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Simulation and Analysis of Double Pipe Heat Exchanger

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Abstract— A heat exchanger is a engineering device used for efficient heat transfer from one fluid to another at different temperatures and thermal in contact. Thermal properties of fluids play a significant role in various cooling and heating uses. Traditional fluids are of low thermal conductivity, so researchers are tried to enhance thermal conductivity by adding nano-particles. The model of double pipe heat exchanger was develop by using ANSYS workbench. Al_2O_3 mixed with water as a base fluid for analyzed their performance in double pipe heat exchanger. Al_2O_3 is a excellent material for heat transfer enhancement because, it has better physical as well as chemical properties. In this paper, we performed CFD analysis on double pipe heat exchanger using ANSYS FLUENT software by varying the concentrations of nano-particle (0.5%, 1%, 2%) in water. CFD analysis on double pipe heat exchanger by using Al_2O_3/water (nano-fluid) as cold fluid and water as a hot fluid. It is observed that nano-fluid with 2% concentration having more overall heat transfer coefficient.

Keywords- **Double pipe heat exchanger, CFD, LMTD, Heat transfer, ANSYS**

I. INTRODUCTION

Fluids thermal properties play an important role in temperature controlling applications in every industrial process. Heat exchangers are used to maintain working liquid temperature. Heat exchangers are crucial engineering devices in process industries, where efficiency and economy depends on performance of heat exchanger. Heat exchanger is device used to transfer thermal energy between two or more fluids at different temperatures and in thermal contact. The significance of using heat exchanger is to maximize heat transfer between two fluids. Heat exchanger is device which transfers energy from hot fluid and cold fluid. The estimation of efficiency is done by calculating overall heat transfer coefficients. The heat exchanger performance relies on physical characteristics of fluid and material used. One of most simple type of heat exchanger is double pipe heat exchanger. Many industries use double pipe heat exchanger doe to its low cost and maintenance. High thermal conductivity and high heat transfer fluids are crucial to improve refrigeration systems. In general fluids like water, ethylene, glycol, plays a crucial role in thermal management systems. Nano-fluids are engineered colloids made up of base fluid and nano-particles of range 1-100 µm. Nano-fluids gives high thermal conductivity as compare to base fluids value of its increases with increasing temperature, particle size, particle concentration, dispersion. Density, specific heat also important factors are responsible to heat transfer enhancement. Double pipe heat exchanger is a device in which one fluid flows inside the pipe and another fluid flows between the pipe. It is one of the simplest type of heat exchanger. In this type of heat exchanger the two fluids flows simultaneously. The flow of working fluid in double pipe heat exchanger may be parallel or counter-flow type. Two flow configurations: parallel in which two fluids flow parallel to each other and in same direction. Counter flow heat exchanger in which two fluid flows in opposite direction and from opposite sides.

II. LITERATURE REVIEW

D. Bhauchandrarao et. al (2013): They performed CFD analysis parallel and counter flow heat exchanger in concentric tube heat exchanger. Concentric heat exchanger used force convection to lower the temperature of working fluid, while cooling medium temperature increased. They used ANSYS fluent software and hand calculations to analyzed temperature drop as function of velocity and inlet temperature. This software modelled parallel and counter flow heat exchanger. The results compared with the hand calculations. Turbulence flow was analyzed during modelling of heat exchanger to determine heat transfer. The counter flow heat exchanger is better them parallel flow heat exchanger. The analysis results were found consistent with theoretical calculations with 5% of each other. [1]

Jibin Johnson et. al (2015): They studied the analytical design of heat exchanger validated by CFD analysis results. They analysed that design had reach better success. Exact maximum heat could have been to increase heat transfer area and increase coolant flow rate. ANSYS is the best software for CFD analysis. [2]

N. T. Ravikumar et. al (2016): They studied overall heat transfer coefficients and effectiveness of Fe_3O_4/water nano-fluid in double pipe heat exchanger with return bend. They used turbulent flow condition. Experiments were performed in volume concentration 0.005% to 0.06% and Re is 14000 to 30000. Nu enhancement is 15.6% at 0.06% volume concentration compared to water. Heat transfer coefficients at annulus side 3.44% enhance and tube side by 3.28% effect of heat exchanger enhancement. 1.008 times at volume concentration 0.06% at Re 28984 as compared to water. [3]

Zahid Imam et. al (2017): They performed CFD analysis on hair-pin heat exchanger by using nano-fluids like aluminium oxide and titanium carbide. Theoretical calculations also done on hair pin heat exchanger by properties of these two nano-fluids. By the copper material and titanium carbide with fraction 0.5, heat transfer rate increases and warmness in heat exchanger. [4]

V. Nageshwara Rao (2017): CFD analysis performed on the U-bend heat exchanger to estimate convective heat transfer and friction factor of copper oxide- water nano-fluid using approach of single phase. ANSYS was used to developed geometry model using volume concentration of 0.1% and 0.3%. They invested volume fraction and Reynolds number and nussult number increased. Nusselt number increases and friction factor decreased. Nussult number enhance by 0.3% nano-fluid 18% enhancement in heat transfer coefficients. Maximum friction penalty of 1.14 times 0.3% volume concentration of CuO nano-fluid at Re 22,500. [5]

V. Rajeshwar et.al (2017): They designed and CFD simulation analysis of hair pin heat exchanger at different nano-fluids. In their proposed study they explained different nano-fluids and mixed with the base fluid (water) are analyzed for heat transfer in heat exchanger. They used titanium carbide and aluminium oxide with volume fraction 0.4 and 0.5. Theoretical calculations are done for input of evaluation and 3D model of hair pin heat exchanger made in creo software. Aluminium and copper materials was used for CFD evaluation. The analysis results on heat exchanger provided that heat extra at titanium carbide with volume fraction 0.4. Heat cost more for Cu than aluminium alloy. Nano-fluid with 0.5 concentrations gave better heat transfer results than 0.4 with copper. [6]

Salman K. et. al (2018): They performed CFD analysis on double pipe heat exchanger with TiO_2/water nano-fluid. Titanium dioxide is better material for heat transfer boosting purpose due to its chemical and physical properties. Thermal analysis on geometry performance on double pipe heat exchanger is studied by changing concentration range of 0-3% volume concentration of nano-particles. The analysis compared with base fluid. CFD models are simulated with the help of ANSYS fluent. Heat transfer enhancement was better in turbulence region as compared to the laminar region for all volume fractions. There was 18% improvement in heat transfer coefficients at 0.3% volume concentration of TiO_2 nano-fluid. Friction factor was increase is proportional with increase of volume concentration and increased velocity. Friction factor enhancement is less as compare to others and heat transfer improved for volume concentration in an analysis. [7]

Shuvam Mohanty et. al (2018): They investigated heat transfer, log mean temperature difference, thermo and physical characteristics of counter flow heat exchanger. Water was used as fluid and in counter current mode, hot fluid in inner tube and cold fluid in outer tube. Due to less mass flow rate in core of counter flow heat exchanger, tubes were uniformly heated. CFD analysis performed on counter flow heat exchanger by experimental data by Nagarshetal. Shell-tube heat exchanger used gave log mean temperature difference as 29.65 while decreasing temperature of cold fluid and average error of 8.5%, but while increasing temperature of hot fluid. LMTD rises more quickly along length with 26.58 average and with % error of 8.9% heat transfer and pressure drop with average error of 11.25%. [8]

III. OBJECTIVES

A. Modelling of double pipe counter flow heat exchanger using ANSYS workbench.
B. To simulate double pipe heat exchanger using ANSYS FLUENT software.
C. To enhance heat transfer rate of double pipe counter flow heat exchanger.
D. To enhance overall heat transfer coefficient of double pipe counter flow heat exchanger.

IV. METHODOLOGY

A. Geometry

The double pipe heat exchanger is modelled using ANSYS workbench. The simplified geometry of double pipe heat exchanger is shown in fig 1. The geometry imported in ANSYS FLUENT and perform CFD analysis. Various operations like add frozen, boolean, extrude used to develop geometry. Al_2O_3 nano-particle dispersed in water as a base fluid. The dimensions of double pipe heat exchanger is shown below in table. 1.

Table.1 Geometry details

Specifications	Dimension
Diameter of outer pipe	80 mm
Diameter of inner pipe	36 mm
Length of outer pipe	2000 mm
Length of inner pipe	2200 mm
Arc radius of inner tube	100 mm

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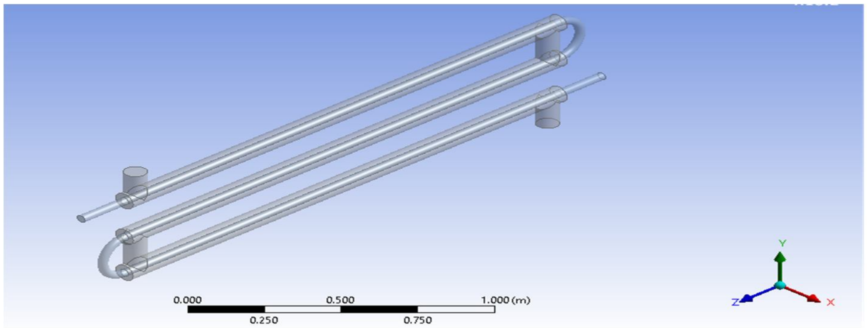


Fig. 1 Model of double pipe heat exchanger

B. Meshing

A mesh is a network which is formed by cells and points. Meshing is a engineering simulation process in which complex geometries are divided into simple elements mesh a can be in any shape and size depending on geometry. Meshing plays an important role to depict flow pattern in the tube. Mesh elements size near wall taken as small to find out the results near boundary walls of heat exchanger. So coarse mesh is generated. The no. of elements are 631216 and no. of nodes are 206584. Tetra and hexahedral meshing used in simulation. Meshing model shown in fig 2.

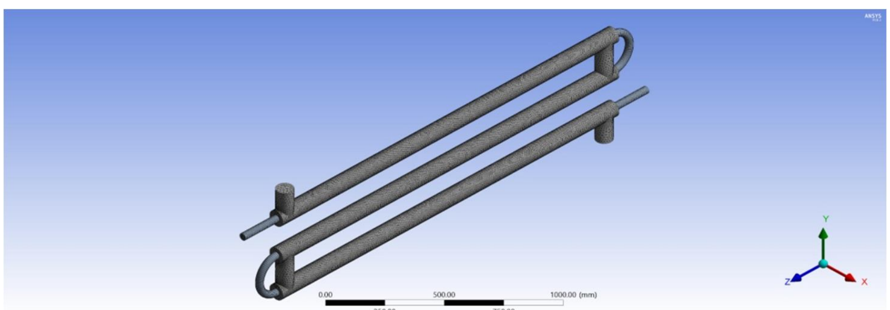


Fig. 2 Meshing model

C. Setup

The mesh was checked. Check the report quality to know maximum aspect ratio and minimum orthogonal quality. Set solver type as pressure based, velocity as absolute and time as steady.

D. Models

Energy was set as ON position and choose viscous model as k-epsilon model with enhance wall treatment.

D. Material selection

We used solid material as aluminium and water used as a hot fluid and Al_2O_3/water used as a cold fluid. Fluid properties are shown below in table .2.

Table. 2 Properties of fluids at various concentrations

Fluid	Density (kg/m3)	Thermal Conductivity (W/m-k)	Specific heat (J/kg-k)	Viscosity (kg/m-s)
Al_2O_3 (0.5%)	1002.98	0.653	4116.99	0.001016
Al_2O_3 (1%)	1017.94	0.662	4054.87	0.001028
Al_2O_3 (2%)	1047.86	0.681	3935.94	0.001053
Water	998	0.644	4181	0.001003

E. Boundary Conditions

Mass flow rate and temperature was selected for each inlet of hot and cold fluid. We used Temperature of hot fluid is 343 K, Temperature of cold fluid is 300 K, Mass flow rate of hot fluid is 0.7 kg/s, Mass flow rate of cold fluid is 0.5 kg/s.

F. Cell Zone Conditions

Assign fluid or solid accordingly. Set water as hot fluid and Al_2O_3/water (nano-fluid) as cold fluid in this cell zone conditions of double pipe heat exchanger.

V. RESULT AND DISCUSSION

A. Temperature Contours

Temperature contours of double pipe heat exchanger with 0.5%, 1%, 2% concentration are shown in the fig. 3, fig. 4, fig 5 respectively. From this figures it is observed that the temperature of inner fluid (hot fluid) water decreased from inlet to the oulet of the pipe and temperature of cold fluid i.e Al_2O_3 nano-fluid increased from inlet to the oulet of the double pipe heat exchanger. The inlets and outlets temperatures at various concentrations 0.5%, 1%, 2% are shown below in table 3, table 4, table 5. The CFD results values are shown in table. 6 below.

1) With 0.5% Volume Fraction:

Table. 3 Inlets and outlets temperature with 0.5% concentration

Fluid	Temperature (k)
Cold inlet	300
Hot inlet	343
Cold outlet	303.57
Hot outlet	336.46

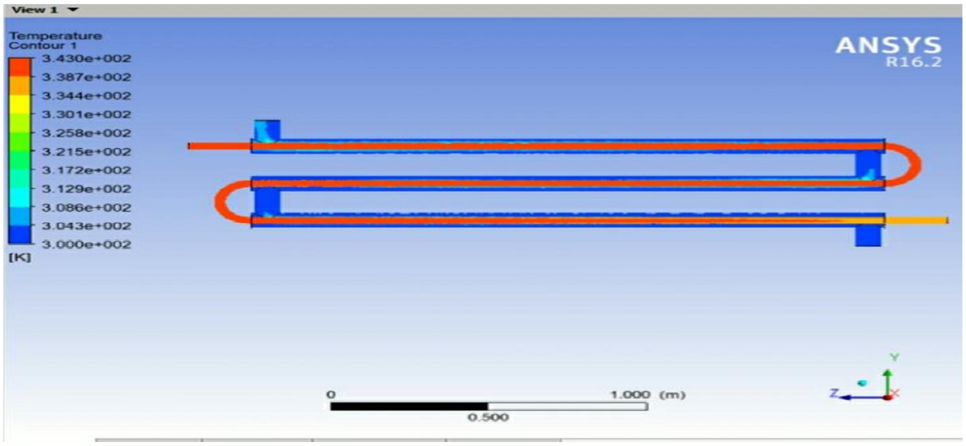


Fig. 3 Temperature contour for 0.5% concentration

2) With 1% Volume Fraction

Table. 4 Inlets and outlets temperature with 1% concentration

Fluid	Temperature (k)
Cold inlet	300
Hot inlet	343
Cold outlet	304.23
Hot outlet	335.82

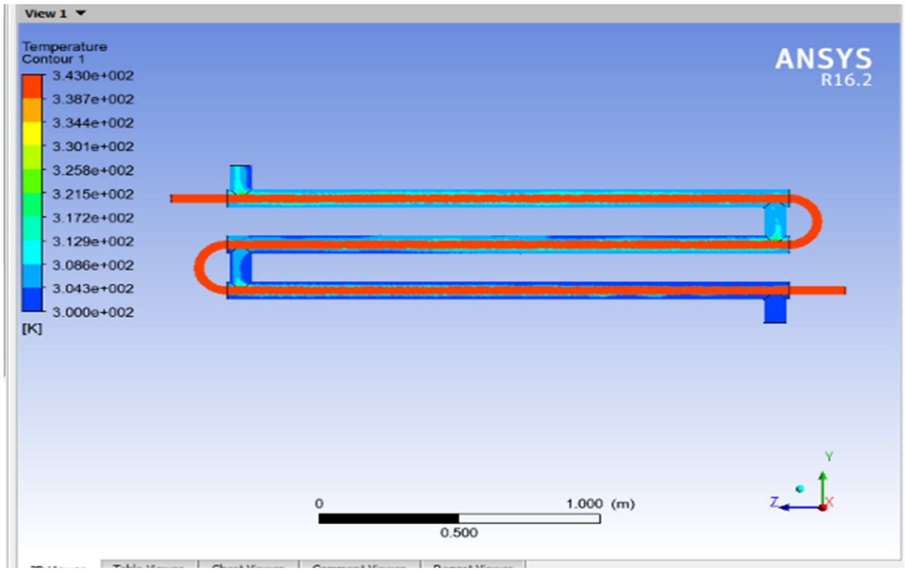


Fig. 4 Temperature contour with 1% concentration

3) With 2% Volume Fraction

Table. 5 Inlets and outlets temperature with 2% concentration

Fluid	Temperature (k)
Cold inlet	300
Hot inlet	343
Cold outlet	304.37
Hot outlet	335.37

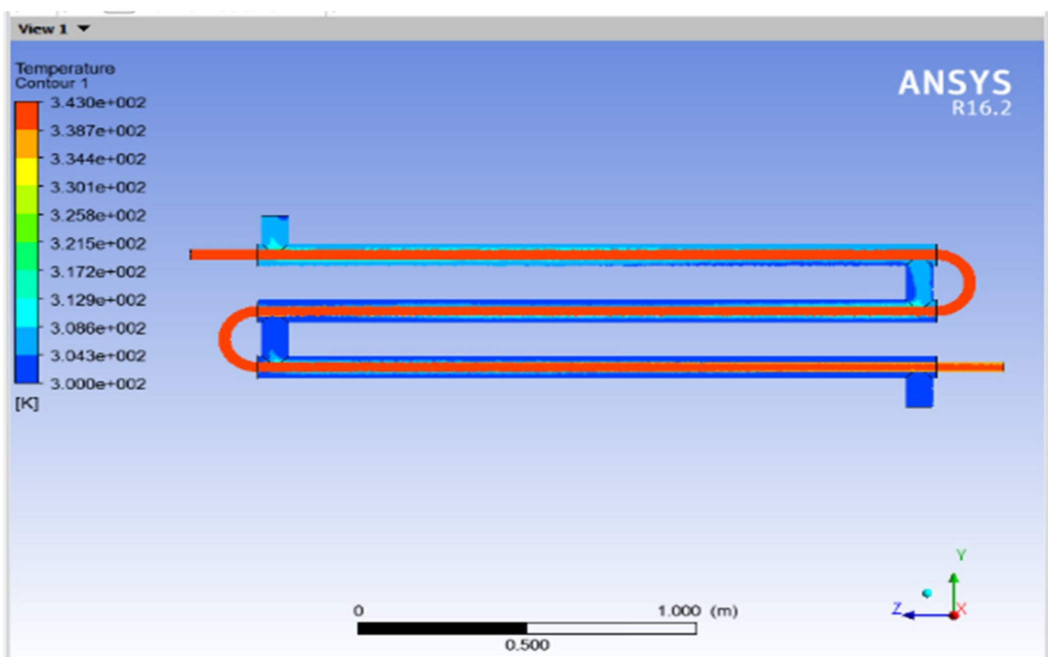


Fig. 5 Temperature contour with 2% concentration

Table. 6 Result values at various concentrations

Fluid	LMTD	T_1	T_2	Q_h	Q_c	h_h	h_c	Overall heat transfer coefficient(U)	Effectiveness
Al_2O_3 (0.5%)	37.93	39.43	36.46	19140.618	7348.83	735.221	277.905	201.67	38.40
Al_2O_3 (1%)	37.27	38.77	35.82	21013.706	8576.05	867.658	314.978	231.09	40.81
Al_2O_3 (2%)	36.98	38.63	35.37	22330.721	8600.03	897.502	327.163	239.76	38.51

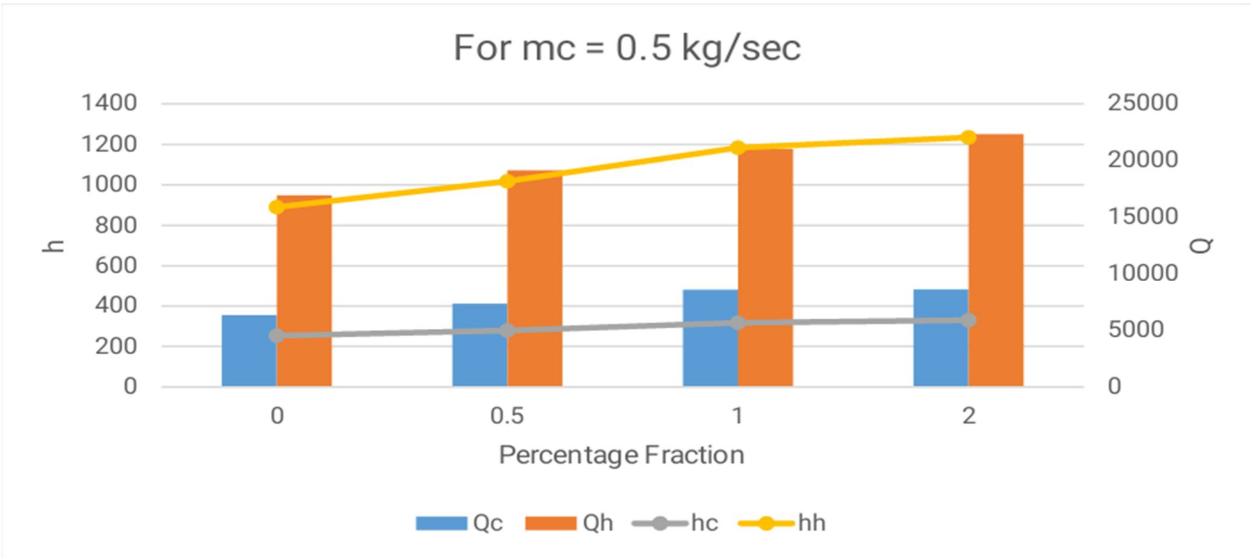


Fig. 6 Graph of various % volume fractions v/s heat transfer rate and heat transfer coefficient

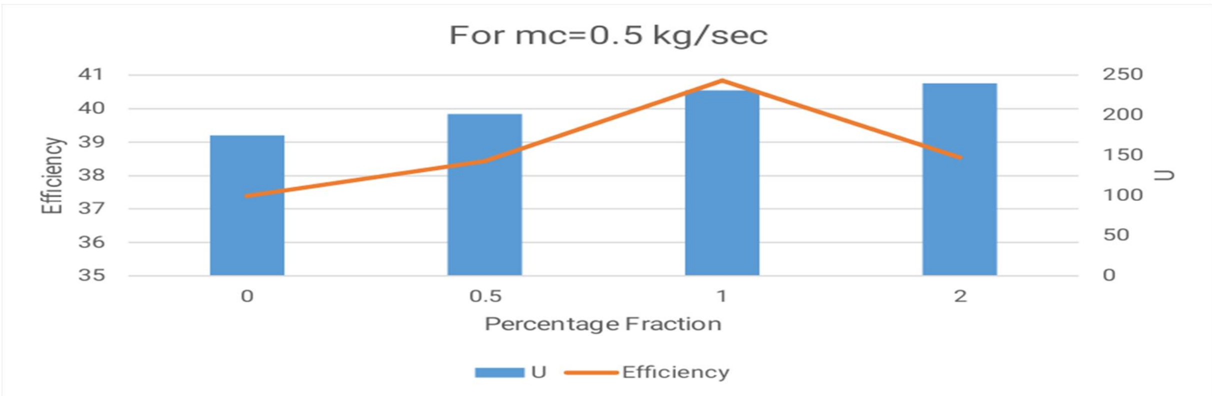


Fig. 7 Graph of various % volume fractions v/s overall heat transfer coefficient and efficiency

VI. CONCLUSION

CFD analysis (ANSYS FLUENT) was used to study heat transfer characteristics of counter flow double pipe heat exchanger and results was determined. We simulate double pipe heat exchanger by using (Al_2O_3/water) nano-fluid as cold fluid and water as hot fluid in this double pipe heat exchanger. As we increases volume concentration of nano-particles in base fluid, it increases the thermal conductivity and hence increases heat transfer rate. It is observed that nano-particle with 2% concentration has highest overall heat transfer coefficient and maximum heat transfer rate.This heat exchanger design is better due to this, temperature of cold fluid increased from inlet to outlet and hot fluid temperature decreased from inlet to outlet.

REFERENCES

[1] D. Bhanuchandrarao, M. Ashok chakravarthy, Dr. Y. Krishna, Dr. V .V. Subba Rao, T. HariKrishna, “CFD Analysis and Performance of Parallel and Counter Flow in Concentric Tube Heat Exchanger”, *“International Journal of Engineering Research & Technology (IJERT)",* ISSN: 2278-0181, Vol. 2 Issue 11, November (2013).

[2] Jibin Johnson, Abdul Anzar, Abith Shani, Harif Rahiman P, Hashmi Hameed T S, Nithin, “CFD Analysis of Double Pipe Heat Exchanger”, “*International Journal of Science, Engineering and Technology Research (IJSETR)"*, Volume 4, Issue 5, May (2015).

[3] N.T. Ravi Kumar, L. Shyam Sundar and P. Bhramara, “Effectiveness and Overall Heat Transfer Coefficient of Fe3O4/Water Nano-fluid Flow in a Double Pipe Heat Exchanger with Return Bend”, *"International Journal of Dynamics of Fluids*, ISSN 0973-1784, Volume 12, Number 1 (2016).

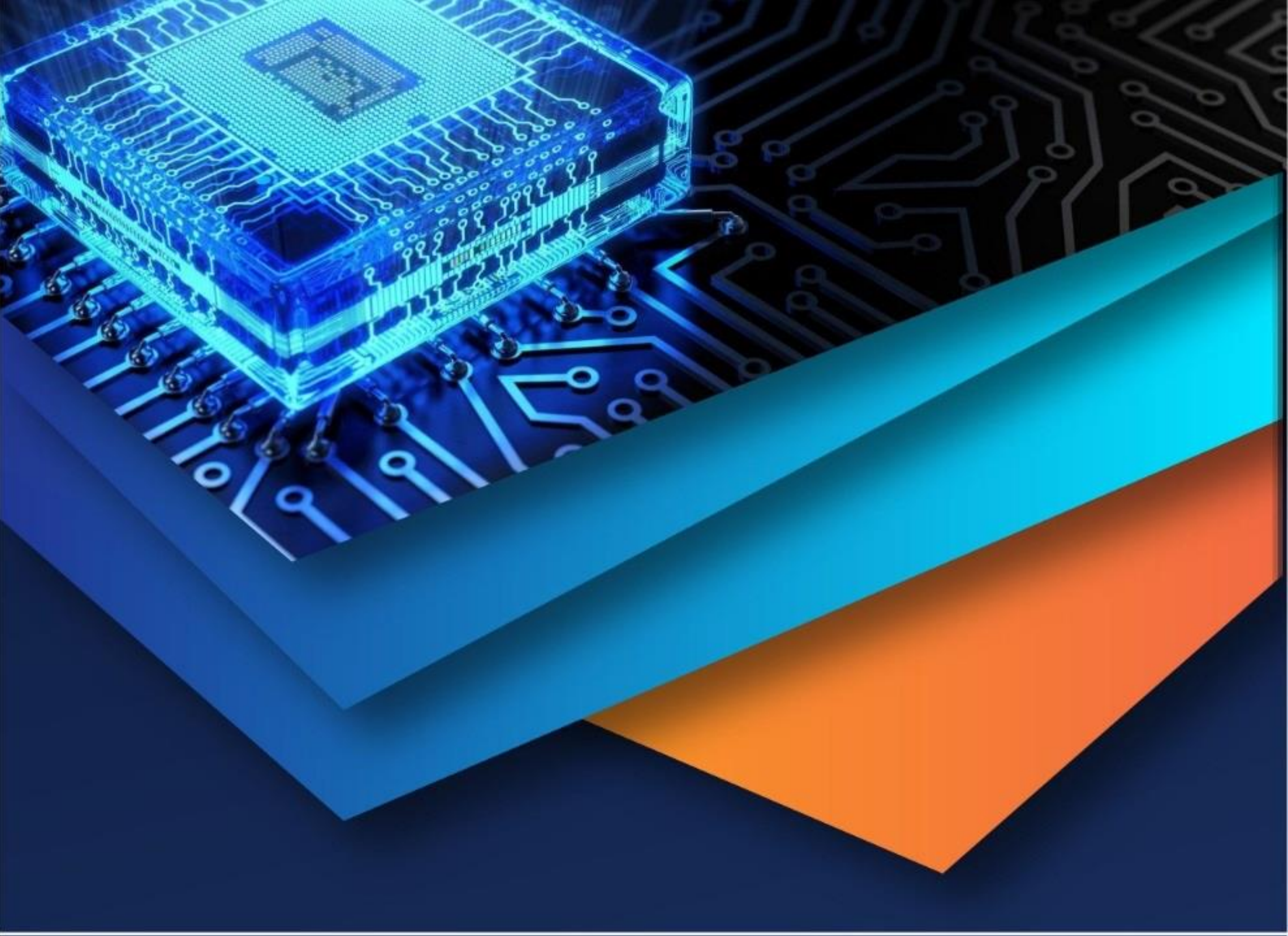
[4] Zahid Imam, P.N. KIRAN KUMAR, ”Design and CFD Analysis of Hair Pin Heat Exchanger at Different Nano-fluids”, "*International Journal of Merging Technology And Advanced Research in Computing",* ISSN: 2320-1363, IJMTARC – Volume-V, SEPT (2017).

[5] V. Nageswara Rao, B. Ravi Sankar, "CFD analysis of CuO/water nano-fluid flow in a double pipe U-Bend heat exchanger”, "*International Journal of Dynamics of Fluids",* ISSN 0973-1784 Volume 13, (2017).

[6] V. Rajeshwar, P. Pramod Kumar, “Design and CFD Analysis of Hair Pin Heat Exchanger at Different Nano-Fluids”, "*International Journal of Scientific Engineering and Technology Research",* ISSN 2319-8885 Vol.06, Issue.31 October (2017)

[7] Salman.K, Prasidh E. Prakash, “CFD analysis of TiO2/water nano-fluid flow in a double pipe heat exchanger”, "*International Journal of Advanced Information in Engineering Technology (IJAIET)"* Vol.5, No.5, May (2018).

[8] Shuvam Mohanty, Shofique Uddin Ahmed, “Computational Modelling of Counter Flow Heat Exchanger for LMTD Analysis”, "*International Journal for Research in Applied Science & Engineering Technology (IJRASET)",* ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887Volume 6 Issue IV, April (2018).



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