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Design and Analysis of Various Baffle System in Shell Tube Heat Exchanger

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Abstract: Heat exchangers are systems of thermal engineering in which its applications are occurred in different industries. Heat exchangers are the basic or heart of once organized plant since it transfers energy to the processing plant Shell and tube heat exchanger is the most common type heat exchanger widely use in refinery and other chemical process, because it suits high pressure application. The process in solving simulation consists of modeling and meshing the basic geometry of shell and tube heat exchanger using CFD package ANSYS 18.0. The objective of the project is design of shell and tube heat exchanger with various baffle structure and study the flow and temperature field inside the shell using ANSYS software tools. The heat exchanger with single, double, and with 10 and 20 degree inclined baffle will be defined. In simulation will show how the pressure varies in shell due to different double baffle angle and flow rate. The flow pattern in the shell side of the heat exchanger with angled baffles was forced to which results in a significant increase in heat transfer coefficient per unit pressure drop in the heat exchanger.

Keywords: Heat exchanger, Baffles, Tube sheet, Shell, Double baffle, Inclined baffles.

I. INTRODUCTION

Shell and tube heat exchangers are used extensively throughout the process industry and as such a basic understanding of their design, construction and performance is important to the practicing engineer. The objective of this paper is to provide a concise review of the key issues involved in their thermal design without having to refer to the extensive literature available on this topic. The optimum thermal design of a shell and tube heat exchanger involves the consideration of many interacting design parameters which can be summarized as follows: Process fluid assignments to shell side or tube side. Selection of stream temperature specifications. Setting shell side and tube side pressure drop design limits. Setting shell side and tube side velocity limits. Selection of heat transfer models and fouling coefficients for shell side and tube side. Mechanical Selection of heat exchanger TEMA layout and number of passes. Specification of tube parameters - size, layout, pitch and material. Setting upper and lower design limits on tube length. Specification of shell side parameters materials, baffle cut, baffle spacing and clearances. Setting upper and lower design limits on shell diameter, baffle cut and baffles spacing. There are several software design and rating packages available, including A spenBJAC, HTFS and CC-THERM, which enable the designer to study the effects of the many interacting design parameters and achieve an optimum thermal design. These packages are supported by extensive component physical property databases and thermodynamic models. It must be stressed that software convergence and optimization routines will not necessarily achieve a practical and economic design without the designer forcing parameters in an intuitive way. It is recommended that the design be checked by running the model in the rating mode. Detailed mechanical design and construction involving tube sheet layouts, thicknesses, clearances, tube supports and thermal expansion are not considered but the thermal design must be consistent with the practical requirements**.**

II. LITERATURE SURVEY

Thirumarimurugan, T.Kannadasan and E.Ramasamy [1] have investigated heat transfer study on a solvent and solution by using Shell and Tube Heat Exchanger. In which Steam is taken as the hot fluid and Water and acetic acid-Water miscible solution taken as cold fluid. A series of runs were made between steam and water, steam and Acetic acid solution .The flow rate of the cold fluid is maintained from 120 to 720 lph and the volume fraction of Acetic acid is varied from 10- 50%. Experimental results such as exchanger effectiveness, overall heat transfer coefficients were calculated. . MATLAB program was used to simulate a mathematical model for the outlet temperatures of both the Shell and Tube side fluids. The effect of different cold side flow rates and different compositions of cold fluid on the shell outlet temperature, tube outlet temperature and overall heat transfer coefficients were studied.

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Usman Ur Rahman [2] had investigated an un-baffled shell-and-tube heat exchanger design with respect to heat transfer coefficient and pressure drop by numerically modelling. The heat exchanger contained 19 tubes inside a 5.85m long and 108mm diameter shell. For this reason, Realizable k – ε model is used with standard and then Non-equilibrium wall functions.Thus in order to avoid this and to include the low Reynolds Jian-Fei Zhang, YaLing He, Wen-Quan Tao [3] developed a method for design and rating of shell-andtube heat exchanger with helical baffles based on the public literatures and the widely used Bell–Delaware method for shell-and-tube heat exchanger with segmental baffles (STHXSB). The accuracy of present method is validated with experimental data. Four design cases of replacing original STHXsSB by STHXsHB are taken. And comparison result shows that all shell and tube heat exchanger with helical baffles have better performance than the original heat exchanger with segmental baffles. Muhammad Mahmoud Salam Bhutta, Nasir Hayat, Muhammad Hassan Bashir, AhmerRaisKhan,KanwarNaveed Ahmad, SarfarazKhani[4] , It focuses on the applications of Computational Fluid Dynamics (CFD) in the field of heat exchangers. It has been found that CFD employed for the fluid flow mal-distribution, fouling, pressure drop and thermal analysis in the design and optimization phase. Different turbulence models such as standard, realizable and RNG, k – ε, RSM, and SST k - ε with velocity-pressure coupling schemes such as SIMPLE, SIMPLEC, PISO and etc. have been adopted to carry out the simulationsThe simulations results ranging from 2% to 10% with the 23 experimental studies. In some exceptional cases, it varies to 36%. ŽarkoStevanović, GradimirIlić, NenadRadojković, MićaVukić, VelimirStefanovićand GoranVučković [5] has developed an iterative procedure for sizing shelland-tube heat Exchangers according to given pressure drop and the thermo-hydraulic calculation and the geometric optimization on the basis of CFD technique have been carried out. A numerical study of threedimensional fluid flow and heat transfer is described. The baffle and tube bundle was modelled by the 'porous media' concept. Three turbulent models were used for the flow processes. Ender Ozden, Ilker Tari. [6] Has investigated the design of shell and tube heat exchanger by numerically modeling in particular the baffle spacing, baffle cut and shell diameter dependencies of heat transfer coefficient and pressure drop. The flow and temperature fields are resolved by using a commercial CFD package and it is performed for a single shell and single tube pass heat exchanger with a variable number of baffles and turbulent flow. It is observed that the CFD simulation results are very good with the Bell-Delaware methods and the differences between Bell-Delaware method and CFD simulations results of total heat transfer rate are below 2% for most of the cases.

III. NUMERICAL METHODOLOGY

Numerical methods, is approximation fast solution for mathematical problems. Such problems can be in any field in engineering. So any result you get from it is approximated not exact, it give you the solution faster than normal ones, also it's easy to be programmed. Here is some issues that numerical analysis is used in: Solving linear/non-linear equations and finding the real roots, many methods exist like: Bisection, Newton-Raphson ... etc. Fit some points to curve, good approximation and simple solution. Interpolation, great to get any value in between a table of values. It can solve the equally spaced readings for unequally spaced methods, Newton general method is implied. Solve definite integration, simple methods is used to compute an integration based on idea that the definite integration is the bounded area by the given curve, these methods approximate the area with great approximation. Many methods there, like Simpson's rule. Solving initial value 1st and 2nd order differential equations, good approximation and simpler than normal analysis. Solving partial differential equations like laplace equation for wave equation, very fast solution.

IV. MODELING AND ANALYSIS

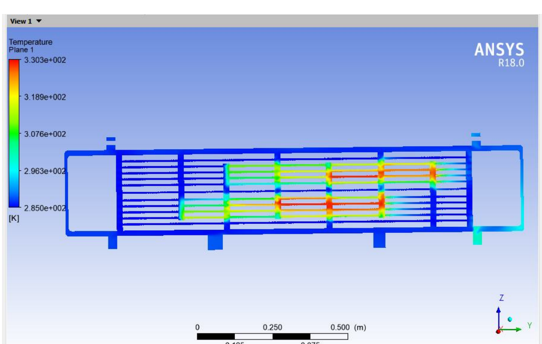

Fig 1: single baffle temperature.

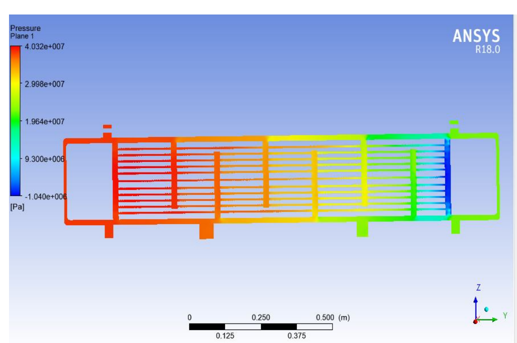

Fig 2: Single baffle pressure

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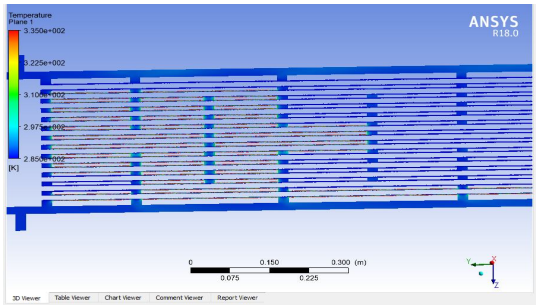


Fig: Double baffle Temperature

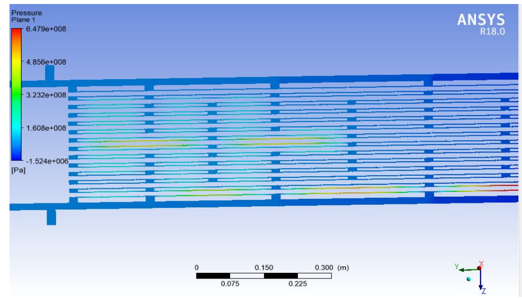


Fig: Double baffle Pressure

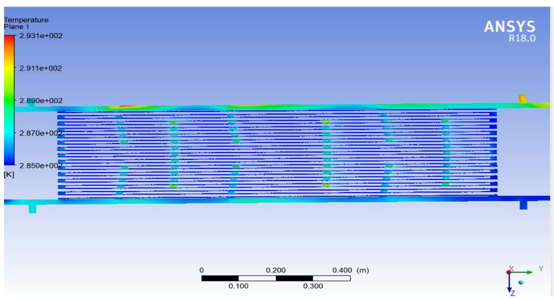


Fig: Double baffle with 10 degree temperature

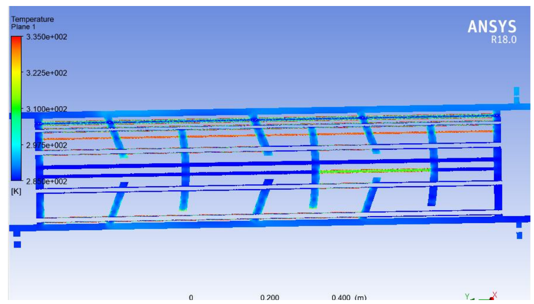


Fig: Double baffle with 20 degree temperature

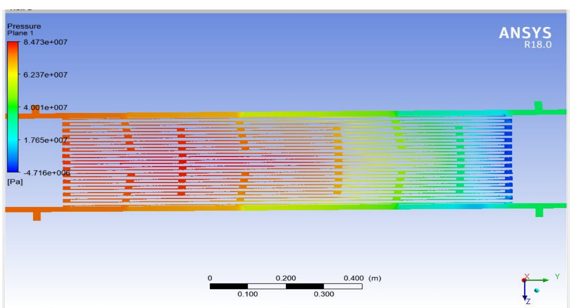


Fig: Double baffle with 10 degree pressure

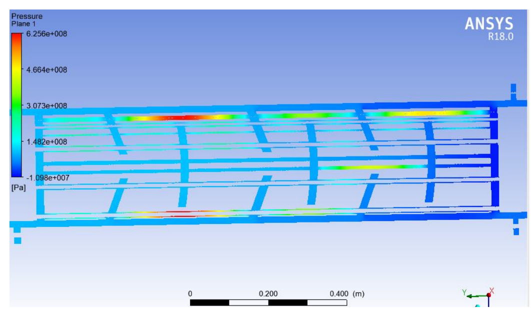
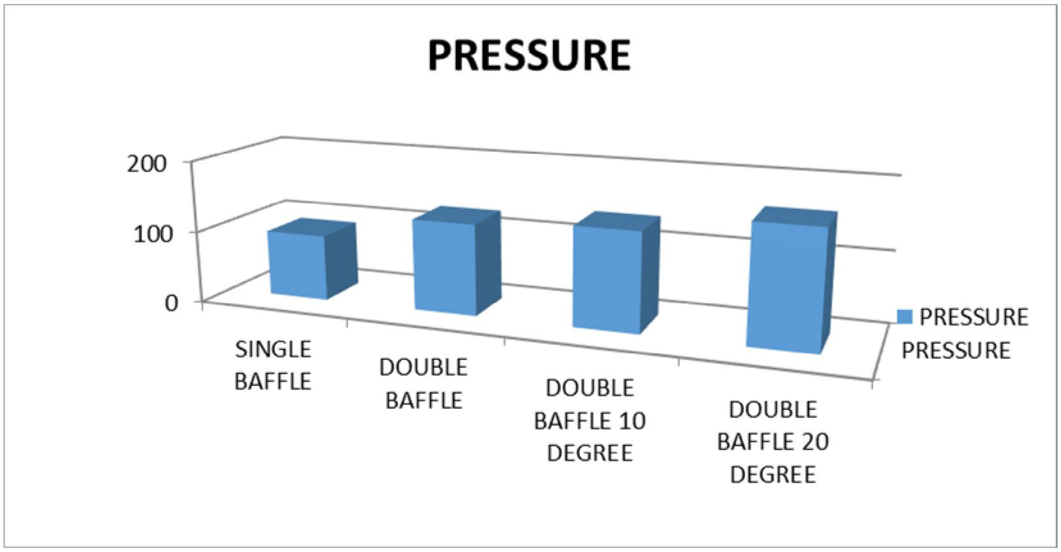


Fig: Double baffle with 20 degree pressure

V. RESULTS

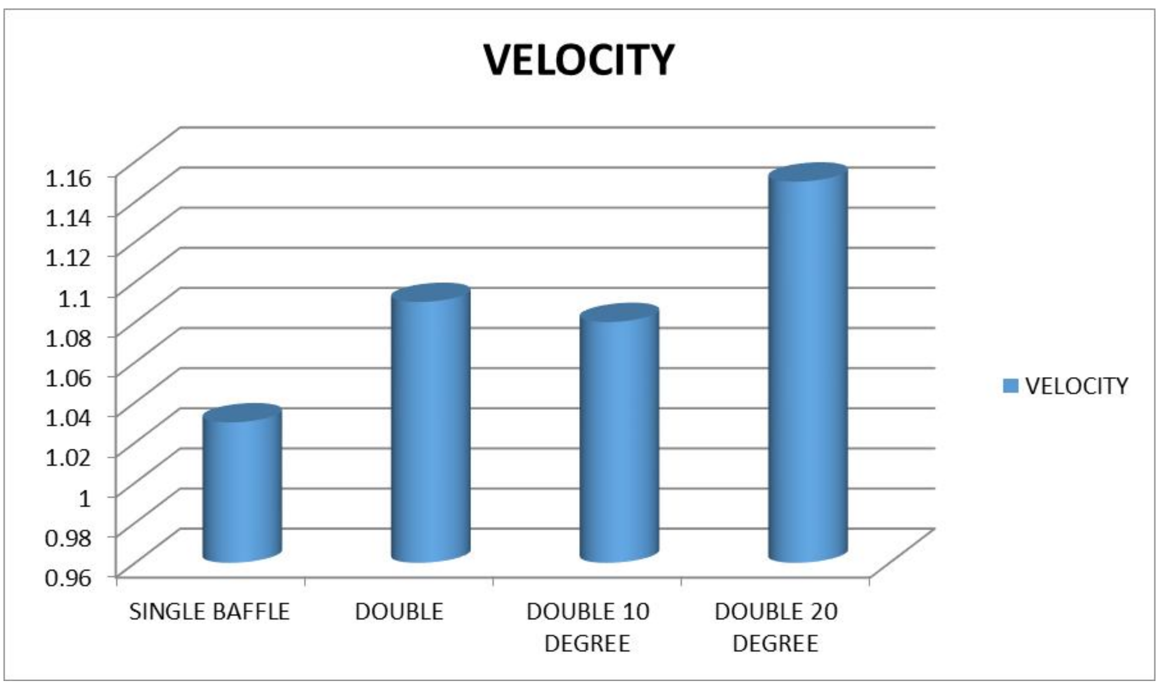
S.NO	BAFFLE	NET PRESSURE (MPa)
1	SINGLE	92
2	DOUBLE	127
3	DOUBLE 10^0	137
4	DOUBLE 20^0	161

Table: Pressure



S.NO	BAFFLE	NET VELOCITY (m/s)
1	SINGLE	1.03
2	DOUBLE	1.09
3	DOUBLE 10^0	1.08
4	DOUBLE 20^0	1.15

Table: velocity



S.NO	BAFFLE	NET TEMPERATURE K
1	SINGLE	303
2	DOUBLE	300
3	DOUBLE 10^0	298
4	DOUBLE 20^0	303

Table: Temperature

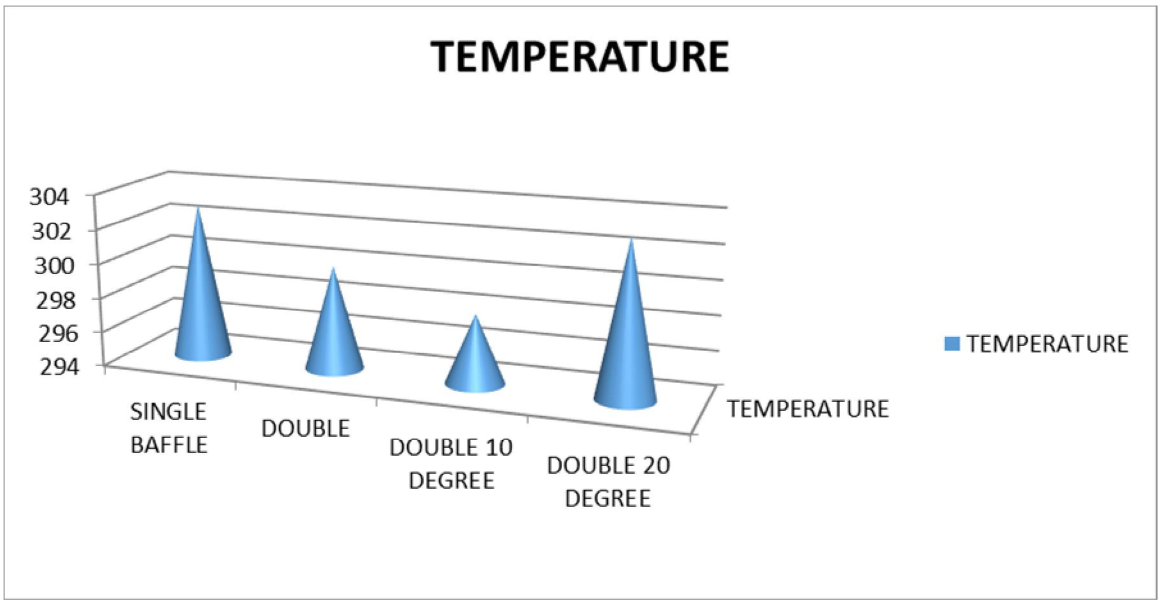


Fig : Temperature

VI. CONCLUSION

From the above study, a computational model is used to compute and compare the performance of the shell side of an STE. Shell side performance is resolved by altering the BAFFLE design parameters. The shell side computations are case sensitive to the low-pressure details; Usage of baffles in the shell side increases the overall heat transfer coefficient in two cases. While examining the turbulent intensity contours, it is seen that the turbulent intensity has higher degree of variation while using segmented baffles. This effect made the heat transfer more efficient. So for single and double baffle with 20 degree Shell and Tube Heat Exchanger is recommended.

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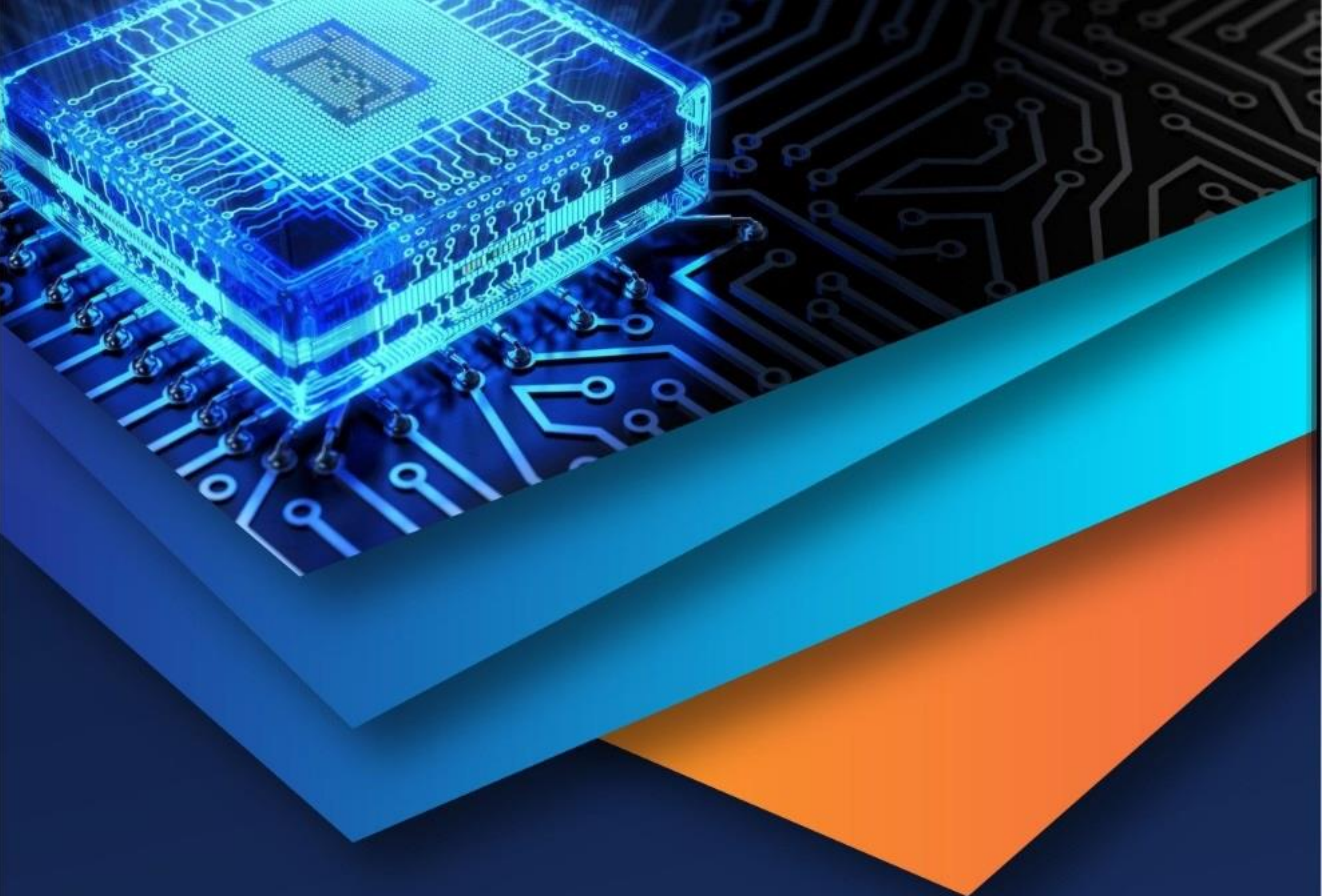

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