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Analysis and Experimentation of Shell and Tube Heat Exchanger with Different Orientation of Baffles

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Abstract— An Experimentation along with CFD analysis is carried on single pass, counter flow shell and tube heat exchanger containing Baffles at 0^0,15^0,30^0,45^0 orientation. To study the heat transfer rate and pressure drop of shell side fluid and compare the result with Bell-Delaware method. Experimental setup is validated with help of Dittus- Boelter correlation. Nusselt number obtain from Experimental set up of 0^0orientation and Dittus- Boelter correlation are within 5.72%. Experimental result of 0^0orientation is also compare with CFD results in which Nusselt number are found to be within 12.50% and pressure drop is found within 5.55%.Results obtain from CFD analysis is also compare with Bell Delaware method and Nu in case of CFD is 3.35% of Bell-Delaware. Pressure drop Results in case of CFD is Found within14.99%.CFD analysis of at 15^0,30^0 & 45^0 baffle orientation is also done and results are validate with help of Belle Delaware method. From this experimental, CFD and Bell Delaware analysis it is found that as baffle angle changes from 0 to 45 degree Nusselt no. is increases that is indirectly heat transfer rate is increase and pressure drop is reduces. As baffle orientation changes from 0 to 45 ^{0} Nusselt number increases from 143.97 to 174.43 and pressure drop are reduces from 4956.22 Pa to 4289.71 Pa in Case of CFD Results. Reduction in Pressure drop with increase in baffle orientation help in reducing the pumping cost of Shell and tube heat exchanger.

Keywords— Nusselt number, Pressure drop, Baffle Inclination angle.

I. INTRODUCTION

A heat exchanger is a device built for efficient heat transfer from one medium to another in order to carry and process energy. The most commonly used type of heat exchanger is the shell and tube heat exchanger. It is essential to mention that a heat exchanger is not only an apparatus for transferring heat from one medium to another, but is at the same time a pressure and/or containment vessel. In addition to heating up or cooling down fluids in just a single phase, shell and tube heat exchangers can be used either to heat a liquid to evaporate (or boil) it or used as condensers to condense a vapor back to a liquid. To increase the heat transfer rate in shell and tube type heat exchanger the segmental baffles are introduced inside the cover pipe. The flow arrangement is counter flow as it is more efficient than parallel flow arrangement. One of the most important parts in shell and tube heat exchangers are the baffles.

The aim of the project is to investigate the heat transfer enhancement by different orientation of baffles in shell for increasing the heat transfer rate & achieving higher efficiency in the application of heat exchanger, nuclear reactor, solar heaters, gas turbine, combustion chamber and many other practical heating devices. . However present study permits the higher heat transfer rate but cause reasonable frictional penalty & axial pressure drop. It is proposed to make some modification to achieve heat transfer augmentation with minimum frictional losses & min. axial pressure drop. The new type of baffle inclination is intended to have high heat transfer rate & minimum pressure drop from existing. By increasing the heat transfer coefficient with the help of increasing the molecular randomness of fluid we meant making the heat transfer operation more economical and efficient. In order to achieve that, we need to modify the construction of heat exchanger,

Nomenclature

A_S	Surface area (m^2)
A_c	Cross sectional area of pipe (m^2)
C_p	Specific heat at constant pressure (J/kg℃)
D_i	Inner diameter of pipe (m)

D_o	Outer diameter of pipe (m)
d_o	Diameter of orifice (m)
h	Average convective heat transfer coefficient [W/m^2℃]
k	Thermal conductivity[W/m℃]
L	Pipe length (m)
$\dot{m}$	Mass flow rate of air (kg/s)
Nu	Nusselt number
Pr	Prandtl number
Re	Reynolds number
f	Friction factor
Δp	Pressure drop along length of tube [N/m^2]
T_s	Average surface temperature (℃)
T_{bm}	Bulk mean temperature(℃)
T_i	Inlet temperature(℃)
T_o	Outlet temperature(℃)
V_a	Velocity of air (m/s)

II. LITERATURE REVIEW

Verities of techniques have been implemented by researchers for heat transfer enhancement in past years for increase in heat transfer rate with low increase in pressure drop which are discussed below.

Sandeep K. Patel, Professor Alkesh M. Mavani [1] studied the Shell & Tube Heat Exchanger Thermal Design With Optimiztion of Mass Flow Rate And Baffle Spacing. This paper state a characteristic of heat exchanger design is the procedure of specifying a design. Heat transfer area and pressure drops and checking whether the assumed design satisfies all requirement or not. The purpose of this paper is how to design the shell and tube heat exchanger which is the majority type of liquid –to- liquid heat exchanger. General design considerations and design procedure are also illustrated in this paper. In design calculation HTRI software is used to verify manually calculated result. From literature review it can be concluded that, • There is increase in pressure drop with increase in fluid flow rate in shell and tube heat exchanger which increases pumping power. Genetic algorithm provide significant improvement in the optimal designs compared to the traditional designs. Genetic algorithm application for determining the global minimum heat exchanger cost is significantly faster and has an advantage over other methods in obtaining multiple solutions of same quality. Thus, providing more flexibility to the designer.Koorosh Mohammadi, Wolfgang Heidemann,§ and Hans Müller-Steinhagen[2] studied Effect of baffle orientation on heat transfer and pressure drop of shell and tube heat exchanger with and without leakage flows. The effect of baffle orientation on the heat transfer and pressure drop of shell and tube heat exchangers in the domain of turbulent flow is investigated numerically using the commercial CFD code FLUENT. The segmentally baffled shell and tube heat exchangers considered follow the TEMA standards and consist of 76 and 660 plain tubes respectively, with fixed outside diameter and arranged in a triangular layout. Air, water and engine oil with Prandtl numbers in the range of 0.7 to 206 are used as shell-side fluids. The simulation results show a significant influence of the baffle orientation on the shell-side pressure drop and heat transfer of shell and tube heat exchangers. In the shell and tube heat exchanger with leakage flows the vertical baffle orientation seems to be more advantageous than the horizontal orientation. The benefit of vertical baffle orientation on horizontal baffle orientation is more noticeable for gases. Contrariwise, the simulation results for shell and tube heat exchangers without leakages show the advantage of the horizontal baffle orientation over the vertical orientation, particularly in the inlet and outlet zone for all investigated shell-side fluids. The comparison of calculation results with and without leakage flows presents different behaviour and underlines the importance of a consideration of tube-baffle leakage and bypass streams for the prediction of the performance factor of technical heat exchangers. Praveen Kumar Jha, K. K. Jain ,Dr. R. K. Dave,Pooja Tiwar [3] Studied Analytical performance analysis of shell and tube heat exchanger by varying number of baffles and mass flow rate. In this paper they study an effort has made for Computational Fluid Dynamic (CFD) analysis of a single pass counter flow Shell and Tube Heat Exchanger (STHX) with varying number of baffles & comparing the mass flow rate i.e 1kg/sec and 2kg/sec. STHX is the most common and widely used type of heat exchangers in oil refineries, condensers and other large chemical processing plants. To

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analyze the performance of STHX, hot fluid has made to flow through shell and cold fluid is allowed to flow through the tube. Our analysis is based on shell side study to find out temperature at the inlet and outlet of shell side, pressure drop and velocity drop. These results shows that as the mass flow rate inside the shell increases temperature drop decreases because time to transfer heat from it minimizes.So it can be concluded that most optimum result obtained at considered Baffle angle is at 8 Baffles at the mass flow rate of 1Kg/Sec**.** Ankit Uppal, Dr. Vinod Kumar, Dr. Chanpreet Singh [4] studied CFD analysis of heat transfer enhancement in a heat exchanger using various baffle arrangements. The present study reports the heat transfer enhancement in a heat exchanger tube by installing seven different baffle arrangements. The purpose of the study is to find out the optimum baffle shape and arrangement According to results, it concluded that in case of single baffle used, rate of heat transfer is maximum for rectangular shape baffle surface and in case of baffle combinations; rate of heat transfer is maximum for rectangular and triangular baffle. The reason behind maximum heat transfer rate was that due to use of baffles, turbulence was increased as they allow more mixing of fluid layers and resulted in increase of heat transfer through the heat exchanger tube. Avinash D Jadhav, Tushar A Koli, [5] studied CFD analysis of shell and tube heat exchanger to study the effect of baffle cut on the pressure drop. In this paper the shell side of a small shell-and-tube heat exchanger is modelled with sufficient detail to resolve the flow and temperature fields. From the CFD simulation results, for fixed tube wall and shell inlet temperatures, shell side heat transfer coefficient, pressure drop and heat transfer rate values are obtained. The sensitivity of the shell side flow and temperature distributions to the mesh density, the order of discretization and the turbulence modelling is observed. By varying baffle cut values of 25% and 30%, for 0.5, 1 and 2 kg/s shell side flow rates, the simulation results are compared with the results from the Kern and Bell–Delaware methods. Using CFD, together with supporting experiments, may speed up the shell-and-tube heat exchanger design process and may improve the quality of the final design. In the near future, improvements in the computer technology will make full CFD simulations of much larger shell-and-tube heat exchangers possible. Nishank Kumar Pandey, Dr. Rohit Rajvaidya [6] studied computational fluid dynamics analysis of single pass shell & tube heat exchanger with different orientation of baffles and without baffles. In this specific project an endeavor is design for CFD evaluation of Single Pass Shell & Tube Heat Exchanger with Different Orientation of Baffles and Without Baffles with counter flow of fluid. In order to research the performance of the heat exchanger, hot fluid was designed to flow inside the seven tubes and cold fluid flows through outer pipe & tube material using Copper as well as Brass & Shell Material using Carbon Steel. The baffles utilized in heat exchanger are usually segmental baffles cut of 25%. The introduction of baffles, force the fluid to have a turbulent flow, thus improving the heat transfer rate. The outcomes of heat transfer rate for flow of fluid with vertical segmental baffle inside heat exchanger are in comparison with the heat exchanger without having baffles. The result of heat transfer rate & pressure drop for flow of fluid for 0^0 baffles is also compared with baffle at 30^0 orientations. They Study the heat transfer in the heat exchanger at different velocity, the end result coming out from heat exchanger having baffles located at outer pipe will be more efficient via heat exchanger without having baffles and The outcomes of heat transfer coefficient coming out by utilization of 30^o baffles will be more efficient than 0^o baffles. As the angle of inclination increases, the heat transfer rate of heat exchanger also increases also the Reynolds number increases in the heat exchanger, the heat transfer coefficient will increase. Swarup S.Deshpande Shreeniket A Hinge [7] studied This paper primarily focuses on the design and comparative analysis of Single segmental Shell and tube Heat Exchanger with perpendicular & parallel baffle cut orientation. For designing Kern Method is used. It predicts heat transfer coefficient, Pressure drop of both arrangements. This method gives us clear idea that rate of heat transfer is greater in Perpendicular-cut baffle orientation than Parallel-cut , Pressure drop approximately remaining same. The Shell side fluid used is Lithium-bromide with average concentration of 58.5% and tube side fluid is hot water. All other parameters of fluid remaining same. From this paper it is evident that there is significant drop in the Reynolds Number corresponding to vertical flow which in turn has a direct impact on the shellside heat transfer coefficient which is found to be lower than that for horizontal flow. However the shell-side pressure drop for the vertical flow is in the same range as that for the horizontal flow design. Also there is a noticeable drop in the Nusselts Number for the proposed design with the Prandtl number being the same for both designs. Therefore based on the results we conclude that changing the flow pattern to vertical to improve the shell-side heat transfer coefficient is not feasible. Ajithkumar M.S., Ganesha T., M. C. Math [8] studied CFD analysis to study the effects of inclined baffles on fluid flow in a shell and tube heat exchanger. They analyse the performance of STHX,for that hot fluid has made to flow through tubes and cold fluid is allowed to flow through the shell. Their main objective is to design the STHX with segmental and helical baffles and to study the flow and temperature field inside the shell side. Also, attempts were made to investigate the effects and heat transfer characteristics of a STHX for three different baffle inclinations namely 0°, 10°, and 20° for a given baffle cut of 36%.The study indicated that flow pattern in the shell side of the heat exchanger with continuous helical baffle was forced to rotate the fluid, which results in significant increase in heat transfer rate and heat transfer coefficient per unit pressure drop than segmental baffle

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STHX. From the CFD simulation results, the shell side outlet temperature, pressure drop, optimum baffle inclination and optimal mass flow rate were determined.mNeeraj kumar, Dr. Pradeep kumar Jhinge, [9] studied effect of segmental baffles at different orientation on the performances of single pass shell and tube heat exchanger. In this paper, experimentation of single pass, counter flow shell and tube heat exchanger containing segmental baffles at different orientations has been conducted to calculate some parameters (heat transfer rate and pressure drop) at different Reynolds number in laminar flow. In the present work, an attempt has been made to study the effect of increase in Reynolds number at different angular orientation "θ" of the baffles. The range of "θ" vary from 0° to 45° (i.e 0°, 15°, 30° and 45°) and Reynolds number ranges from 500 to 2000 (i.e 500, 1000, 1500 and 2000). Based on the experimental result it has been observed that the angular orientation of baffles and the Reynolds number effects the heat transfer rate and pressure drop in the shell and tube heat exchanger. The heat transfer rate increases up to 30° angular orientation of the baffles and after that there is a drop in heat transfer rate at θ = 45°.

III. MATHEMATICAL EQUATIONS

The Nusselt number are calculated from experimental data in turbulent flow region. Equations used for calculation of parameters are listed below.

The mass flow rate of water is calculated by,

$$\dot{m} = \rho A_c V_w$$

Where, ρ is the density of water, A_c is the cross sectional area, V_w is the velocity of water

Heat Transfer Calculation,

$$Q = \dot{m_h} \times cp_h \times (T_{hi} - T_{ho})$$

The average heat transfer coefficient is calculated as

$$Q = h \times A_s \times (T_s - T_{bm})$$

The average Nusselt number is calculated as

$$Nu = \frac{h \times d}{k_{water}}$$

The Reynolds number is obtained as

$$Re = \frac{\rho v D}{\mu}$$

where μ is dynamic viscosity of fluid.

Prandtl number is given as

$$p_r = \frac{\mu c_p}{k}$$

Equation used in Bell-Delaware Analysis,

Shell-Side Reynolds number, Re_s

$$Re_s = \frac{d_o G_s}{\mu_s}$$

The maximum shell-side cross flow mass velocity, G_s

$$\dot{G_S} = \frac{\dot{m}}{s_m}$$

The ideal tube bank-based coefficient h_i is calculated from,

$$h_i = J_i (cp)s \left(\frac{ms}{As}\right)\left(\frac{ks}{(cp)s\mu s}\right)^{\frac{2}{3}}\left(\frac{\mu s}{\mu s,w}\right)^{0.14}$$

heat transfer coefficient h_s is expressed as,

$$h_s = h_i (J_c \times J_i \times J_b \times J_s \times J_r)$$

pressure drop in the interior cross flow section,

$$\Delta pc = \Delta pbi(Nb-1)RlRb$$

pressure drop in an equivalent ideal tube bank in one baffle compartment of central baffle spacing,

$$\Delta pbi = 4 f i \frac{Gs^2}{2\rho s}\left(\frac{\mu s,w}{\mu s}\right)^{0.14} Ntcc$$

The pressure drop in the two end zones Δp_e

$$\Delta pe = \Delta pbi\left(1 + \frac{Ntcw}{Ntcc}\right) RbRs$$

the total shell-side pressure drop Δps, excluding nozzles, is

$$\Delta ps = \Delta pc + \Delta pw + \Delta pe$$

IV. EXPERIMENTAL SETUP

The schematic diagram of experimental set up is shown in fig.2. Experimental setup consists of Storage tank. Inside of tank heater coil & pump is mounted so that hot water is pumped and passes through Shell. Hot water temperature is measured with the help of J-type thermocouple. Water is heated until 75^0C. Heater input is control by Dimmerstat and set at value such that constant supply of water at 75^0C is obtained. Thermostat is used which shut off power to heater as 75^0C temperature of water exceeds. Flow control valve (Regulator Valve & Ball valve) are used to maintain the measured of quantity flow through the test section. Orifice meter along with U –tube manometer are used to measure the mass flow rate of Fluid.5 J-type Thermocouple are used to measure inlet and outlet temperature of shell and tube fluid and to measure the surface temperature. Outer surface of test tube is well insulated with asbestos insulation to reduce convective heat loss to surrounding. Connecting pipe of 38mm diameter are used, inside of pipe orifice plate is mounted having diameter of 15mm with the help of flange arrangement. Stainless steel of SS304 material is used for Shell having outer diameter of 160mm, inner diameter of 152mm and 1000mm length of test section is used.

Fig.1: Actual Photograph of Experimental Setup

Fig.2: schematic view of Shell and Tube

Tube is made up of Copper material having outer diameter 20mm, inner diameter 16mm and length of 1000mm is used.19 tubes are inserted in shell during this triangular pitch of 30mm is maintained. Baffles are made up of SS304 material having thickness of 3mm such 10 baffle are mounted at distance of 86mm each i.e. baffle spacing of 86mm is used.

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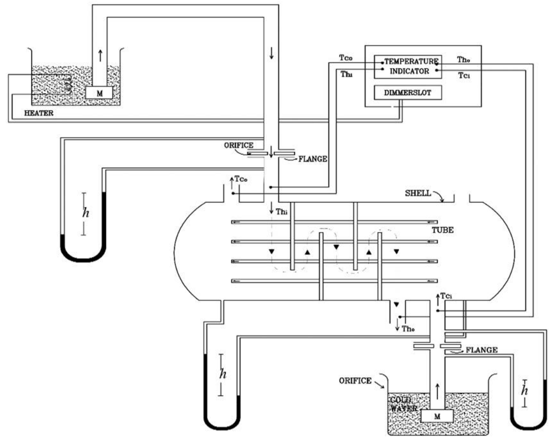

Fig.3: 2-D view of experimental setup.

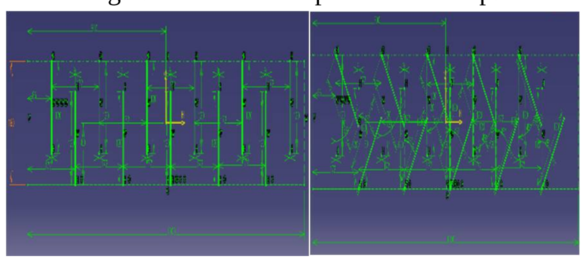

Fig.4: 0 and 45^0 Orientation of Baffles.

A. Baffle Inclination: Four types of Baffle inclination are used 0^0 Orientation of Baffle, 15^0 Orientation of Baffle, 30^0 Orientation of Baffle 45^0 Orientation of Baffle. Figure3 shows 2D sketch of baffle cut with dimensions.

V. RESULT & DISCUSSION

A. Validation of experimental Setup

In the beginning, results of the present single pass counter flow Shell and tube heat exchanger with 0^0 orientation of baffles are validated with those obtained from the standard empirical correlation of Dittus-Boelter as given below;
Nusselt number correlation
Empirical correlation of Dittus-Boelter;

$$Nu = 0.023Re^{0.8}Pr^{0.4}$$

$$Nu = 0.023 \times (26330)^{0.8} \times 5.39^{0.4}$$

$$\boldsymbol{Nu = 155.1400}$$

$$\%Nu_{increase} = \frac{Nu_{by\ Experimentation} - Nu_{By\ D-B}}{Nu_{by\ Experimentation}} \times 100 \qquad \%Nu_{increase} = \frac{164.55 - 155.1400}{164.55} \times 100$$

$$\boldsymbol{Nu_{increase} = 5.72\%}$$

It is found that Nusselt numbers obtain from present experimental setup having 0^0 degree orientation of baffles agree well with those achieved from Dittus-Boelter correlation within ±5.72 %. In this way Experimental set up is first validate with standard Empirical correlation of Dittus-Boelter

B. CFD Results

Mesh Formation: Figure shows the finite element mesh using Hypermesh

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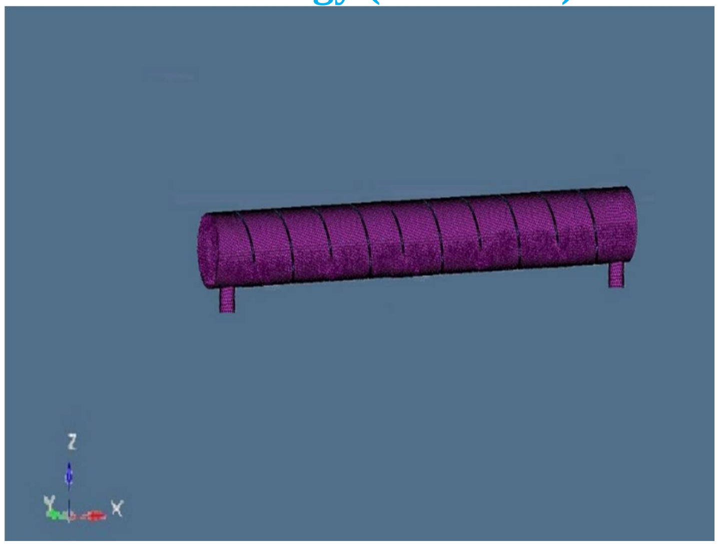

Fig.5: Mesh Generation for 25% Baffle cut

Variation of Temperature: The temperature Contours plots across the cross section at different inclination of baffle along The length of heat exchanger will give an idea of the flow in detail. Four different plots of temperature Profile are taken in comparison with the baffle inclination at 0^0,15^0,30^0 and 45^0.

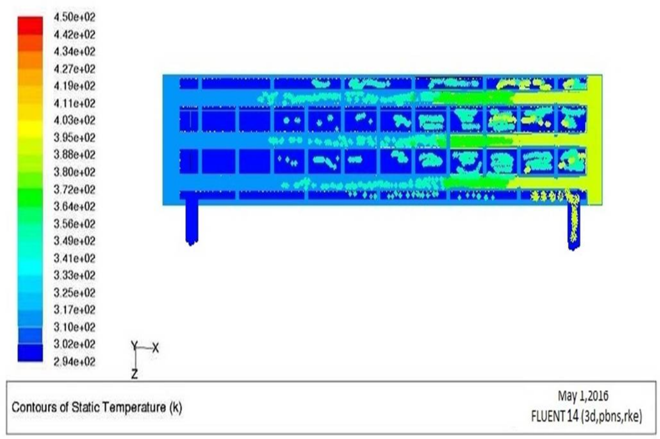

Fig.6: Temperature Distribution for 0^0 baffle inclination.

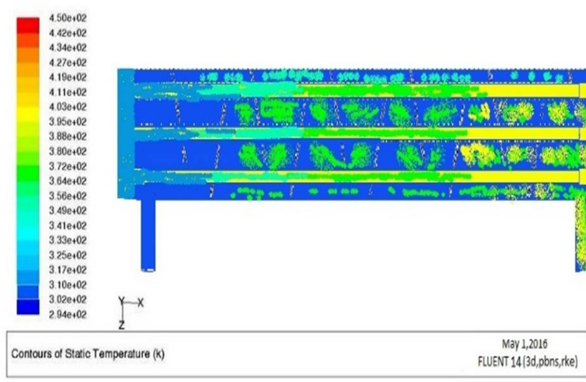

Fig.7: Temperature Distribution for 15^0 baffle inclination.

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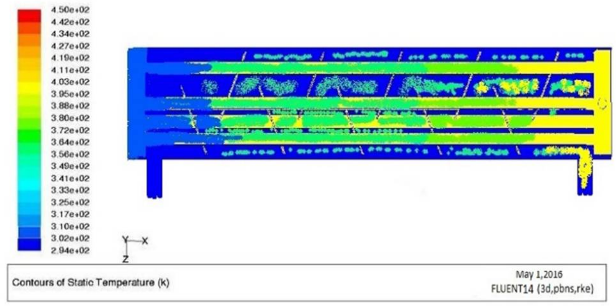

Fig.8: Temperature Distribution for 30^0 baffle inclination

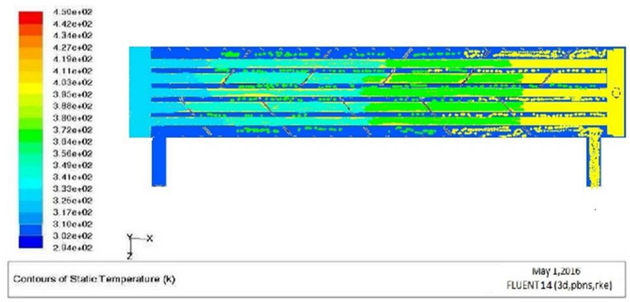

Fig.9: Temperature Distribution for 45^0 baffle inclination

Variation of Pressure: Pressure Distribution across the shell and tube heat exchanger is given below in Figure. With the increase in Baffle inclination angle pressure drop inside the shell is decrease. Pressure vary largely from inlet to outlet. The contours of static pressure is shown in all the
Figure to give a detail idea.

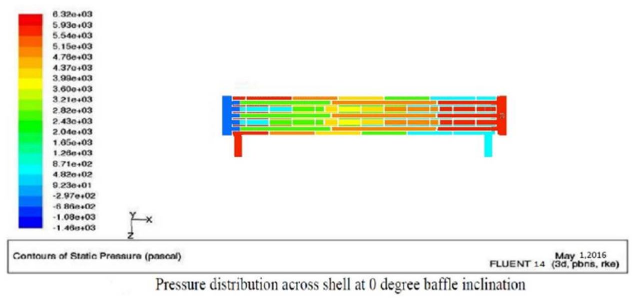

Fig.10:Pressure Distribution for 0^0 baffle inclination.

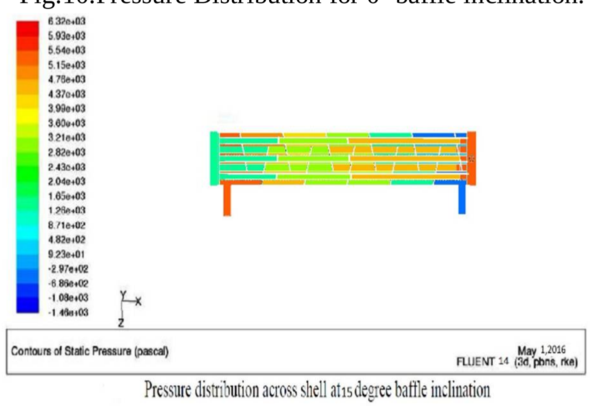

Fig.11:Pressure Distribution for 15^0 baffle inclination.

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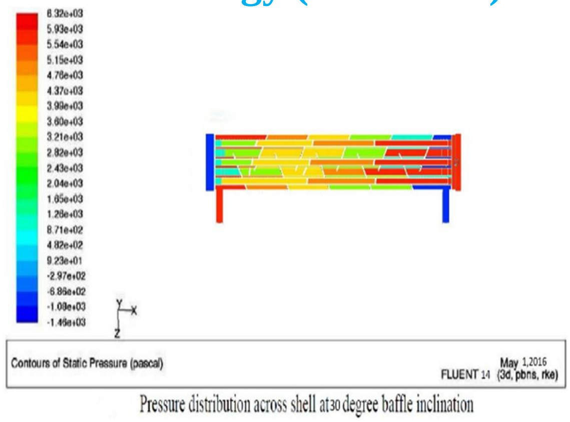

Fig.12: Pressure Distribution for 30^0 baffle inclination.

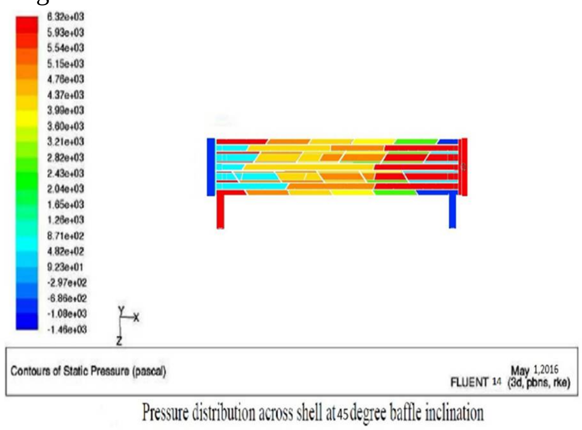

Fig.13: Pressure Distribution for 45^0 baffle inclination.

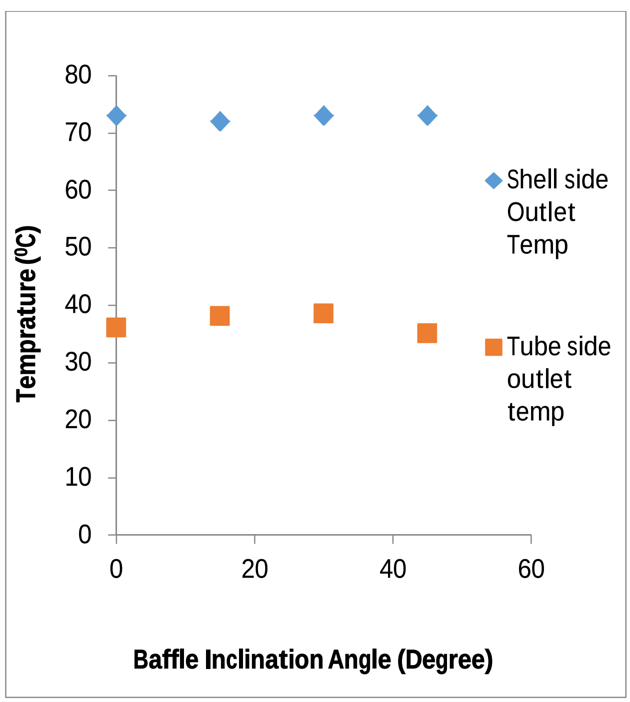

Fig.14: Plot of Baffle inclination angle vs Outlet Temperature of shell and tube side.

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It has been found that there is much effect of outlet temperature of shell side with increasing the baffle inclination angle from 0^0 to 45^0.

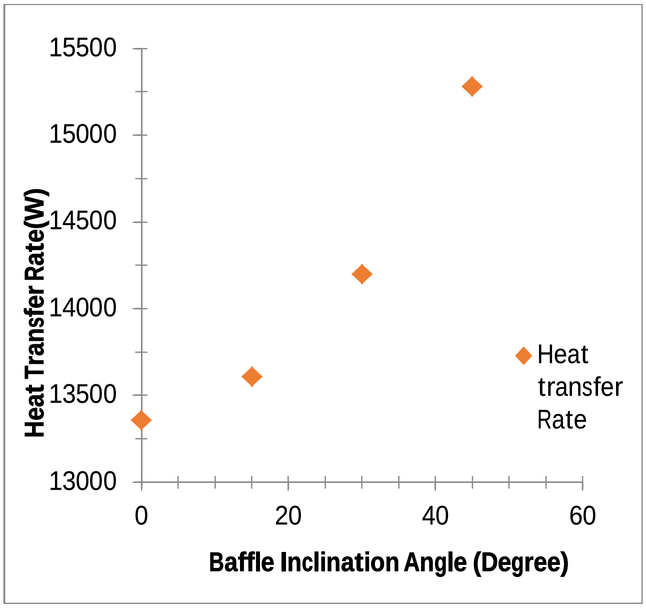

Fig.15: Plot of Baffle angle vs Heat transfer Rate

Plot shows that with increase in baffle inclination heat transfer rate is increased.

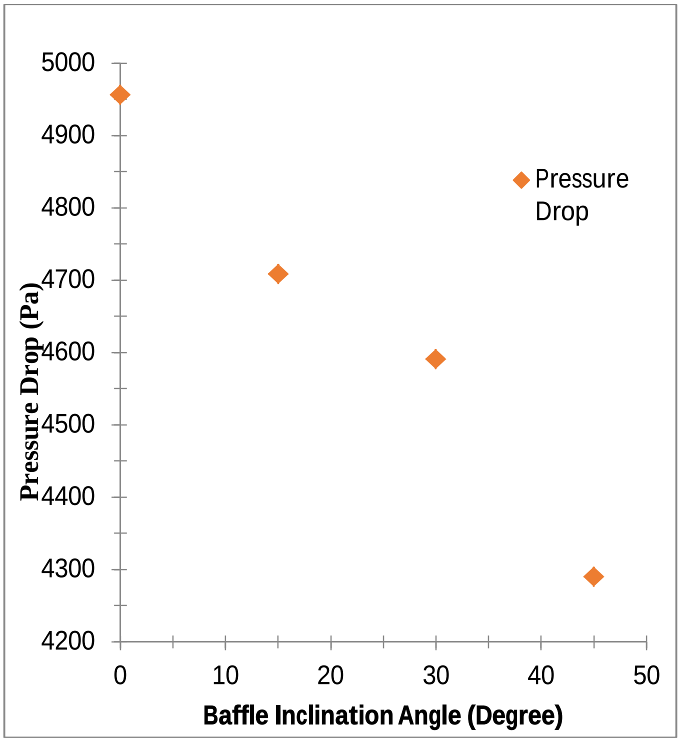

Fig.16 Plot of Baffle angle vs Pressure Drop

The shell-side pressure drop is decreased with increase in baffle inclination angle i.e., as the Inclination angle is increased from 0° to 45°. The pressure drop is decreased by 13.44%, when baffle inclination changes from $0^0$to 30^0 pressure drop is decreased by 7.3791% and when baffle inclination changes from $0^0$to 15^0 Pressure drop is decreased by 5%. Hence it can be observed with increasing baffle inclination pressure drop decreases, so that it affect in heat transfer rate which is increased.

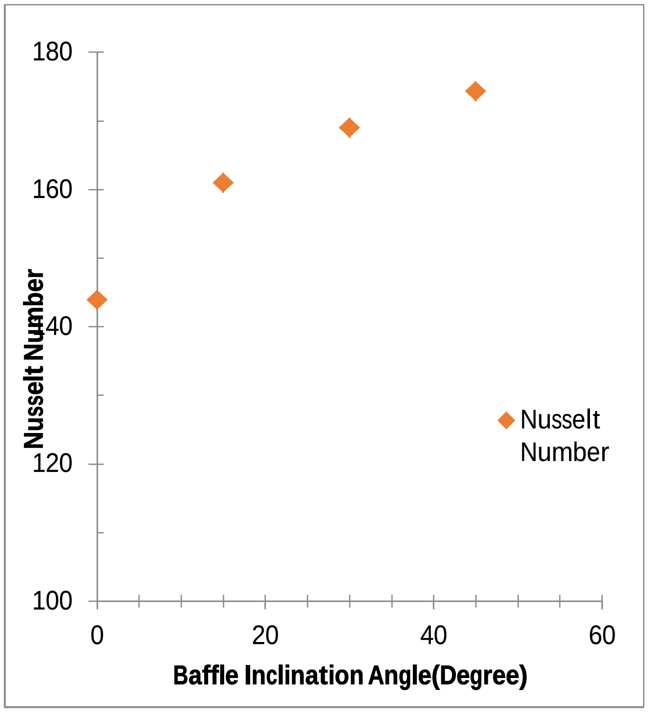

Fig.17 : Plot of Baffle angle vs Nusselt Number

Figure shows that as baffle inclination angle change from 0^0 to 45^0 Nusselt number is increased by17.4625%,whereas when baffle inclination angle change from 0^0 to 30^0 Nusselt number increased by 14.87% and when Baffle angle change from 0^0 to 15^0 Nusselt number increased by10.6167%. Due to change in baffle inclination angle from 0^0 to 45^0 Nusselt number is increases it means due to change in baffle inclination heat transfer coefficient is changes, which indicates convective mode of heat transfer is increase also fluid become more turbulence because of increase in baffle inclination from 0^0 to 45^0.

C. Comparison of Experimentation,CFD and Bell-Delaware Result,

It is found that Nusselt number obtain from present experimental setup having 0^0 degree of baffle orientation agree well with those achieved from CFD analysis within ±12.50 % and with Bell-Delaware analysis is within ±15.58 % , whereas Nusselt number obtain from CFD Result and from Bell-Delaware analysis is within ± 3.5146%. Pressure drop obtain from Experimentation and CFD analysis for 0^0 degree of baffle orientation is well within ± 5.55% and with Bell-Delaware analysis is within ± 9.99%, whereas Pressure drop obtain from CFD analysis and from Bell-Delaware analysis is within ± 14.99%. It is found that Nusselt number obtain from CFD analysis having 15^0 degree of baffle orientation agree well with those achieved from Bell -Delaware analysis within ±12% . Shell side pressure drop obtain from CFD analysis having 15^0 baffle orientation agree well with those achieved from Bell-Delaware analysis is within ± 15.01%.Whereas due to increase in Baffle orientation from 0^0 to 15^0.Heat transfer coefficient is increase by 10.6167%, Nusselt number is increase by 10.6167% and Shell side Pressure drop is decrease by 5% in case of CFD analysis. In case Bell –Delaware analysis due to change in Baffle angle from 0^0 to 15^0 degree heat transfer coefficient is increase by 2% ,Nusselt number is increase by 1.99% and Shell side Pressure Drop is decrease by 5.02%. It is found that Nusselt number obtain from CFD analysis having 30^0 degree of baffle orientation agree well with those achieved from Bell -Delaware analysis within ±14.91% . Shell side pressure drop obtain from CFD analysis having 30^0 baffle orientation agree well with those achieved from Bell-Delaware analysis is within ± 15.36%.Whereas due to increase in Baffle orientation from 0^0 to 30^0 Heat transfer coefficient is increase by 14.87%, Nusselt number is increase by 14.87% and Shell side Pressure drop is decrease by 7.3791% in case of CFD analysis. In case Bell – Delaware analysis due to change in Baffle angle from 0^0 to 30^0 degree heat transfer coefficient is increase by 3.46%,Nusselt number is increase by 3.4676 % and Shell side Pressure Drop is decrease by 7.77 %. It is found that Nusselt number obtain from CFD analysis having 45^0 degree of baffle orientation agree well with those achieved from Bell -Delaware analysis within ±14.19% . Shell side pressure drop obtain from CFD analysis having 45^0 baffle orientation agree well with those achieved from Bell-Delaware analysis is within ± 15.31%.Whereas due to increase in Baffle orientation from 0^0 to 45^0 Heat transfer coefficient is increase by 17.45%, Nusselt number is increase by 17.4625% and Shell side Pressure drop is decrease by 13.44% in case of CFD analysis. In case Bell –Delaware analysis due to change in Baffle angle from 0^0 to 45^0 degree heat transfer coefficient is increase by 7.7364%,Nusselt number is increase by 7.184 % and Shell side Pressure Drop is decrease by 13.76 %.

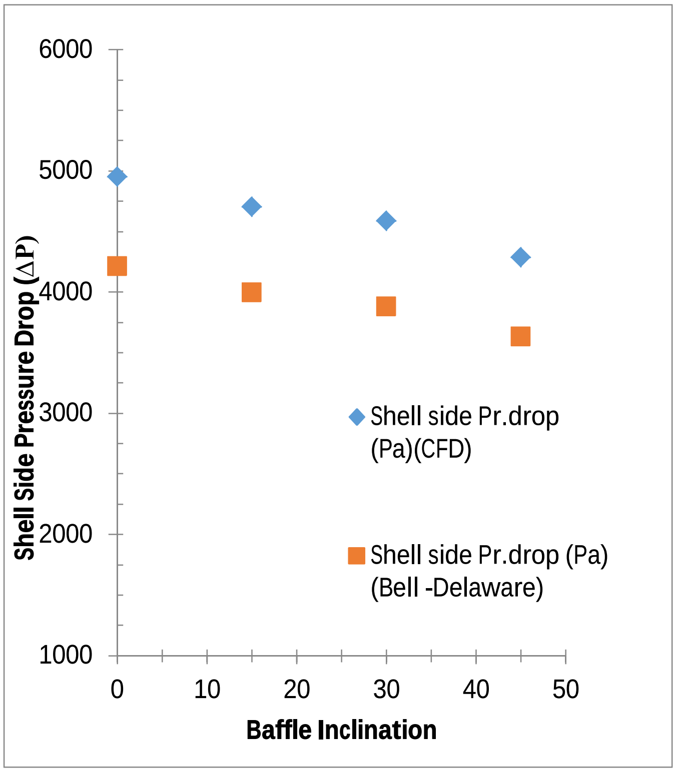

Fig.17 Comparison of Pressure drop result for CFD and Bell-Delaware analysis.

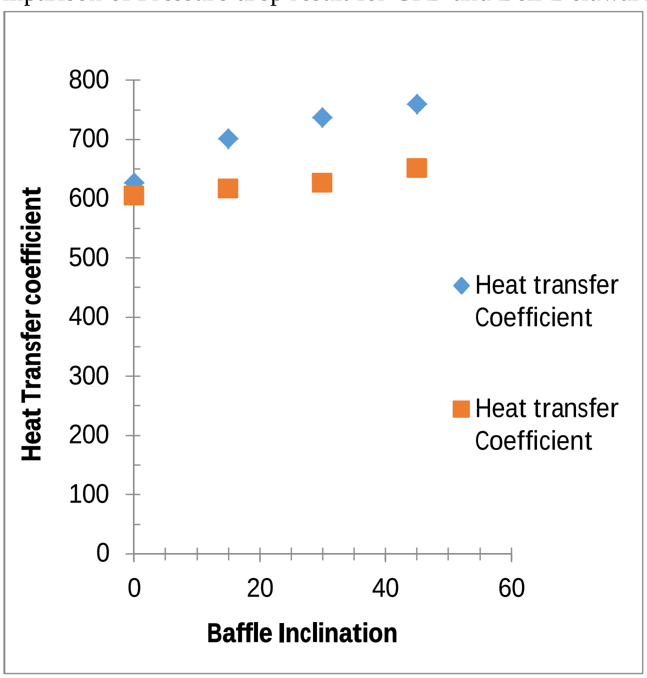

Fig.18 Comparison of heat transfer coefficient result for CFD and Bell-Delaware analysis.

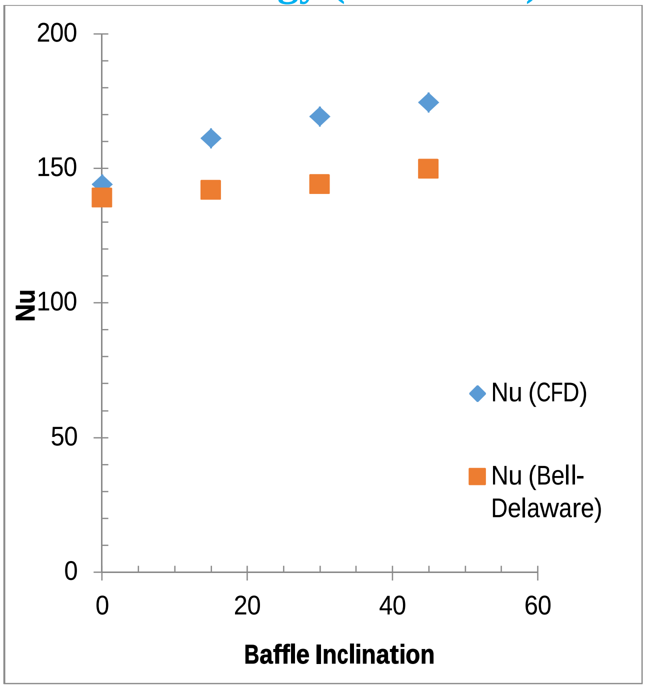

Fig.19 Comparison of Nusselt number result for CFD and Bell-Delaware analysis.

Figure17, 18, 19 shows comparison of CFD and Bell-Delaware result in terms of heat transfer coefficient, Nusselt number and Pressure drop. Whereas due to increase in Baffle orientation from 0^0 to 45^0 Heat transfer coefficient is increase by 17.45%, Nusselt number is increase by 17.4625% and Shell side Pressure drop is decrease by 13.44% in case of CFD analysis. In case Bell – Delaware analysis due to change in Baffle angle from 0^0 to 45^0 degree heat transfer coefficient is increase by 7.7364%,Nusselt number is increase by 7.184 % and Shell side Pressure Drop is decrease by 13.76 %.

VI. CONCUSION

In the present work an Experimentation along with CFD analysis is carried on single pass, counter flow shell and tube heat exchanger containing Baffles at 0^0,15^0,30^0,45^0 orientation. Experimental pressure drop. The results are presented in the form of Nusselt number, heat transfer rate and pressure drop. The overall conclusions are as follows, the experimental setup is validate with Dittus-Boelter correlation. The results are in good agreement within 5.72% for Nusselt number. It is observed that, Nusselt number with change in baffle inclination is higher than 0^0 baffle inclination. Nusselt number, heat transfer coefficient, heat transfer rate is increased by 10% to 17% when baffle angle inclination changes from 0^0 to 45^0,whereas pressure drop is decreased by 5% to 13.44% with change in baffle inclination from 0^0 to 45^0 which helps in reducing the pumping cost of shell and tube heat exchanger. Due to change in baffle inclination angle more turbulence will be created across the shell side, because of this heat transfer coefficient is increases which results in increase of Nusselt number and hence the heat transfer rate will increase. By varying the baffle inclination with fixed baffle spacing and the baffle cut values of 25% for 4.84 kg/sec shell side flow rates, the experimental results for 0^0 baffle inclination are compared with CFD simulation result and then compare with Bell-Delaware result, it is observed that experimentation and CFD result for 0^0 baffle inclination are in good agreement with Bell –Delaware results. The simulation results for 15^0, 30^0,45^0baffle inclination compared with result from Bell-Delaware method. For properly spaced baffles, it is observed that the CFD simulation results are in good agreement with the Bell-Delaware results. The results are also sensitive to baffle cut selection, for this counter flow shell and tube heat exchanger with 10 baffles and baffle inclination of 45^0 gives slightly better result.

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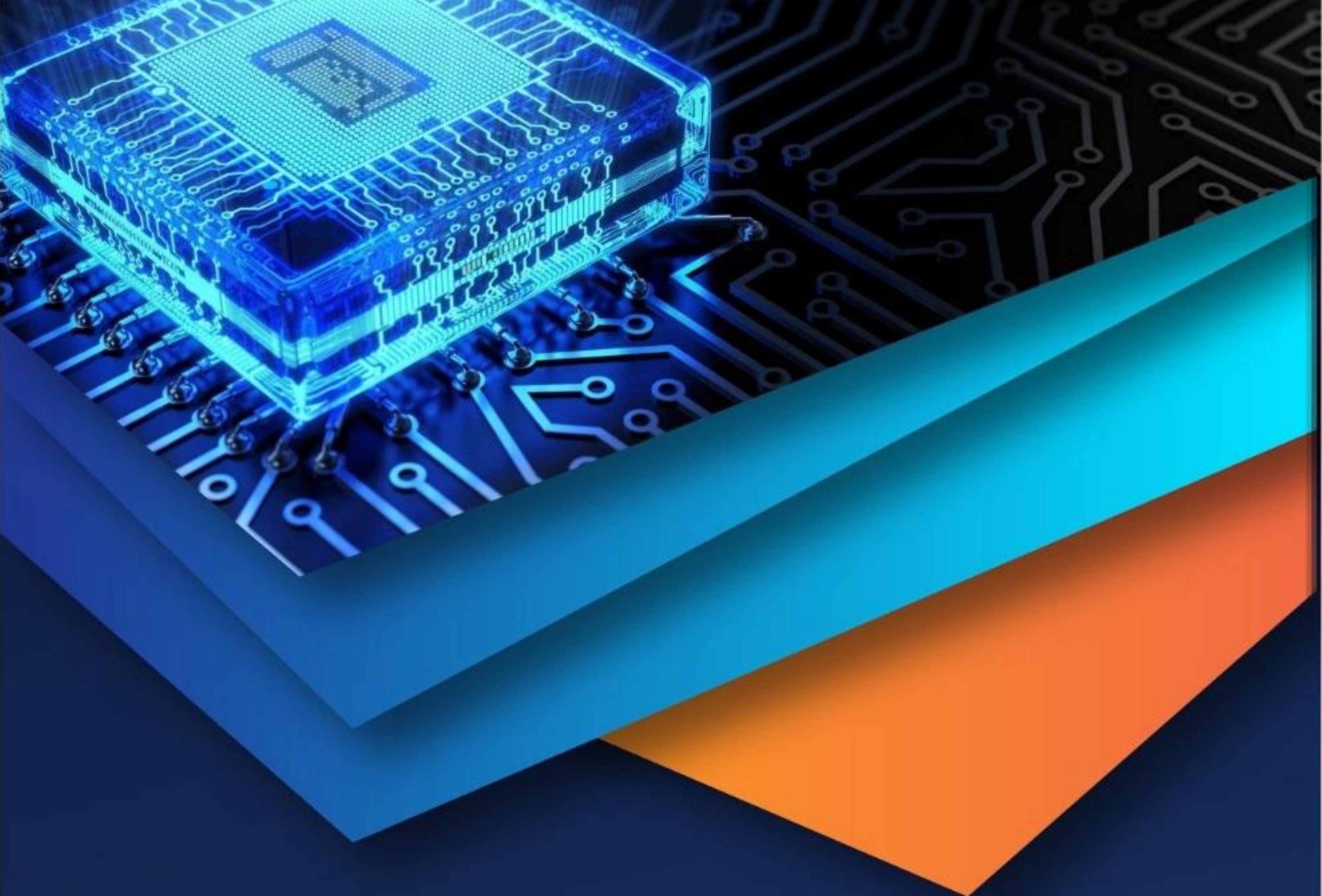

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