin.etc. and if turbulence in flow is more then it helps to improve the contact of air with heated pipe and this phenomena helps to improve heat transfer rate. Heat transfer rate increases with increase in internal area of channel.

Figure 2. Divergent duct with triangles

Heat transfer enhancement in a tube by inserts triangular dimples is due to flow blockage, partitioning of the flow and secondary flow. Because of Flow blockage there is increases in the pressure drop and leads to increased viscous effects due to the reduced free flow area. Blockage also increases the turbulence and flow velocity and in some situations leads to a significant secondary flow. In Secondary flow there is a better thermal contact between the surface and the fluid because secondary flow creates turbulence and the resulting fluid mixing improves the temperature gradient, which leads to enhancement in heat transfer coefficient.

IV. RESULT, STUDIES AND FINDINGS

Following Results for V - 88 volt, I - 0.48 amp

Table 1.

Parameters	Plain Divergent Duct	Divergent Duct with Triangles
Hydraulic dia. Test section (m)	0.03	0.03
Velocity (m/s)	4.5	4.5
C/S area (m)	0.0009	0.0009
S/F area (m)	0.015	0.015

S/F temp (^{0}C)	50.66	50.66
Air temp.	42.5	44
Heat taken by air Qa	0.02261	0.03618
Air flow rate Q (m^3/s)	20.35125	32.62
Practical heat transfer coeff. (W/m^2 ^{0}C)	166.13	325.62
Renolds no.	8862.35	8862.35
Nusselt no.	83.066	162.81

Following results for V - 100volt, I - 0.55 amp.

Table 2.

Parameters	Plain Divergent Duct	Divergent Duct with Triangles
Hydraulic dia. Test section (m)	0.033	0.033
Velocity (m/s)	4.5	4.5
C/S area (m)	0.0009	0.0009
S/F area (m)	0.015	0.015
S/F temp (^{0}C)	52.33	52.33
Air temp.	43.50	45
Heat taken by air Qa	0.0284	0.069
Air flow rate Q (m^3/s)	28.49	40.70
Practical heat transfer coeff. (W/m^2 ^{0}C)	215.03	370.02
Renolds no.	8862.35	8862.35
Nusselt no.	107.51	185.01

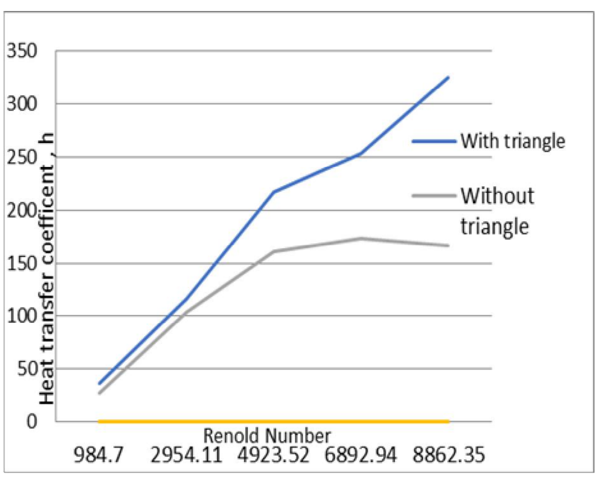

Figure 1. Result Graph

IV. CONCLUSION

This study focused on investigating whether the use of bumps can enhance heat transfer characteristics for a divergent duct. In this experimental study we get different Reynolds numbers ranging from 17621.1454 to 44052.8634, which gives the good heat transfer enhancement. The advantages of the divergent channel with internal Triangles are fluid mixing is more as compared to cylindrical pipe, pressure drop is less and boundary layer separation occurs as well as the heat transfer coefficient increases 30 to 40 % as compare to plain divergent channel. Fluent, and the experimentation is carried out for the triangles in the divergent channel, which gives the good heat transfer enhancement.

1. The computations and the measurements are in good agreement with each other. The maximum error between the averaged experimental heat transfer enhancements with numerically predicted enhancement is 20%.
2. Enhancement efficiency obtains by bumps experimentally about 30 to 40 % greater than plain divergent duct.

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