**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 07, Issue 1, January 2017, ||V-3|| PP 20-25

# Numerical Investigation on Dimple tube of Counter and Parallel flow Heat exchanger

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***ABSTRACT:*** *These instructions give you guidelines for preparing papers for International Journal of Science, Engineering and Technology Research. Use this document as a template if you are using Microsoft Office Word 6.0 or later. Otherwise, use this document as an instruction set. The electronic file of your paper will be formatted further at International Journal of Computer Theory and Engineering. Define all symbols used in the abstract. Do not cite references in the abstract. Do not delete the blank line immediately above the abstract; it sets the footnote at the bottom of this column.*

***INDEX TERM:*** *Heat transfer enhancement; Augmentation; Dimple Tube; Raynold's number; convective heat transfer coefficient; tube in tube heat exchanger.*

## I. INTRODUCTION

Enhancement of heat transfer is the process of improving the thermal performance of heat exchanging devices. Efficient heat exchanging devices required in the industries are responsible for the huge development and research in the methods of heat transfer augmentation. One of the frequently used methods to improve heat transfer enhancement is by geometric modification prompting earlier transition to turbulence, creating vortices that increase mixing or restarting the thermal boundary layer to decrease its thickness. An effective method of heat transfer enhancement is required to not only improve the heat transfer, but also minimize the flow resistance as much as possible. Accordingly much research has been carried out on various heat transfer augmentations such as pin fins, louvered fins, off set strip fins, slit fins, ribs, protrusions, and dimples in order to improve the thermal efficiency of heat exchangers. Among various heat transfer enhancers, a dimpled surface shows a high heat transfer capacity with relatively low pressure loss penalty compared to other types of heat transfer enhancers that are available. Therefore, many studies have been conducted in order to determine the heat-transfer characteristics that are induced by the dimpled surface. The present review covers the heat transfer enhancement characteristics in dimple tubes.

## II. LITERATURE REVIEW

Dimples in narrow channel have been investigated by Johann
Review Vortex structure and heat transfer enhancement mechanisms of turbulent flow over a staggered array of

***Manuscript received May, 2015***.
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Turnow et al.The vortices on dimpled surfaces are created inside of concave cavities preventing a blockage of the channel and keeping the additional resistance at a minimum. Its formation was in the focus of many studies, but unfortunately, main attention has been paid to time averaged values whereas the flow structures within the cavities and their contribution to the heat transfer mechanism remain still unclear and are not completely understood. Especially, in the turbulent range and at large ratio of dimple depth to dimple diameter d/D the flow is complicated. Since the form of vortex has a strong impact on heat transfer. The objective of this study is too clarify the role of the vortex formation with respect to the heat transfer on staggered arrangement dimple package and measurement of pressure and velocity. It was revealed that heat transfer and friction factor increase for a decreasing channel height and rising dimple depth. Heat transfer rate enhanced up to 201% by using staggered arrangements of dimple having depth to diameter ratio 0.26[1]. Prof. Pooja Patil and Prof. Padmakar Deshmukh states that Computational investigation of convective heat transfers in turbulent flow past an almond shape dimpled surface. A parametric study is performed with k-ε turbulence model to determine the effects of Reynolds number of range 25000 to 95000 on heat transfer enhancement. In this paper we have computed heat transfer characteristics in a circular tube as a function of the Reynolds number. The mass flow rate of air varied for getting turbulent flow Reynolds numbers. The almond shape dimple geometry was considered with diameter 10 mm and required elongated length 22.5mm. The tube diameter 19mm and dimple depth 3mm with ratio L/D =4.3 was kept constant. . The results showed that more heat transfer was occurred downstream of the dimples due to flow reattachment. As the Reynolds number increased, the overall heat transfer coefficient was also increased as compared with base line plain tube with minimum pressure drop penalty[5]. Chyu *et al*. studied the enhancement of surface heat transfer in a channel using two different concavities- hemispheric and tear drop. Concavities serve as vortex generators to promote turbulent mixing in the bulk flow to enhance the heat transfer at Re no.= 10,000 to 50,000, H/d of 0.5, 1.5, 3.0 and δ /d =0.575. Heat transfer enhancement was 2.5 times higher than smooth channel values and with very low pressure losses that were almost half that caused by conventional ribs tabulators[13].Yu Rao *et al*. investigate the effects of dimple depth on the pressure loss and heat transfer characteristics in a pin fin-dimple channel, where dimples are located on the end wall transversely between the pin fins. The study showed that, compared to the baseline pin fin channel, the pin fin-dimple channels have further improved convective heat transfer performance by up to 19.0%, and the pin fin-dimple channel with shallower dimples show relatively lower friction factors by up to 17.6% over the Reynolds number range 8200 to 50,500[8] .

## III. DATA REDUCTION AND ERROR ANALYSIS

The area averaged convective heat transfer coefficient of the test channels is defined by

$$h = \frac{Q_{net}}{A_{net} \vartriangle T_{lm}}$$

Here Q net is the net heating power, which is equal to the total electrical heating power educating the minor heat loss due to heat conduction and radiation, which amounts to 2.8–11.0% of the total heating powers depending on the Reynolds number. $A_{hea}$t is the flat heating area of the test late. ΔT lm is the log mean temperature difference between the heating wall and the cooling flow. The log mean temperature difference between the heating wall and the cooling flow $\vartriangle T_{lm}$ , is calculated based on the equation below:

$$\vartriangle T_{lm} = \frac{(T_W - T_{in}) - (T_W - T_{out})}{\ln\left(\frac{T_W - T_{in}}{T_W - T_{out}}\right)}$$

In this equation, Tw is the average temperature of the surface of the heating wall. The averaged Nusselt number is defined by:

$$Nu = \frac{hD_h}{\kappa}$$

where k is the thermal conductivity of the fluid.[6]

The hydraulic diameter is defined as

$$D_h = \frac{2Hw}{H + w}$$

where H and w are the height and width of the channel cross section, respectively. [3]

The Reynolds number is

$$Re = \frac{\rho u_{in} d_h}{\eta}$$

Where $u_{in}$ is the inlet average velocity which is given by, $u_{in} = q_m/Ac$ where $A_c$=

$Hw$

And Dittus-Boelter Equation,

*For circular duty duct ,Nu =0.022Re0.8Pr0.5*

## IV. GEOMETRIC MODEL

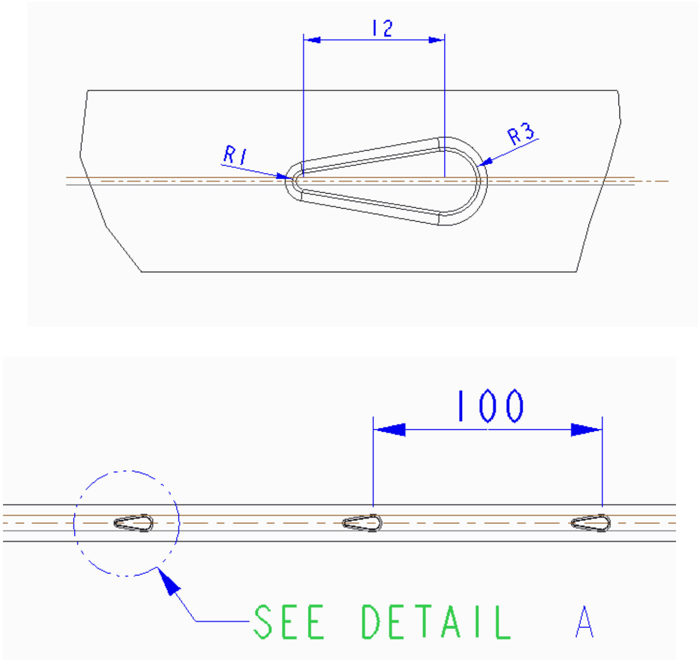



**Fig.1:** Geometrical Configuration of Test tube

**Fig.2:** Tube with Almond shape dimples

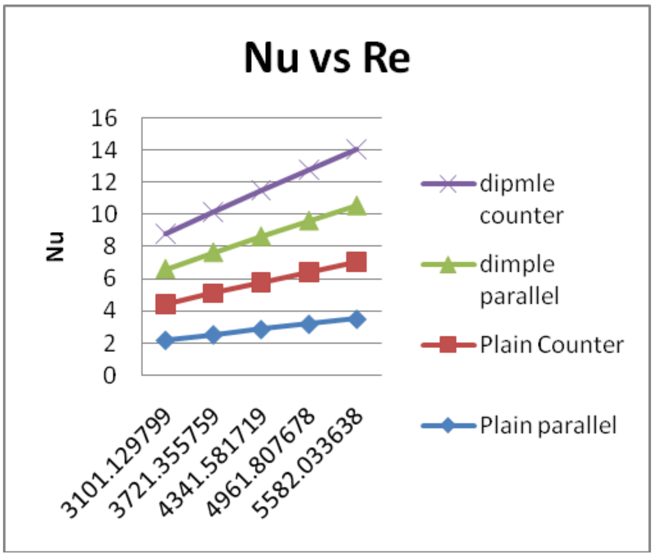
## V. FIGURES AND TABLES

| Re No. | Nature of flow | To | h | Nu. No. |
|---|---|---|---|---|
| 3101.12 | parallel | 27.6 | 449.178 | 2.19987 |
| | counter | 34.2 | 646.200 | 4.18775 |
| 3721.35 | parallel | 26.8 | 441.998 | 2.54532 |
| | counter | 33.9 | 575.465 | 4.78657 |
| 4341.58 | parallel | 26.6 | 477.521 | 2.87939 |
| | counter | 33.7 | 638.937 | 5.10254 |
| 4961.80 | parallel | 26.5 | 535.867 | 3.20401 |
| | counter | 33.3 | 646.760 | 5.89870 |
| 5582.03 | parallel | 26.2 | 496.060 | 3.52059 |
| | counter | 33.2 | 668.887 | 6.32055 |

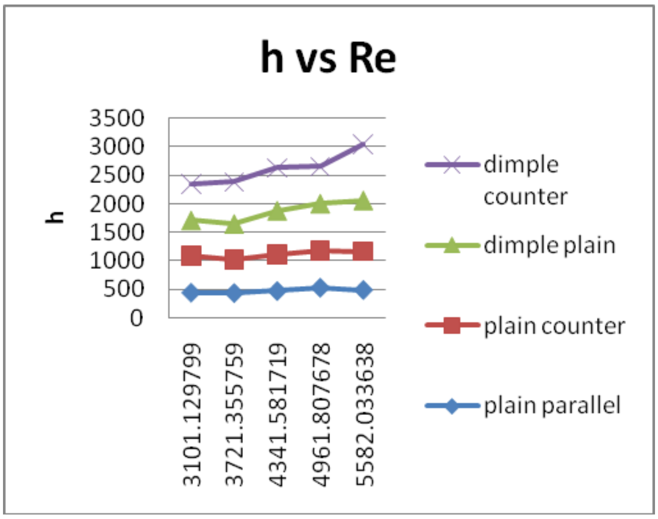
**Table1:** Result Table For Plain Tube

| Re No. | Nature of flow | To | h | Nu. No. |
|---|---|---|---|---|
| 3101.12 | parallel | 31 | 626.110 | 6.19987 |
| | counter | 30.7 | 616.515 | 9.19987 |
| 3721.35 | parallel | 31.7 | 726.195 | 7.54532 |
| | counter | 30.6 | 632.123 | 10.04532 |
| 4341.58 | parallel | 32.2 | 739.948 | 8.17939 |
| | counter | 30.6 | 766.588 | 11.57939 |
| 4961.80 | parallel | 32 | 642.587 | 9.20401 |
| | counter | 30.5 | 824.565 | 13.20401 |
| 5582.03 | parallel | 31. 8 | 978.544 | 10.52059 |
| | counter | 30.6 | 898.986 | 14.02059 |

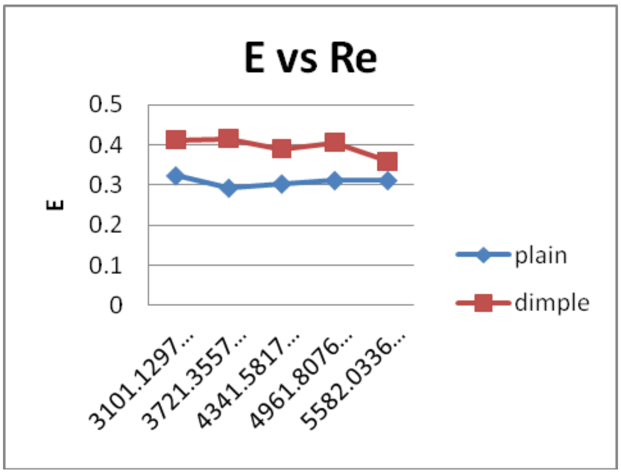
**Table2:** Result Table For Dimple Tube




Graph1: Nusselt No Vs Reynolds No




**Graph2:** Heat Transfer Coeff. Vs Reynolds No.




**Graph3:** Effectiveness Vs Reynolds No.

## VI. RESULT AND DISCUSSION

From the above result table and graph we studied the behavior of fluid through various channels like Plain And Dimple tube:

**1. Reynolds Number and Nusselt Number:**

As we studied the heat transfer through plain and dimple tube or channels Reynolds no for fluid flow ranges from 2900-6000.likewise nusselt no for dimple tube is 30-40% higher than that for plain tube considering both parallel and counterfluid flow.as the Reynolds no increases gradually there is increase in nusselt no with reference to graph1.

**2. Heat transfer coefficient:**

Convective heat transfer coefficient can be calculated using heat flow and surface area available. From the graph2 it is clear that convective heat transfer coefficient is slightly increased for dimple tube as compared to plain tube.

**3. Effectiveness:**

In the Reynolds number range from 3000 to 5600, the effectiveness factor for the plain tube geometry did not rise as much as the one for the dimpled array geometry did. Effectiveness is about 37% higher than plain tube geometry. In general effectiveness follow the same trend of decreasing with increasing Re no as other parameters compare before.

## VII. NOMENCLATURE

D- Dimple diameter (m)
Di- inner diameter of the tube (m) f -friction factor
h -heat transfer coefficient (W/m2 K) L -length of circular channel (m)
m -mass flow rate of the air flow in the channel (kg/m2) Nu- area averaged Nusselt number of dimple tube
Nu0- area averaged Nusselt number of tube without dimple Pr- Prandtal number
k- Fluid thermal conductivity. (W/mK) Q -net heating power (W)
Re -Reynolds number
Tin -inlet fluid temperature (K) Tout- outlet fluid temperature (K) Tw -mean wall temperature (K)
∆Tlm- log mean temperature difference (K) qm -mass flow rate (kg/sec)

*Greek symbols*
P- Density,(kg/m3)
µ -dynamic viscosity (Pa.s) in -inlet
m- Mean Out- outlet w- Wall

## VIII. CONCLUSION

The heat transfer enhancement for almond shape dimple array geometries are studied at Reynolds no range 3000 to 6000.Results have been obtained experimentally. The following major conclusions can be drawn:

1. The computations and the measurements are in good agreement with each other. The maximum increment between the experimental heat transfer enhancement coefficient for the dimple tube over plain tube was found to be 12.7%.

2. The experimental and numerical results both show that the almond shape dimple geometry provides the highest heat transfer over the plain tube in this study.

3. from the experimental calculations it was found that Effectiveness of dimple tube over plain tube is increased by 21.95%.

## REFERENCES

[1]. n. K. Z. H. Johann Turnow, "Flow structures and heat transfer on dimples in a staggered arrangement," International Journal of Heat and Fluid flow, vol. 35, pp. 168-175, 2012.
[2]. C. W. X. Yu Rao, "An Experimental study of pressure loss and heat transfer in the pin fin -dimple channels with various dimple depths," International Journal of Heat and Mass Transfer, pp. 6723-6733, 2012.
[3]. G. T. C.Bi, "Heat transfer in mini channel heat sinks with dimples and cylindrical grooves," Applied Thermal Engineering, no. 18March2013, pp. 121-132, 2013.
[4]. N. S.A.Isaev, "Influence of the Reynolds number and the spherical dimple depth on turbulent heat transfer and hydraulic loss in a narrow channel," International Journal of Heat and Mass Transfer, no. 28October2009, pp. 178-197, 2010.
[5]. Pooja Patil,Prof. Padmakar Deshmukh, “ Numerical study of flow and heat transfer in circular tube with almond shape dimple”. International journal of engineering research and technology,2014,pp.1-3.
[6]. Jonghyeok Lee, Kwan-Soo Lee, “Correlations and shape optimization in a channel with aligned dimples and protrusions”, International Journal of Heat and Mass Transfer, 2103, 64, pp.444-451.
[7]. Somin Shin, Ki Seon Lee, Seoung Duck Park, Jae Su Kwak, “ Measurement of the heat transfer coefficient in the dimpled channel:effects of dimple arrangement and channel height”, Journal of Mechanical Science and Technology, 2009, 23, pp.624-630.
[8]. Yu Rao a,Yamin Xu, Chaoyi Wana, “An experimental and numerical study of flow and heat transfer in channels with pin fin-dimple and pin fin arrays”, Experimental Thermal and Fluid Science, 2012, 38, pp.237-247.
[9]. YuChen, Yong Tian Chew, Boo Cheong Khoo, “ Enhancement of heat transfer in turbulent channel flow over dimpled surface”, International Journal of Heat and Mass Transfer, 2012, 55, pp.8100-8121.
[10]. Nopparat Katkhaw, NatVorayos, Tanongkiat Kiatsiriroat, Yottana Khunatorn, Damorn Bunturat, AtipoangNuntaphan,“Heat transfer behavior of flat plate having 450 ellipsoidal dimpled surfaces”, Thermal engineering, 2013.
[11]. J.E. Kim, J.H. Doo, M.Y. Ha , H.S. Yoon, C. Son,”Numerical study on characteristics of flow and heat transfer in a cooling passage with protrusion-in-dimple surface”, International Journal of Heat and Mass Transfer, 2012, 55, pp.7257-7267.
[12]. Sumantha Acharya,” Experimental and computational study of heat/mass transfer and flow structure of four dimple array in square channel” ,Journal of Turbomachinery, 2012
[13]. M.K. Chyu, Y. Yu, H. Ding, J.P. Downs and F.O. Soechting,” Concavity enhanced heat transfer in an internal cooling passage”e, International Gas Turbine & *Aeroengine Congress & Exhibition ASME paper 97-GT-437.*
[14]. Mohammad A. Elyyan,” Heat Transfer Augmentation Surfaces Using Modified Dimples/ Protrusions”, Ph.D, Virginia, Blacksburg, 2008.
[15]. Cengel, Y. A., Heat and Mass Transfer: A Practical Approch, 3rd ed., Tata McGraw Hill, New York, 2010.

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