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Heat Transfer Enhancement Analysis of Flow over the Bumps on Divergent Channel

#1S.A.More, #2D.B.Shelke

1more.dypcoe@gmail.com

2digshelke@gmail.com

#1 Dr.D.Y.Patil school of Engineering, Academy, Ambi, Talegaon dabhade, Pune, Maharashtra, India

#2 Dr.D.Y.Patil College of Engineering, Ambi, Talegaon dabhade, Pune, Maharashtra India

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ABSTRACT

Effective fluid mixing is one of the requirements in food processing and chemical industry. The effect of divergent channels is a good way 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 bump in the divergent channel it can help us to increase the heat transfer enhancement and bump surface present the highest performance of the heat transfer enhancement. The bump 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 channel with internal Bumps 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 .

***Keywords*— a Heat transfer enhancement, Divergent channel, Extended Surface (Bumps), Heat transfer rate, Heat transfer coefficient.**

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I. INTRODUCTION

Heat transfer enhancement or heat transfer intensification is of very importance in the applications of thermal systems where overheating can damage the components or assemblies of the system. Hence, in order to avoid such type of problems, some heat transfer intensification techniques are being used in industrial applications. Enhancement of heat transfer intensity in all types of thermo technical apparatus is of great significance for industry. Beside the savings of primary energy, it also leads to a reduction in size and weight. Several heat transfer enhancement techniques have been developed. 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.

Iftikarahamad H. Patel, Dr. Sachin L. Borse, et al.-[1] Heat transfer rate from the test surface increases with increase in Reynolds number of flowing fluid and heat input. The use of dimples on the surface results in heat transfer augmentation in forced convection heat transfer with lesser pressure drop penalty.

Wang.L.H, Tao.W.Q, Wang.Q.W, Wong.T.T, et al.-[2] 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 channel, (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.

Sivakumar, K., Natarajan, E., Kulasekharan, N, et al.-[3] 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 channel inlet and the outlets.

Soo Wban Abn and Kang Pil Son, et al.-[4] 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.

C. Bi, G.H. Tang, W.Q. Tao, et al.-[5] The convective cooling heat transfer in mini-channels with dimples, cylindrical grooves and low fins is numerically studied by using the field synergy principle.

Hemant C. Pisal, Avinash A. Ranaware, et al.-[6] this investigation presents experimental and numerical results for the heat transfer characteristics of a heat sink for laminar airflow conditions using two different types of dimples. The average heat transfer and heat transfer enhancement were obtained experimentally.

Dr. Mohammed Najm Abdullah, et al.-[7] the aim of this study is to investigate the heat transfer and pressure drop characteristics in an Eccentric Converging-Diverging Tube (ECDT) with twisted tape inserts. Experiments were conducted with tape inserts of three different twist ratios. Cold and hot water are used as working fluids in shell and tube sides, respectively. The effect of the twist ratio and other parameters on heat transfer characteristics and pressure drop are considered.

Hemant C. Pisal, et al.-[8] an investigation was conducted to determine whether dimples on a heat sink fin can increase heat transfer for laminar airflows.

Tang*, W.Q. Tao, et al.-[9] the results show that the dimple surface presents the highest performance of heat transfer enhancement. The geometry size effects of dimple are studied over a Reynolds number range of 2700-6100, and the most favorable dimple geometric structures are optimized by using the performance evaluation plot of enhanced heat transfer techniques.

TuqaAbdulrazzaq, et al.-[10] 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 channel, the peak is at the midpoint between the two ribs.

Francisco Oviedo-Tolentino a, Ricardo Romero-Méndez a,* Abel Hernandez-Guerrero b, Benjamin Girón-Palomares b, et al.-[11] the results of this investigation are important since they illustrate that promotion of mixing is possible by using a divergence of the sinusoidal wavy channel.

Kirti Chandra Sahu, Rama Govindarajan, et al. - [12] although the critical Reynolds number for linear instability of the laminar flow in a straight pipe is infinite. They shown that the critical Reynolds number for linear instability of laminar flow is finite in case of divergent channel and it approaches to infinity as the inverse of the divergence angle.

However, all of the above techniques will inevitably bring too much flow resistance, resulting in unnecessary power consumption. An effective method of heat transfer enhancement is required to not only improve the heat transfer greatly, but also minimize the flow resistance as much as possible. Recently, an effective method called dimple surface has been investigated in the literature, and all of the studies have proved that the dimple surface can significantly enhance the heat transfer without bringing too much flow resistance.

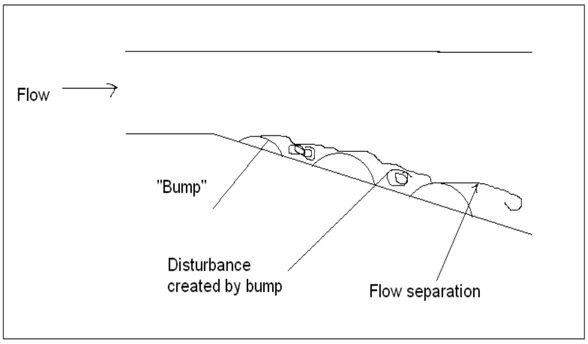

Fig.1 Creation of Disturbances in the flow

In this project we are using divergent channels for heat transfer because of it is a good way to promote the flow mixing in channel flow also if use divergent channel then we get flow difference means low pressure drop it is also called pressure recovery also the new concept we using bumps in the divergent channel it can help us to increase the heat transfer enhancement and bump surface present the highest performance of the heat transfer enhancement. The Bumps surface it can also called as artificial 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 channel with internal bumps 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.

II.EXPERIMENTAL SETUP

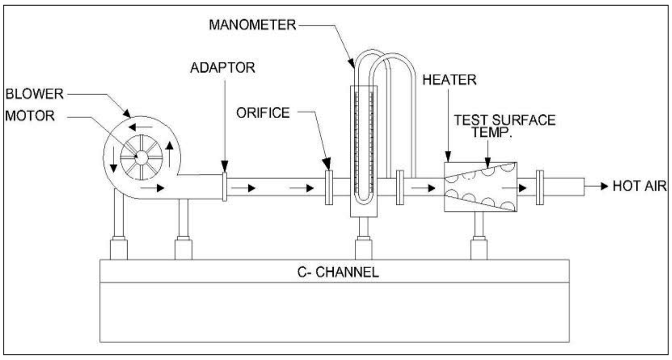

Fig.3 Experimental set up

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 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.

III.OBSERVATION TABLE

TABLE I. A
DIVERGENT CHANNEL WITHOUT BUMPS

Sr No	V	I	Temperature in °c					
			T1	T2	T3	T4	T5	T6
1	60	0.35	28	63	64	66	65	38
2	60	0.35	28	55	57	59	55	37
3	60	0.35	28	45	46	48	47	34
4	60	0.35	28	43	45	46	44	33

TABLE II.
DIVERGENT CHANNEL WITH BUMPS

Sr No	V	I	Temperature in °c					
			T1	T2	T3	T4	T5	T6
1	60	0.35	28	51	54	56	52	36
2	60	0.35	28	40	41	43	42	33
3	60	0.35	28	37	38	40	39	32
4	60	0.35	28	36	37	38	36	32

TABLE III.
DIVERGENT CHANNEL WITHOUT BUMPS

Sr No	V	I	Temperature in °c					
			T1	T2	T3	T4	T5	T6
1	100	0.58	28	65	68	72	66	37
2	100	0.58	28	56	58	63	59	38
3	100	0.58	28	49	54	55	51	35
4	100	0.58	28	45	46	49	48	33

TABLE IV.
DIVERGENT CHANNEL WITH BUMPS

Sr No	V	I	Temperature in °c					
			T1	T2	T3	T4	T5	T6
1	100	0.58	28	56	60	63	58	37
2	100	0.58	28	48	53	55	49	36
3	100	0.58	28	43	45	47	46	34
4	100	0.58	28	38	40	43	42	32

IV.DATA REDUCTION

The data reduction of the measured results is summarized in the following procedures:
The local heat transfer coefficient was calculated from the total net heat transfer rate and the difference of the local wall temperature and the local bulk mean air temperature.

$$\mathrm{h} = \frac{qa}{As(Ts-Ta)} \tag{1}$$

$$qa = Ma \times Cp \times \Delta\mathrm{T} \tag{2}$$

$$qa = Ma \times Cp \times \Delta\mathrm{T} \tag{3}$$

$$Q = V \times \mathrm{Acs} \tag{4}$$

$$\Delta\mathrm{T} = (\mathrm{T}_{\mathrm{out}} - \mathrm{T}_{\mathrm{in}}) \tag{5}$$

$$\mathrm{Ta} = \frac{(Tout-Tin)}{2} \tag{6}$$

$$\mathrm{Ts} = \frac{T1+ -----+Tn}{n} \tag{7}$$

$$\mathrm{Nu} = \frac{h\times L}{K} \tag{8}$$

The local and the duct average Nusselt number were defined by

$$\mathrm{Nu} = 0.023 \times \mathrm{Re}^{0.8} \times \mathrm{Pr}^{0.3} \tag{9}$$

As for most cases of the internal convection heat transfer, the fluid properties are evaluated at the mean temperature of the fluid in the duct. The Reynolds number was defined by

$$\mathrm{Re} = \frac{\rho VL}{\mu} \tag{10}$$

$$\mathrm{V} = \frac{Q}{Ac} \tag{11}$$

V.RESULT & DISCUSSION

A The experimentation is carried out with the divergent duct heat transfer enhancement methods. Heat transfer coefficient and Reynolds Number are calculated for all conditions. Parameters were plotted for different values of Reynolds number, for the arrangement without bumps and with bumps in the divergent duct.

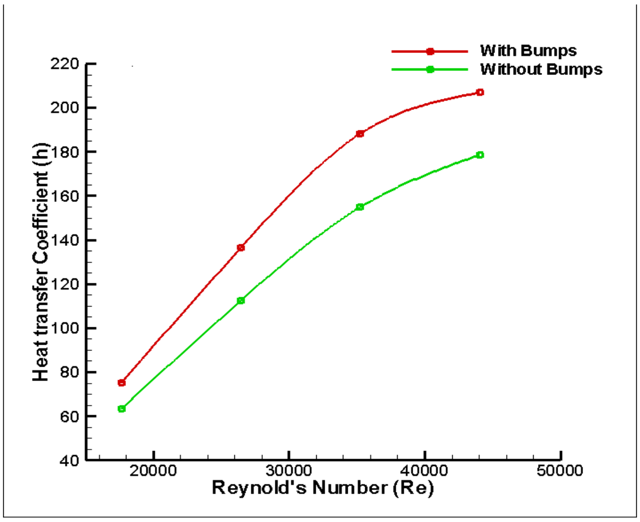

Fig.1 Heat transfer coefficient Vs Reynolds Number (at 60 volt.)

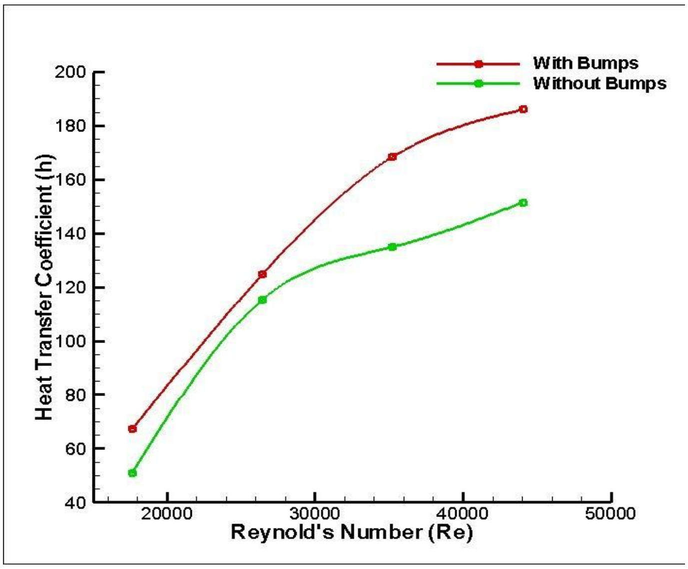

Fig.2 Heat transfer coefficient Vs Reynolds Number (at 100 volt.)

From the Fig.1and 2, at 60 voltage and 100 voltages, 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. From the Fig.1 and 2 it is observed that the Divergent duct without using bumps gives the less heat transfer coefficient with the use of bumps in the divergent duct create more turbulence in duct which increases the heat transfer coefficient.

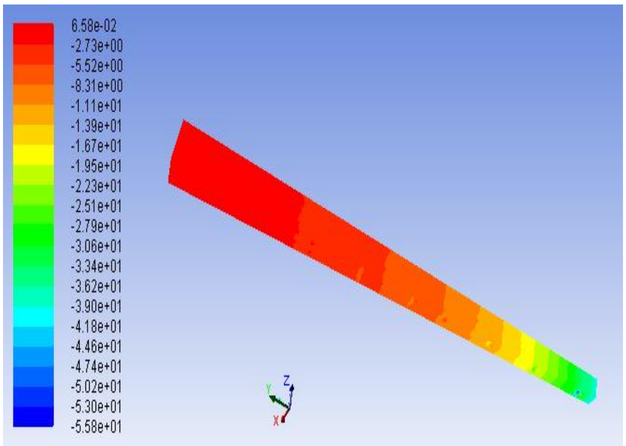

Fig.3: The Pressure plot for 0.00874944 kg/sec

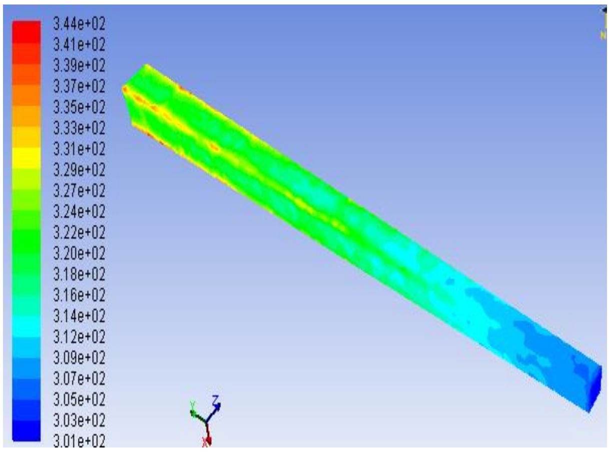

Fig.4: Static Temperature Contour Plots for 0.00874944 kg/sec

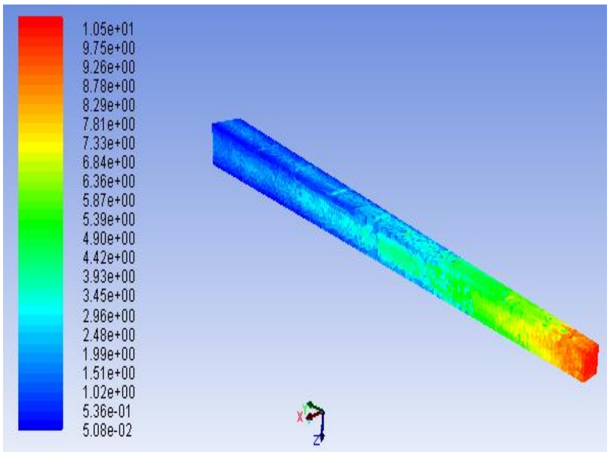

Fig.5.The Velocity Vector Plot for 0.00874944 kg/sec

VI.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 Bumps 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 .

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