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Numerical Investigation of Heat Transfer Enhancement on Hybrid Fluids

S Gangadhar[1], Dr. V. Sridhar Patnaik[2], K. Ravindra[3], U. S. Ramakanth[4]
[1, 2, 3]M. Tech, Student, Department of Mechanical Engineering,#Visakha Technical Campus, Vizag, AP
[4]Associate Professor, Lendi Institute of Engineering and Technology, Vizianagaram, AP

Abstract: This thesis presents a numerical investigation of heat transfer enhancement of low volume concentration of Carbon Nanotube - Fe3O4/Water Hybrid Nanofluids in a tube with Passive augmentation methods. Heat exchangers with twisted tape inserts of H/D = 10 have been investigated Several attempts were done in this work for particle volume concentrations of 0.1% and 0.3% using CFD software.

3D numerical simulations were performed for fluid flow and heat transfer using 3ddp steady state with k-ε turbulence model with Realizable for turbulent regime. The results indicate that a maximum0of 28.5% enhancement in Nusselt number was observed for particle concentration of 0.3% at a Reynolds number of 22,000 as compared to base fluid data. The Nusselt number is further enhanced to 32.37% for 0.3% nanofluid flow through a tube with twisted tape of H/D = 10 at a Reynolds number of 22,000 compared to base fluid data and results are validated with the experimental data available in literature.

Keywords: Heat Transfer, Reynolds number, Nanofluid, Hybrid Nanofluids, CFD

I. INTRODUCTION

Space management is a major concern of any industry. It indirectly affects the cost and performance of the system. For this reason, an attempt was made to reduce the size of the current devices without affecting the operating conditions. In connection with various engineering applications such as chemical processing industry, nuclear reactors, power plants, automobile cooling systems, etc., there is a great need to improve the heat transfer rate. The main idea behind this is to adjust the flow pattern to transfer and dissipate maximum heat. This can be achieved by creating a break in the liquid flow by combining multiple inlets in the form of obstacles without significantly affecting the pressure drop. The creation of secondary vortex fusion recycling improved radial and tangential fluctuations in turbulence intensity, resulting in reduced boundary layer thickness and increased mixing of fluid within the heat exchanger tubes. The inlets partially block the liquid and give the nano particle enough time to absorb heat, improving heat transfer.

Kuhn and Rohr [1] have studied to direct the mixed convection of a heated undulating surface. The channel flow between the sinusoidal surface and a flat top wall is examined with a combined method of DPIV and PLIF to study the spatial changes with white flow space components and normal wall velocity and evaluate the Conc a Tracer dye field injected into the liquid. They found that the presence of the wavy surface further improved the transport properties compared to the mixed convection of a flat plate. Amador et al. [2] found that better heat transfer can be achieved without the need for higher volume flows in the turbulent fluid, where much more pumping power is required. When the asymmetrical wall duct is operated in an appropriate Reynolds number range, a substantial improvement in heat transfer is noted. Sui et al. [3] examined heat transfer and laminar fluid flow in 3D corrugated micro channels. It can be seen that the position and quantity of the eddies can vary along the flow direction, resulting in disorganized advection, thus the mixing of the convective fluid and thus the heat transfer performance of the micro channels can be greatly improved same cross section that crimping works best with.

Lee et al. [4], observed in their fully developed flow experiment, and heat transfer in intermittent wavy channels with rectangular cross-sectional areas is considered using direct numerical reproduction to extend Reynolds numbers from unchanged laminar flow administrations to administrations of Transition. It has been found that due to effective mixing in corrugated channels, the heat exchange performance is fundamentally better than that of straight channels with the same transverse segments; meanwhile, the disadvantage of pressure drops in corrugated conduit can be much less than improving heat transfer. Ramagadia and Saha [5] numerically simulated fluid flow and heat transfer through a sinusoidal channel with a surface area described by a sinusoidal function. Finally, the heat production at a Reynolds number of 600 was examined for different geometries. It is observed that the pressure drop penalties suffered by the corrugated wall geometries decrease with a fixed L / a ratio in the wave amplitude. The heat transfer through the geometry of a corrugated wall is always greater than the configuration of parallel plates. Naphon [6] presented the numerical results of the flow and temperature distributions in the channel with corrugated sheets of different geometries. The effects of relevant parameters on flow and temperature structures are also considered. It can be said that the sharp edge of the corrugated sheet has a significant effect on improving heat transfer, especially of the V-shaped corrugated sheet. Therefore, the use of corrugated sheet is a suitable method to increase the heat production and greater compactness of the heat exchanger.

Mohammad et al. [7] the water flow and heat transfer properties were numerically investigated in a rectangular corrugated channel micro channel heat sink (WMCHS) with various wave amplitudes in the range from 125 to 500 µm. This study covers the Reynolds number in the range from 100 to 1000. The water flow field and heat transfer phenomena in heated corrugated micro channels are simulated and the results compared with straight micro channels. This article reports on the effects of using a corrugated flow channel on MCHS thermal performance, pressure drop, friction factor, and wall shear stress. The heat transfer performance of the corrugated micro channels was much better than that of straight micro channels with the same cross section. Nandi and Chattopadhyay [8] numerically investigated the simultaneously developing unstable laminar fluid flow and heat transfer within a two-dimensional structure corrugated micro channel due to the speed component, which changes sinusoid ally at the input. The flow developed both thermally and hydro dynamically while the walls of the channel were kept at a uniform temperature. The simulation was carried out in the laminar range for Prandtl number 7 and Reynolds number in a range from 0.1 to 100. Based on the comparison with the constant flow in the corrugated duct, it was found that the sinusoidal velocity imposed at the entrance can provide better heat transfer performance at different amplitudes (0.2, 0.5, 0.8) and frequencies (1, 5, 10).

Kuhn et al. [9] numerically studied the mixed convective water flow on a heated wave surface in a range of Reynolds and Richardson numbers, including transient and turbulent flow regimes. The integral heat transfer for the corrugated wall configuration is significantly improved (approximately 2.5 times) for Re = 1000, 2000 compared to the standard configuration for flat horizontal walls. Sui et al. [10] carried out an experimental study of flow friction and heat transfer in sinusoidal microchannels with rectangular cross-sections. The considered microchannels consist of ten identical wave units with an average width of about 205 mm, a depth of 404 mm, a wave length of 2.5 mm and a wave length of 0 to 259 mm. Each sample is made of copper and contains 60-62 parallel corrugated microchannels. Deionized water is used as the working medium and the Reynolds numbers taken into account are between approximately 300 and 800. The experimental results, mainly the Nusselt number and the general friction factor, for corrugated microchannels are compared with those for linear channels. straight lines with the same cross-section and the same profile length. It has been found that the heat transfer performance of today's corrugated microchannels is much better than that of basic linear microchannels. At the same time, the pressure drop penalty of today's corrugated microchannels can be much less than the increase in heat transfer. Earlier studies [11-14] on turbulent flow properties and heat transfer performance in square grooved channels Different cylindrical shapes are analyzed and numerically compared in your research. The new groove geometries are conventional cylindrical grooves with smooth transitions to adjacent flat surfaces and with modifications to their bases. The aim of this thesis is to determine the optimal settings to increase heat transfer rates with minimal pressure drop penalties. This research shows that conventional cylindrical grooves have an overall improvement in heat transfer similar to conventional square fins, but the pressure loss is very small compared to square fins. The smooth transition of the grooves has a great advantage over conventional cylindrical groove surfaces, both in terms of improving the heat transfer and reducing the pressure loss.

II. HEAT TRANSFER AND ENHANCEMENT TECHNIQUES

The study of the transformation phenomenon, in which moment, energy, mass, etc. are transferred, has been identified as a unified system of fundamental importance that depends on currents and thermodynamic forces. The transmission of these phenomena is caused by the force associated with the temperature gradient, velocity gradient, concentration gradient, chemical affinity, etc. The transfer of thermal energy due to the temperature or gradient difference is called heat transfer. Reynolds number the dimensionless speed is defined by the relationship between the dynamic pressure (ρ u2) and the shear stress (μ u / L).

$$R_e = \rho u L / \mu$$

For heat transfer across a boundary (surface) within a fluid, the Neselt number is the ratio of heat transfer through charge to conductivity across (natural) boundaries. In this context, convection encompasses both adduction and conduction. It's a dimensionless number. The conductive component is measured under the same conditions as convection, but with fluid (or stationary) in motion (or stationary).

$$\mathrm{Nu}_L = \frac{hL}{k_f}$$

The Prandtl number is a dimensionless number; the ratio of momentum diffusivity (kinematic viscosity) to thermal diffusivity.

$$P_r = V / \alpha$$

The Grashof number is a dimensionless number in fluid dynamics and heat transfer that approximates the relationship between buoyancy and viscous force acting on a liquid. It often arises in the study of cases involving natural convection.

$$\mathrm{Gr}_L = \frac{g\beta(T_s - T_\infty)L^3}{\nu^2} \quad \text{for vertical flat plates}$$

$$\mathrm{Gr}_D = \frac{g\beta(T_s - T_\infty)D^3}{\nu^2} \quad \text{for pipes}$$

$$\mathrm{Gr}_D = \frac{g\beta(T_s - T_\infty)D^3}{\nu^2} \quad \text{for bluff bodies}$$

RAYLEIGH (Ra): defined as the product of the Grashof number, which describes the relationship between the buoyancy and viscosity of a liquid, and the Prandtl number, which describes the relationship between momentum and heat diffusion. Therefore, the same Rayleigh number can also be seen as the ratio of buoyancy to viscosity multiplied by the ratio of moment to heat diffusion.

$$\mathrm{Ra}_x = \mathrm{Gr}_x \mathrm{Pr} = \frac{g\beta}{\nu\alpha}(T_s - T_\infty)x^3$$

III. PROBLEM DESCRIPTION AND METHODOLOGY

The engineering consists of a cylinder with an internal diameter of 14 mm, an outer diameter of 16 mm, a length of 1750 mm with a twisted strip of a width of 13 mm and a thickness of 1 mm. The arithmetic field is divided into two areas, the solid and the fluid. Arithmetic range combined with tetrahedral elements using ANSYS ICEM. 3D grid model for basic heat exchanger with 1.6 million mesh H / D = 10 twisted spiral heat exchangers with network number of 4.2 million. Respectively to capture the effect near the wall, the prism layers were created as shown in Figure 1.1. To solve the boundary layers, the wall was preserved and + for all cases under 5. An independent study The network was also implemented and determined that the solution did not change with the highest number of grids.

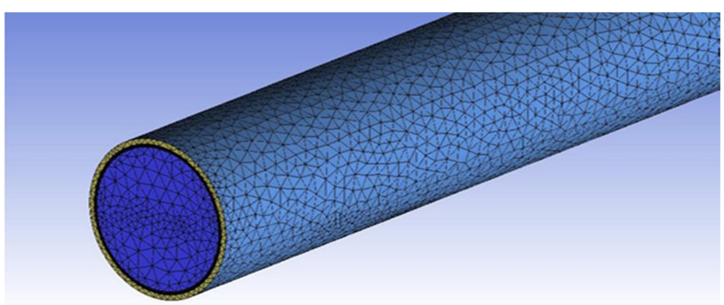

Figure 1.1 Zoomed view of mesh heat exchanger.

The terms in the arithmetic field are divided into one of two categories, namely solid or liquid. The cu thickness section is a solid part in which the thermal reaction takes place between the nichrome heater and cold water. The water inlet (speed inlet) and the water outlet (outlet) each of these limits are now considered in turn. The speed of the inlet from which water is introduced is determined with an initial temperature of 200 ° C, which is taken into account from the experimental data. The flow in the outlet is considered to be the remaining surfaces as walls in the case of twisted strip, the entry is considered as another solid field 0 and the surfaces are kept as a wall that interacts with the adjacent liquid field 0 Induction. 3D digital simulation was performed using commercial software. With the standard k-standard turbulence model with Achievable, it is considered with the second degree wind chart available in the trading program for all accounts. The SIMPLE chart is used for pressure-speed pairing for all accounts.

IV. NUSSELT NUMBER OF NANOFLUID IN A TUBE WITH TWISTED TAPE INSERTS.

In order to improve the additional heat transfer of the working fluid, twisted strip inserts with a torsion ratio (H / D = 10) were placed. The number of Noselt nano particles was estimated from the equation. (7) It is mentioned in Figure 4.5. The numerical data for 0.3% of the nano fluids from Fe3O4 carbon nano tubes are shown with twisted strip inserts H / D = 10 inFigure 4.5 Comparison with data from Sundar et al. [7] Fe3O4 nano-liquids in tube inserted with twisted strip. It was observed that Sundar et al. [7] From experimental data under the prediction of the same concentration 0 Reynolds number and rotor insertion this occurs due to carbon nano tubes in the nanofluorocarbon-Fe3O4 and the knowledge that heat transfer from nano composites is better than the thermal transfer of individual nano particles 0 while flowing into a tube With inserts. From experimental water data, different concentrations of Fe3O4 carbon nano tubes were proposed in a tube with twisted strip inserts to connect the Nusselt number and expression in the equation. 8. Show clearly from Figure 1.2 and 1.3 total pressure drop and velocity vectors of different cases. That you find this the profile obtained with the results of the CFD showed good compatibility with L. Syam Sundar et.al, [8] numeric data. From Figure 4.3 it can be seen that the number of Nestlett increases with increasing concentrations of volume and Reynolds numbers, but the torsion ratio decreases. Nano fluorine appears in a tube with twisted strip entries Nusselt number higher compared to the water in the tube, the reason is that twisted strip inserts generate a vortex flow inside the fluid path leading to better fluid mixing and a thinner heat boundary layer along the wall of the Nano fluid tube at a concentration of 0.3 volume % In the tube By inserting a rotating tape H / D = 10, the number of Neselt increased by 30.176% and 32.3768% for the number of Reynolds 6000 and 22,000 compared to the water in the tube.

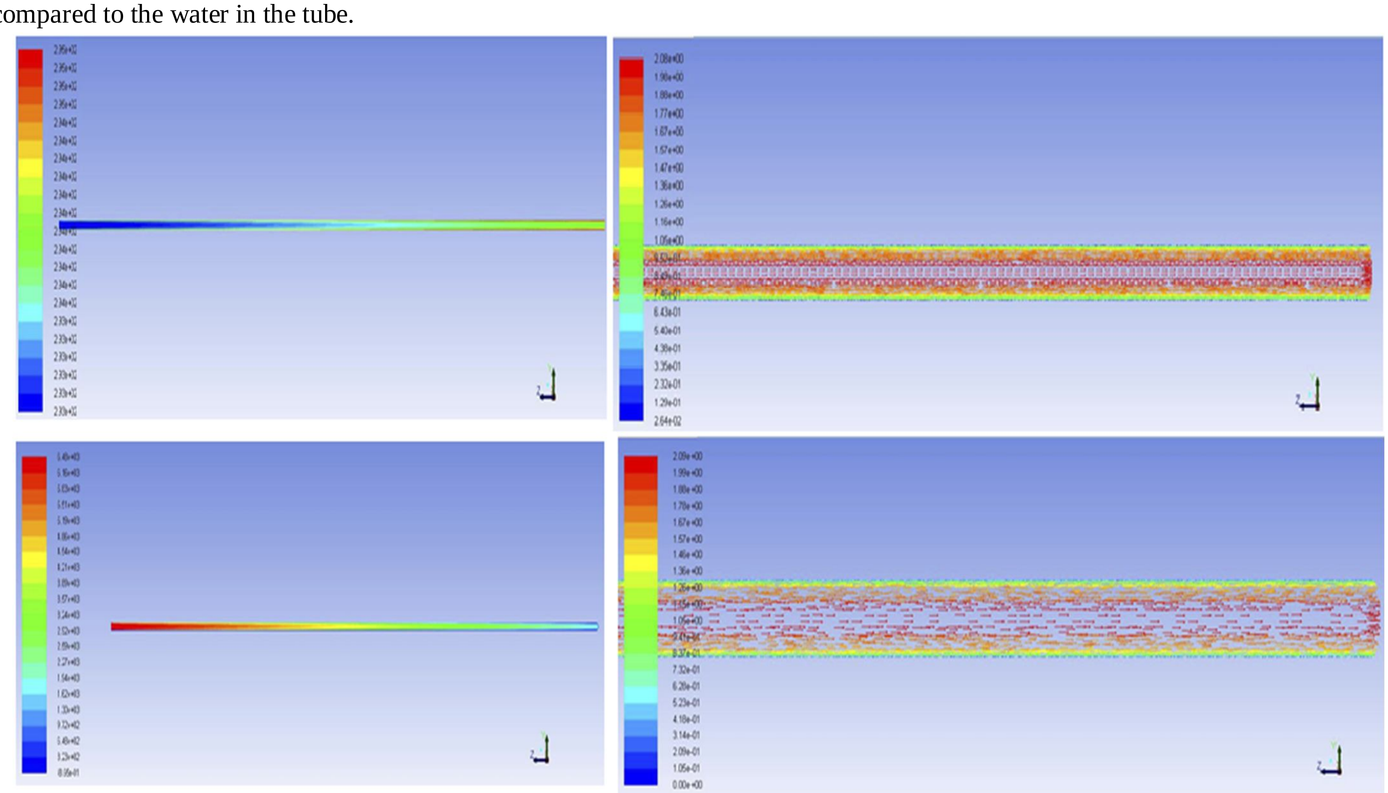

Figure 1.2Total Pressure dropand velocity vectors contours

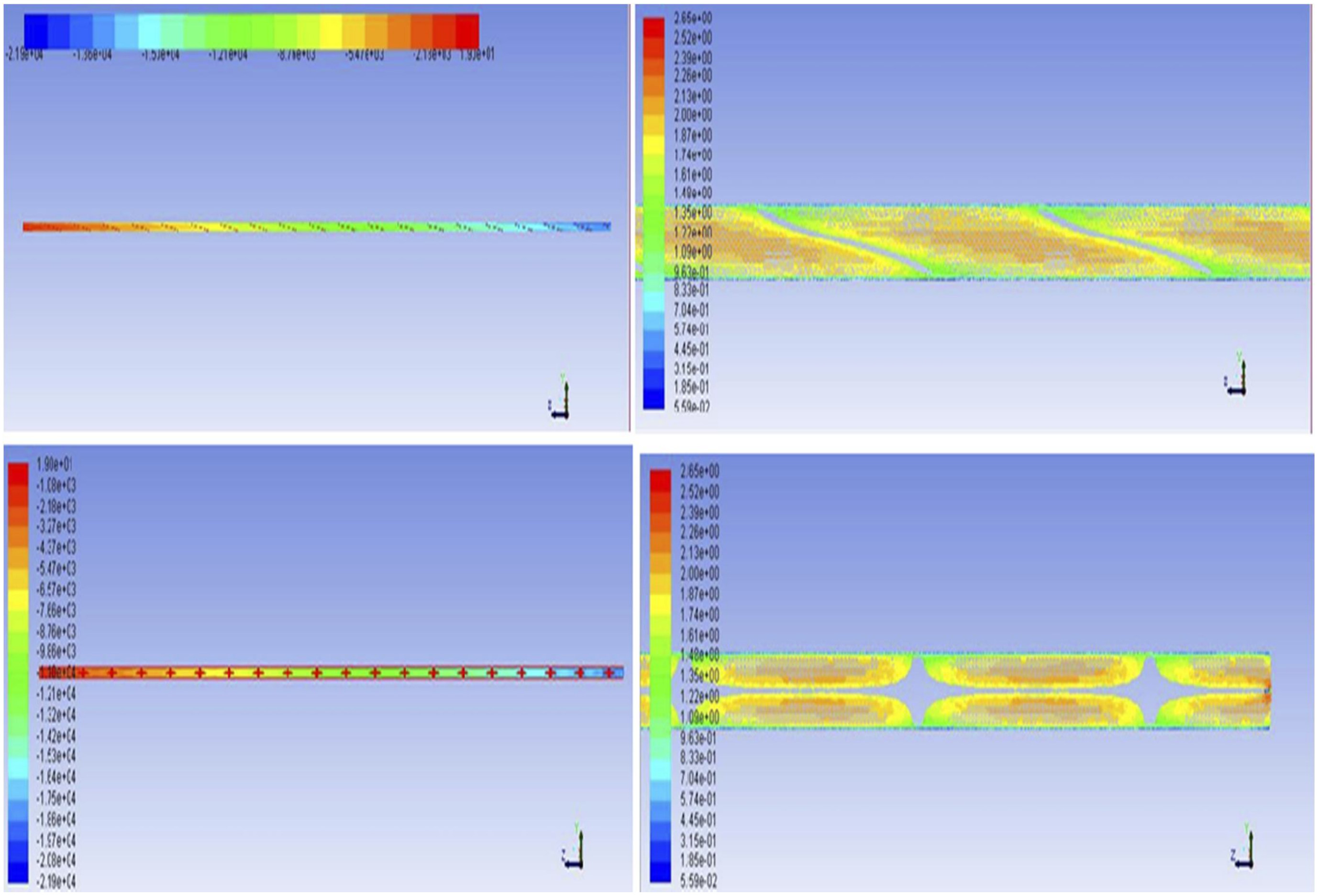

Figure 1.3 Total Pressure dropand velocity vectors contours

Various heat optimization techniques have been identified for single tube heat exchangers. Numerical simulation is carried out by building engineering with solid and meshwork with ICEMCFD and solved using ANSYS FLUENT for core copper tube heat exchangers with passive reinforcement techniques. All engineering dimensions are according to ISO standards. Simulation was performed using the ANSYS FLUENT academic edition on various Reynolds numbers ranging from 6000 to 22000. A network independence study was conducted and it was determined that the solution did not change with the highest number of networks.

V. CONCLUSION AND FUTURE WORK

The results showed that the improvement in the Nusselt number for 0.1% of nano-floyd is 8.2% and 18.98%, and 0.3% of nano-fluid is 14.91% and 28.5%, in Reynolds numbers 6000 and 22000 respectively for the copper core tubes. The thermal performance of nano fluids based on a superior hybrid compound compared to mono-nano particles such as aluminum oxide and Fe_3O_4.Negative reinforcement techniques worked well and noted that the nano fluid with a concentration of 0.3% in a tube with the inclusion of a rotating tape H / D = 10, the number of Neselt increased by 30.17% and 32.37% to number 6000 and 22,000 Reynolds compared to the water in the tube.The results of the analysis were validated with the experimental results and the results showed good agreement with CFD with maximum difference in the order by 7%.

Experiments can be extended at higher particle concentrations to measure heat transfer coefficients. The variance in the nanomatic / aqueous fluid stability may also be studied with increasing particle concentration. Carbon Nano tubes (CNT) have very high thermal conductivity, i.e. about 3100 W / (mk). Therefore, nano fluorine / nano particles with different surfactants can be studied at different concentrations of particles. Limited work has been reported in nano-fluid cooling applications using carbon nanotubes (CNT). Experiments can also be extended to different basic fluids, for example transformer oil, ethylene glycol, etc to investigate the heat transfer properties.

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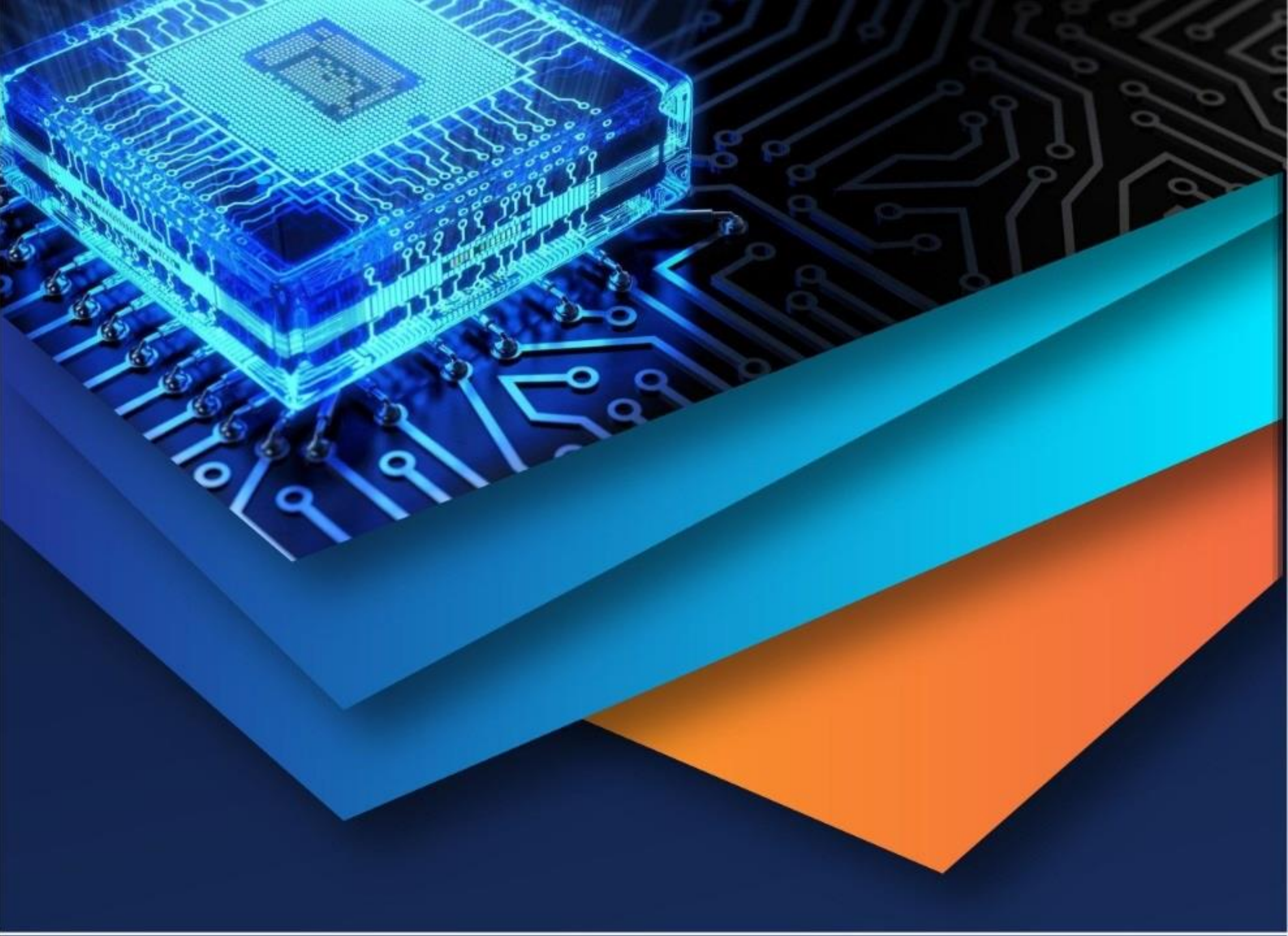

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