iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VI **Month of publication:** June 2019

DOI: http://doi.org/10.22214/ijraset.2019.6169

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

Experimental Investigation of Heat Transfer Enhancement by using Varying Width Twisted Tape Inserts with Circular Holes

Prof. A. R. Mankar[1], Aamar Matre [2]
[1]Professor, Mechanical Engineering Department, Guru Nanak Institute of Technology, Dahegaon, Nagpur – 441501 (India)
[2]Student, M. Tech. (Heat Power Engineering) Guru Nanak Institute of Technology, Dahegaon, Nagpur – 441501 (India)

Abstract: The heat transfer properties were experimentally investigated by means of copper twisted tape inserts with circular holes in natural convection. Thus turbulent flow was produced by the insertion of the twisted tape inserts into the test pipe which creates high rate of turbulence in pipe, which consequences in increasing heat transfer augmentation and pressure drop. The tape consists of the circular holes and twisting with various twist ratios (TR=2.5, 5, 10). The inner diameter of test pipe is 0.014 m respectively. Twisted tape insert with different twist ratio of 0 < H/D < 10 is used. The result shows that the enhancement in heat transfer coefficient is observed with the decrease in twist ratio of twisted tape inserts.
Keywords: Twisted Tape Inserts, Heat Transfer Enhancement, Passive Technique.

I. INTRODUCTION

In heat exchanger, the enthalpy is transferred between two or more fluids, at different temperatures. The use of heat exchangers are in various industrial processes for heating and cooling applications such as air conditioning and refrigeration systems, heat recovery processes, food and dairy processes, chemical process plants etc. The major challenge in designing a heat exchanger is to make the equipment more compact and achieve a high heat transfer rate using minimum pumping power. Techniques for heat transfer augmentation are relevant to several engineering applications. In recent years, the high cost of energy and material has resulted in an increased effort aimed at producing more efficient heat exchange equipment. Sometimes there is a need for miniaturization of a heat exchanger in specific applications, such as space application, through an augmentation of heat transfer. These problems are more common for heat exchangers used in marine applications and in chemical industries. The heat transfer rate can be improved by introducing a disturbance in the fluid flow there by breaking the viscous and thermal boundary layer. Therefore, to achieve a desired heat transfer rate in an existing heat exchanger at an economic pumping power, several techniques have been proposed in recent years and are discussed under the classification section. The heat transfer enhancement techniques are performed in general applications. The results of those studies have been shown that although heat transfer efficiencies are improved, the flow frictions are also considerably increased. In this twisted tapes with circular holes are used for heat transfer enhancement having various twist ratios. Kumbhar D.G., Dr. Sane N.K. [1], studied heat transfer behavior in a tube with Conical Wire Coil Inserts, Heat transfer, friction factor and enhancement efficiency characteristics in a horizontal circular tube fitted with conical wire coil tabulators have been investigated experimentally. In the present work two enhancement heat transfer devices are applied. One is the conical coil inserts and other is full length wire coil inserts are placed in test tube. The coiled wire inserts of 6mm, 9mm and 12mm spring pitches are introduced in each run. In addition, the conical wire inserts of pitch ratio 2.5mm and 3.5mm are also tested The Reynolds number is varied from 2000 to 10000. The experimental results revel that the tube fitted with the conical coil inserts and full length wire coil inserts provides Nusselt number values of around 5% to 12% and enhancement efficiency varies between 0.78 to O. 98 compared with the plain tube. Naga Sarada S., Kalyani K. Radha [2], studied experimental investigations in a circular tube to enhance turbulent heat transfer using mesh inserts, the results obtained from experimental investigations of the augmentation of turbulent flow heat transfer in a horizontal tube by means of mesh inserts with water as the working fluid. Sixteen types of mesh inserts with screen diameters of 22 mm, 18 mm, 14 mm and 10 mm for varying distance between the screens of 50mm, 100mm, 150mm and 200mm in the porosity range of 99.73 to 99.98 are considered for experimentation. The Reynolds number is varied from 7000 to 14000. Correlations for Nusselt number and friction factor are developed for the mesh inserts from the obtained results. It is observed that the enhancement of heat transfer by using mesh inserts when compared to plain tube at the same mass flow rate is more by a factor of 2 times whereas the pressure drop is only about a factor of 1.45 times. Haydar Eren, Nevin Celik [3], studied heat transfer & friction factor of coil-springs inserted in the horizontal concentric tubes. The goal of this investigation is to obtain

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

definitive information about the heat transfer characteristics of circular coil-spring turbulators. This is achieved by measuring the wall temperatures on the inner tube of the exchanger. Also the inlet and outlet temperatures and pressure loss of the fluid are measured. These results are parameterized by Reynolds numbers $2500<Re<12,000$, outer diameters of the springs (Ds=7.2 mm, 9.5 mm, 12 mm, and 13 mm), numbers of the springs (n=4, 5, and 6), and the incline angles of the springs (=0 deg, 7 deg, and 10 deg). Additionally, another goal of this work is to quantify the friction factor f of the turbulated heat exchanger system with respect to aforementioned parametric values. As a result, it is found that increasing spring number, spring diameter, and incline angle result in significant augmentation on heat transfer, comparatively 1.5–2.5 times of the results of a smooth empty tube. By the way, friction factor increases 40–80 times of the results found for a smooth tube. Furthermore, as a design parameter, the incline angle has the dominant effect on heat transfer and friction loss while spring number has the weakest effect. Pedram s. s., Dr. kolhe k.p.[4], studied experimental investigation of heat transfer performance of wavy twisted tape inserts using matlab. The present experimental work will be carried out with copper and aluminium wavy twisted tape inserts 1mm thick and 24 mm wave-widths. The inserts will be placed in the path of the flow of the fluid, to create a high degree of turbulence resulting in an increase in the heat transfer rate and the pressure drop. The work includes the determination of friction factor and Nusselt number for various wavy twisted tapes inserts with varying twist ratios, different wave-widths & different materials. Correlations for Nusselt number and friction factor will be developed for the wavy twisted tape inserts. The results of varying twists in wire with two materials will be compared with the values for the smooth tube. The experimental results of heat transfer in circular tube equipped with the different inserts will be studied using a MATLAB program and used to predict the output functions by designing a program. A. karami et. al. [5], studied fuzzy logic modeling of heat transfer in an air cooler equipped with butterfly insert. This paper highlights the use of fuzzy logic to model and predict the experimental results of heat transfer in an air cooled heat exchanger equipped with the butterfly inserts. Experiments included Reynolds number ranging from 4021 to 16118 and the inclined angle of the butterfly inserts from 45° to 90°. Experimental results showed that, the maximum heat transfer by the use of butterfly insert was obtained with the inclined angle of 90°. A fuzzy inference system named Mamdani was used to expect the output membership functions to be fuzzy sets. It has been also shown that, fuzzy logic is a powerful instrument for predicting the experiments due to its low error. The average error of fuzzy with respect to experimental data was found to be 0.41% for this study.

II. EXPERIMENTAL SET-UP AND PROCEDURE

The set up consists of test section of 0.8 meter length of copper tube of 0.0014 m inner diameter. The heat input in terms of constant heat flux is supplied to the outer wall of the copper tube within the test section. The thermocouples are located at regular interval within the test section in order to measure the temperatures at the various locations within the test section. The experimentation is takes place by the conventional coolant such as distilled water and at various flow rate within the test section with twisted tape inserts with three different twist ratios i.e. 2.5, 5, 10.

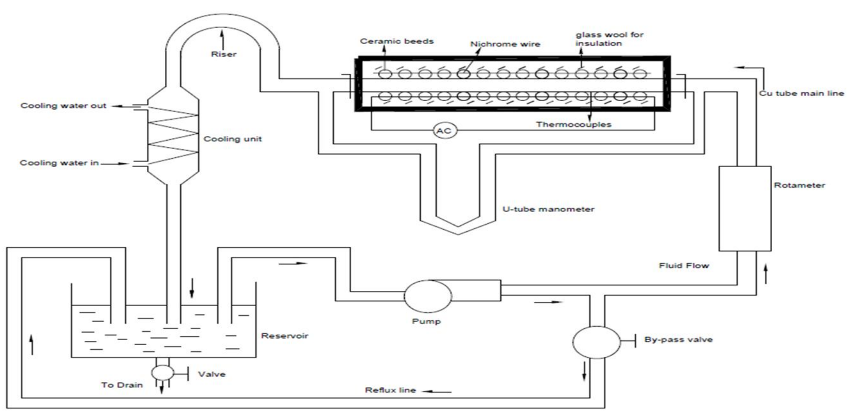


Figure 1: Experimental set up

The temperature at the various locations as well as at inlet and at the exit of the test section is measured for the distilled water. After the experimental set up is assembled, the storage tank is filled with the working fluid. Experiments are conducted with water to determine the heat transfer coefficients for a flow in a tube. The convective heat transfer coefficient is calculated for the water and for with inserts and without inserts experimentally and then it is compared with the theoretical values of the convective heat transfer coefficient calculated by using the empirical relation such as Saider- Tate equation.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

III. MANUFACTURING PROCESS OF INSERTS

A. *Twisting On Torsion Machine*

1) Take 600 mm long copper strips.
2) Then mark required pitch on the strip.
3) There are 3 strips of different pitches.
4) Calculate the no. of pitches on each strip.
5) Punch the centers of each pitch.
6) Drill 6mm diameter holes at center of each pitch.
7) Manufacture the fixtures to hold the copper strip according to thickness of that strip.
8) Also use nut bolts to fit the strip in the fixture to avoid slippage of strip in running condition of torsion machine.
9) Consider the condition that 1 rotation of torsion machine is equal to 1 twist & 1 twist is equal to 1 pitch.

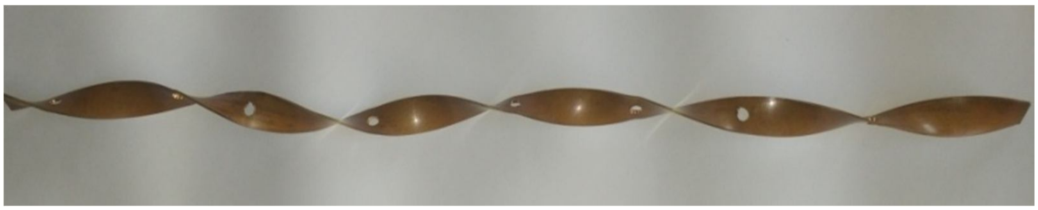


Figure 2 Twisted tape with TR – 2.5

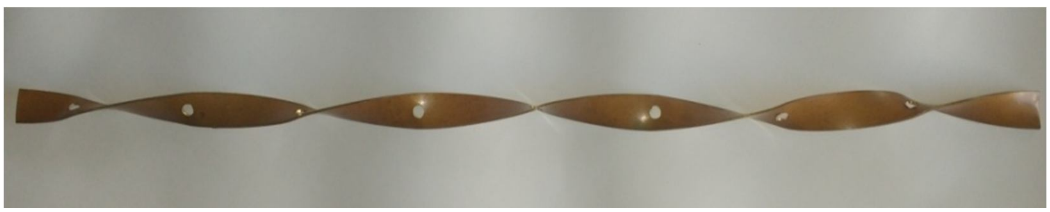


Figure 3 Twisted tape with TR – 5

Figure4 Twisted tape with TR – 10

B. *Calculation for pure distilled water at 30 LPH*

The following properties of water are taken from data book at 40^0 C

Density ρ_w = 997 Kg/m^3

Thermal conductivity k_w = 0.62 W/mk

Specific heat C_{pw} = 4187 J/kgk

Dynamic viscosity $\mu_w = 6.54 \times 10^{-4}$ $N\text{-}s/m^2$

Heat input, Q = V x I
= 100 x 1.65
= 165 Watts

Heat gained by water is, $Q = (\rho\ U\ A) \times C_p \times (T_o - T_i)$

Convective heat transfer rate is, $Q = (\pi\ d\ L)\ h_{w\,(exp)}\ [(T_w - \frac{To+Ti}{2})]$

Hence, convective heat transfer coefficient is given as,

$$h_{w\,(exp)} = \frac{(\rho\ U\ A)\quad C_p\quad (T_o - T_i)}{(\pi\ d\ L)\ [(T_w - \frac{To+Ti}{2})]}$$

Assume mass flow rate of water is, 30 LPH = $(30\times10^{-3}\times997)/3600 = 8.30\times10^{-3}$ kg/sec

$$h_{w\,(exp)} = \frac{8.30\times10^{-3}\times4187\times(49-40)}{(\pi\times14\times10^{-3}\times0.8\,(72-\frac{49+40}{2})}$$

$= 324.02$ W/m^2 K.

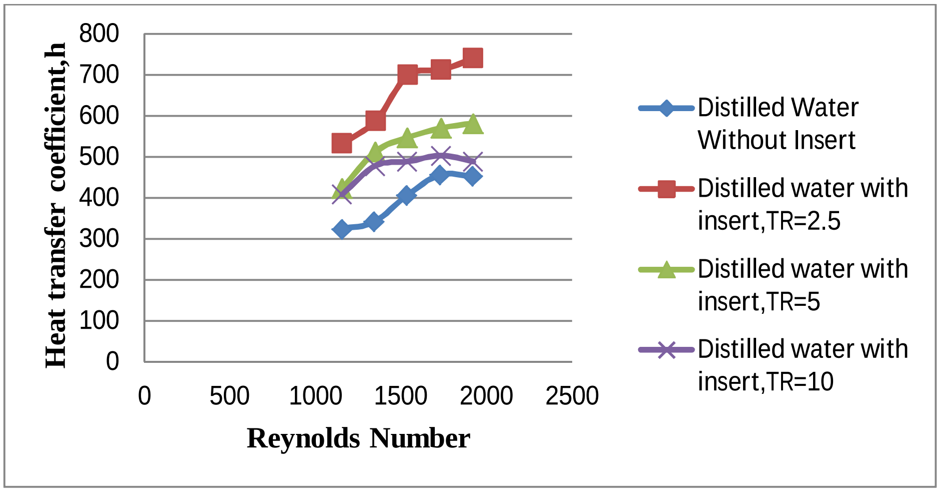
$$Nu_{exp} = \frac{hw(exp)\times d}{kw}$$

$$= \frac{324.02\times0.014}{0.62}$$

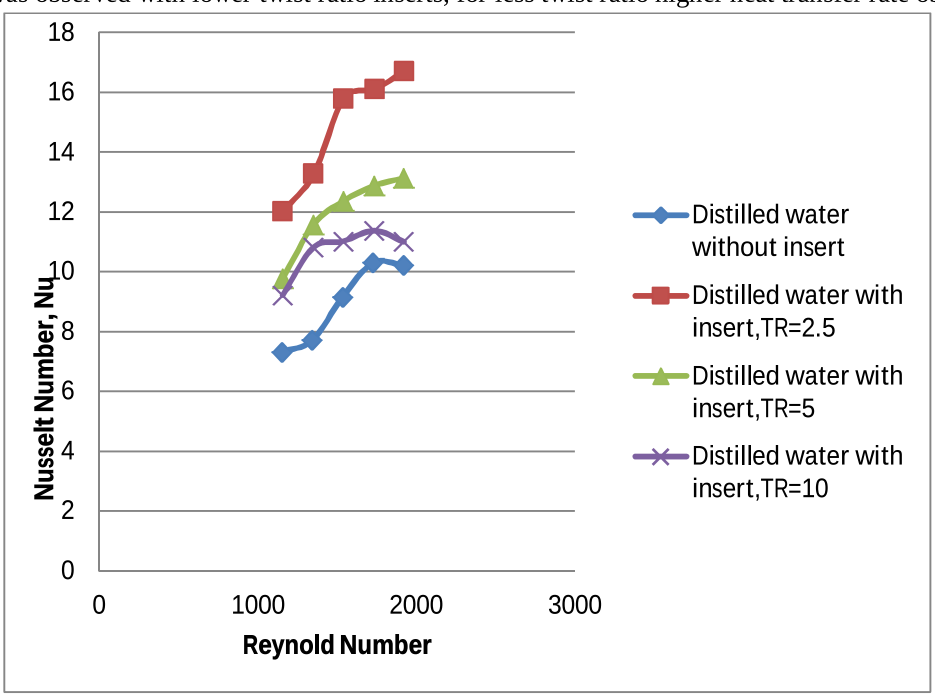
$= 7.32$

IV. RESULTS AND DISCUSSION

The trial has been successfully conducted on the test set up with inserts and without inserts at the twist ratio of TR=2.5, 5, 10 along with the conventional distilled water.



A. Graph 1 Heat transfer coefficient (W/m^{2}K) Vs Reynolds Number for pure distilled water with inserts and without inserts. More swirl generation was observed with lower twist ratio inserts, for less twist ratio higher heat transfer rate observed.



B. Graph 2 Nusselt Number Vs Reynolds Number for distilled water with inserts and without inserts. As the maximum increase in heat transfer rate was observed with twist ratio, TR=2.5 therefore the maximum nusselt number was found for TR=2.5.

1) Heat transfer rate increases as the twist ratio decreases, a higher degree of swirl is created which increases turbulence and hence the heat transfer coefficient increases as the twist ratio decreases. So it was found that heat transfer coefficient is more at TR=2.5. The maximum 69.45% increase in heat transfer coefficient for pure distilled water was found.

2) As the Δ h values were very small (0.1 – 0.5 cm of Hg) for low Re and the manometer least count was 0.1 cm of Hg, so it was not possible to measure those low pressure drops with higher accuracy.

3) The experimental result did not show any significant increase in pressure drop of pure distilled. But the insertion of twisted tape inserts results in an increase in pressure drop.

4) The pressure drop founds to be constant, but a significant increase in pressure drop was found with a decrease in twist ratio when the experimentation takes place with inserts for working fluid, for 2.5, 5, 10 twisted tape inserts as compare to the values obtained for without inserts.

V. CONCLUSION

The entire experimentation overview about twisted tape inserts with circular hole at different twist ratios which is an exciting new class of heat transfer element, the comparison of heat transfer coefficient and pressure drop of with and without twisted tape inserts in laminar flow of pure distilled with twist ratio of TR=2.5, 5, 10 were used in the experimental study.

A. The difference in heat transfer coefficient for the actual and theoretical values for low Reynolds number upto 6000 in the smooth tube can be attributed to the natural convection which along with the forced convection. This phenomenon is prominent in case of low Re. In case of higher Re, natural convection is negligible as compare to forced convection.

B. The greater enhancement shown by TR=2.5 as compared to results obtained with pure distilled water without insert.

C. The pressure drop was found to be constant for the working fluid, the change in pressure drop founds with the inserts only because as the twist ratio decreases, a higher degree of swirl is created which leads to higher pressure drop and higher friction factor.

D. It is also suggested that further research still has to be done on twisted tape inserts with different geometrical shapes and for different twist ratio so that they may be applied as more efficient and compact heat transfer systems.

REFERENCES

[1] Anil Singh Yadav et al. ―Effect Of Half Length Twisted-Tape Turbulators On Heat Transfer And Pressure Drop Characteristics Inside A Double Pipe U-Bend Heat Exchanger‖, Jordan Journal of Mechanical and Industrial Engineering, Volume 3, Number 1, March. 2009, ISSN 1995-6665, Pages 17- 22

[2] S.D.Patil et al. ―Analysis of Twisted Tape with Winglets to Improve the Thermo hydraulic Performance of Tube in Tube Heat Exchanger‖, International Journal of Advanced Engineering Research and Studies E-ISSN2249 – 8974

[3] Sami D. Salman et al. ―Cfd Analysis of Heat Transfer and Friction Factor Characteristics in a Circular Tube fitted With Parabolic-Cut Twisted Tape Inserts‖ Australian Journal of Basic and Applied Sciences, 7(7): 69-76, 2013

[4] Prof. Naresh B. Dhamane et al. ―Heat Transfer Analysis Of Helical Strip Insert With Regularly Spaced Cut Sections Placed Inside A Circular Pipe‖ International Journal of Modern Engineering Research (IJMER) Vol. 2, Issue. 5, Sep.-Oct. 2012 pp-3711-3716

[5] J. U. Ahamed et al. ―Forced Convection Heat Transfer Performance of Porous Twisted Tape Insert‖, Engineering e-Transaction (ISSN 1823-6379) Vol. 5, No. 2, December 2010, pp 67-79

[6] Eiamsa-ard, N.Piriyarungroj, C.Thianpong, S.Eiamsa-ard, A case study on thermal performance assessment of a heat exchanger tube equipped with regularly-spaced twisted tapes as swirl generators, Case Studies in Thermal Engineering 3(2014)86–102

[7] Bodius Salam , Sumana Biswas , Muhammad & Mostafa Kama l Bhuiya , "Heat T ransfer Enhancement in a Tube Using Twisted Tape Insert", Proceedings of the 13th Asian Congress of Fluid Mechanics, Page 835- 838.

[8] Ift ikarahamad H. Patel, Dr. Sachin L. Borse, Experimental Investigation of Heat Trans fer enhancement over the dimpled surface, International Journal of Engineering Science and Technology (IJEST), Vol. 4 No.08 August 2012.

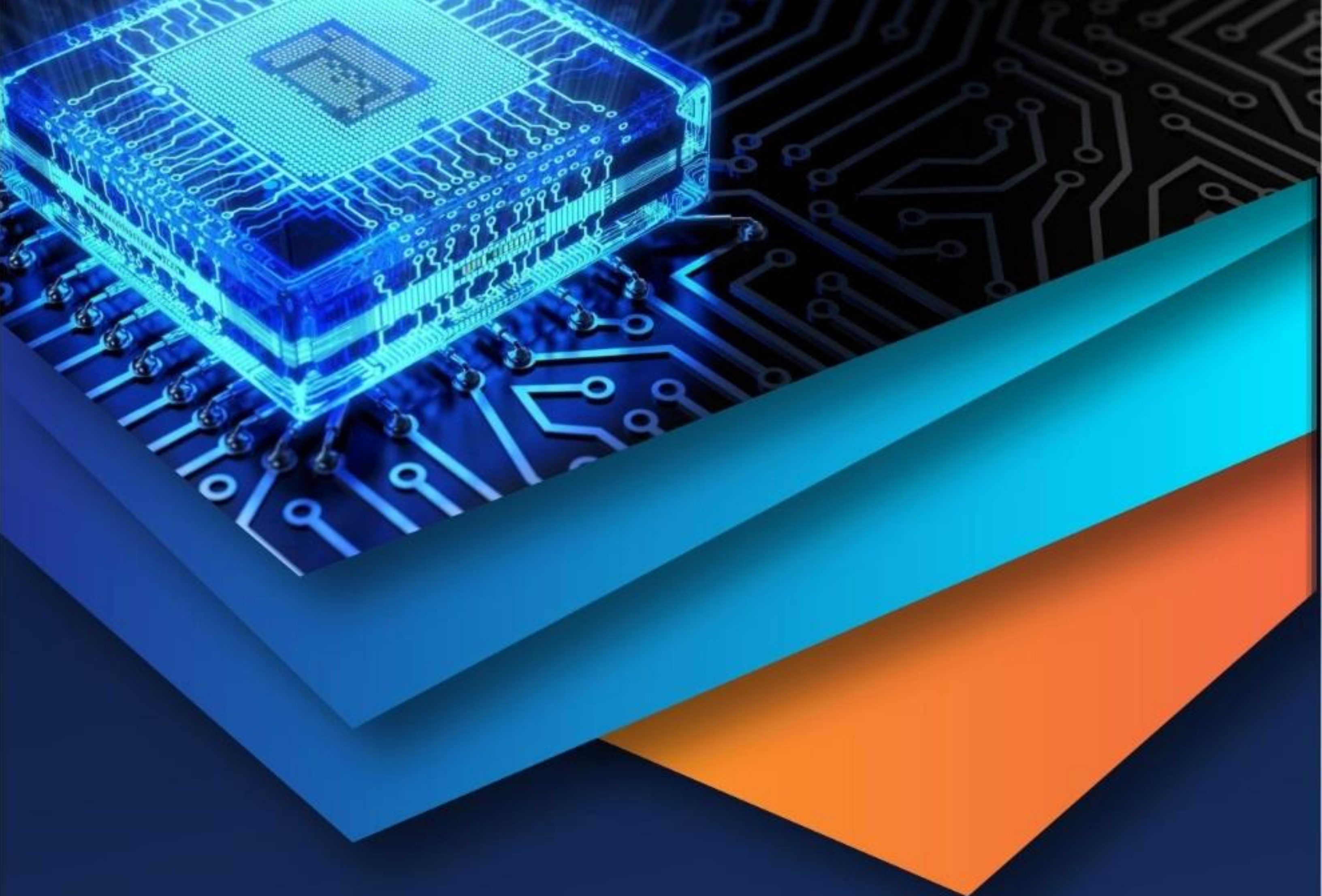
[9] Kaustaubh Kumbhar, Dr. Sachin L. Borse, Heat Transfer enhancement by using twisted tapes with elliptical holes, International Journal of Applied Engineering Research (IJAER), Vol. 10 No.07 August 2015.

[10] A. V. N. Kapatkar, B. Dr. A. S. Padalkar and C. Sanjay Kasbe, Experimental investigation on heat transfer enhancement in laminar flow in circular tube equipped with different inserts, Proc. of. Int. Conf. on Advances in Mechanical Engineering (2010) pp. 58-63

[11] S. Naga Sarada, A.V. Sita Rama Raju, K. Kalyani Radha, L. Shyam Sunder, Enhancement of heat transfer using varying width twisted tape inserts, International Journal of Engineering, Science and Technology, Vol.2, No. 6, 2010, pp. 107-118.

[12] Naga Sarada S., Kalyani K. Radha and A. V. S. Raju, Experimental investigations in a circular tube to enhance turbulent heat transfer using mesh inserts, ARPN Journal of Engineering and Applied Sciences, VOL. 4, NO. 5, July (2009), pp. 53-60.

[13] S.W Chang, Tsun Lirng Yang andJin Shuen Liou, Heat transfer and pressure drop in tube with broken twisted tape insert, Experimental Thermal and Fluid Science Vol. 32 (2007), pp. 489- 501.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY