iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** V **Month of publication:** May 2020

DOI: http://doi.org/10.22214/ijraset.2020.5250

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Review on Enhancement of Radiator Efficiency using Nanotechnology

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Abstract: ***The main function of a radiator in an automobile is to cool it's engine. This cooling action is executed by radiator via cooling fluid, which we know as coolant. This coolant is responsible for heat dissipation from the internal combustion engines to outside of the vehicle. But this is what the problem is- "coolant"- the coolants which are used nowadays have comparatively lower thermal conductivity and it leads to overheating of vehicles, which ultimately facilitates subsequent operational and environmental problems. We know the modus operandi of convection heat transfer which is used to cool the circulating fluid which is a mixture of water and anti-freezing material like Ethylene Glycol with some additives. This is where improving the heat transfer characteristics of coolant is obligatory and we propose the use of novel heat transfer fluid called 'Nanofluid' which incorporates the use of Nanoparticles in preparation of coolant. This paper reviews the use of Al_2O_3 based nanofluid prepared my combination of several methods studied through extensive research and various researchers predict that it exhibits better heat transfer capability to that of normal coolant. This nanofluid improves the effectiveness of a radiator and facilitates in increased heat dissipation out of the vehicle.***

Keywords: ***Al_2O_3 Nanofluid, Coolant, Radiator, Heat Dissipation, Effectiveness, Nanotechnology***

I. INTRODUCTION

Al_2O_3 based Nanofluids are a relatively new type of fluids which involves a base fluid with nanosized particles suspended inside them. These nanoparticles or metal oxide, increase conduction and convection coefficients, allowing for more heat dissipation out of the coolant. While reviewing the literature related to this topic we witnessed that there has been many developments recently which have made the nanofluids more stable to be used as coolant. Notably in past ten we have witnessed substantial growth in research on nanofluids. In this review, papers listed in reputed national and international journals are only considered. The following study initiate to be captivated on fusion, preparation, characterization and flexibility of diverse nanofluids to various industrial and commercial applications. Various papers published in the past period of ten years belong to nanofluids and we observed that this publication rate should be of intense interest among the scientific community on the nanofluids research. We have put an effort to combine the research accessible in this topic on usage of nanofluids in radiator to improve its heat transfer capability, and recognized experiments that offer concentrated viewpoint on this topic and for its future activities in research on nanofluid. Important topic from few literature are gathered into segments and put forth in tabular format for better comprehension.

II. LITERATURE REVIEW

Sr. No	Title Of Paper	Conclusion
1	Performance Analysis And Design Of Automobile Radiator (2017)	Aluminum is most common material used in manufacturing of radiator. Aluminum decreases the overall weight of radiator. There are many advantage of circular cross section of radiator like increased heat transfer of fluid to surrounding, also the circular cross section has fewer perimeters. Various cross section like rectangular have problem of stress concentration while it is eliminate in circular cross section tubed radiator. Manufacturing of circular shape is easy. Material requirement for circular tubed cross section radiator is less and thus the overall cost of product decreases.
2	Design And Analysis Of Radiator (2017)	In this paper comparison between Aluminum and Copper alloy radiator model is carried out. The copper radiator has higher temperate drop than aluminum radiator. But the Aluminum radiator is much economical than copper radiator. Aluminum radiator model is better for low cost & low weight and exhibit better corrosion resistance.
3	Improving The Cooling Performance Of Automobile Radiator With Al2O3/Water Nanofluid (2011)	In this paper pure water and water based Nanofluid coolant are used in automobile radiator for measuring heat transfer coefficient at different concentration and temperature. Nanofluid has better thermo physical properties & higher thermal conductivity so higher heat transfer coefficient, and by using nanofluid because of this radiator of reduced size can be used for same amount of heat removal which ultimately responsible for better car performance and increased fuel economy. The higher % of particle of $Al2O3$ in water can increase the heat transfer rate of automobile radiator.
4	Experimental Investigation Of Cooling Performance Of An Automobile Radiator Using Al2o3-Water+Ethylene Glycol Nan fluid (2015)	This paper highlights the two step method used for preparation of nanofluid- Al_2O_3-Water+Ethylene Glycol prepared by two step method. In two step method 10.5litres of distilled water mixed with 4.5 liters of ethylene glycol and it is used as based fluid. Oscar ultra sonicator is used for preparation of nanofluid. Al_2O_3 nanoparticle in water+ethylene glycol base solution increase the heat transfer rate of radiator. The degree of heat transfer increases depends on the amount of nano particle mixed with the water+ethylene glycol.
5	A Comparative Study On Thermal Conductivity Of Al2o3/Water, Coo/Water And Al2o3 – Cuo/Water Nanofluids (2015)	CuO/water & Al_2O_3/water have better thermophysical properties. CuO has higher density & thermal conductivity than Al_2O_3. But CuO was not concluded as economical alternative. Percentage volume concentration formula given in this paper. $$\%\ \text{Volume Concentration}(\varphi) = \left[\frac{\frac{W_{nanopartile}}{\rho_{nanopartile}}}{\frac{W_{nanoaprtile}}{\rho_{nanopartile}} + \frac{W_{water}}{\rho_{water}}} \right] X100$$

		Different volume concentration is used to calculate thermal conductivity of nanofluids. Thermal conductivity varies with temperature and volume concentration was studied.
6	Investigation on Physical Properties of Al2O3/Water Nano Fluid (2015)	In this paper we studied different physical properties of Al_2O_3 water nanofluid and experimentally investigated the effective thermal conductivities and viscosity of nanofluid. The equipment called KD2 thermal property analyzer uses to measure thermal conductivity and thermal resistivity. The KD2 analyzer also calculate thermal data and display thermal conductivity in 90 just seconds. It showed the thermal conductivity of Al_2O_3 nanofluids increases with a partial volume concentration & the viscosity of nanofluid depend on volume percentage. The electrical conductivity is higher than best fluids available as coolant.
7	Performance Investigation Of Automobile Radiator Using Al2O3 As Base Nan fluid (2016)	This paper concluded that nanofluid having better heat transfer rate as compare to other coolant. Heat transfer rate increases with the temperature increases. Because of higher heat transfer rate in radiator we can use compact sized radiator for same coolant and this reduced frontal area of automobile and it result in reduced aerodynamic drag and ultimately increase fuel economy.
8	Study Of Heat Transfer Characteristics Of Nano Fluid In An Automotive Radiator (2018)	In this paper detail procedure for preparation of nanofluids is explained. Nanofluid preparation done by two step method, which involve the use of Ultrasonic Sonicator for Mechanical Vibration which tends to dissolve nanoparticle in the base fluid. Followed by Mechanical Exciting to fluid to dissolve the denser particles. And eventually the use of Magnetic Stirrer to obtain a homogeneous mixture of Al_2O_3 nanoparticles with base fluid. By virtue of experimentation the overall heat transfer coefficient, Nusselt number and Reynolds number increase with coolant flow rate which gives higher heat transfer rate compare to base fluids. It is concluded that nanofluid has higher heat transfer properties than other base fluid like water and ethylene glycol and good economy.
9	Experimental Investigation Of Heat Transfer Potential Of Al2O3/ Water-Mono Ethylene Glycol Nanofluids As A Car Radiator Coolant (2018)	Ethylene glycol / water is a normal coolant used in a car radiator. In this paper Al2O3 water–mono ethylene glycol nanofluids is used as a coolant for car radiator. This coolant have higher thermophysical properties than normal coolant. Heat transfer rate increases with concentration of nano particle. It has higher heat transfer rate. By experimentation it is concluded that use of nano fluid provides scope for design of compact radiator size & reduce weight of system because of this the car can possess better aerodynamics at similar rate of heat dissipation.
10	Effect of heat transfer enhancement and NOx emission using Al2O3/ Water Nanofluid as coolant in IC engine	NOx emission from engine reduce to 12.5 % at full load for nanofluid as compared to distilled water based coolant because of the lower overall operating temperature of the IC engine. Overall heat transfer coefficient was increased by 20%, 25% and 29% for Al2O3/water nanofluid with volume concentration of 1%, 1.5% and 2% respectively at Peclet no 3000 compared to those of distilled water coolant at part load.

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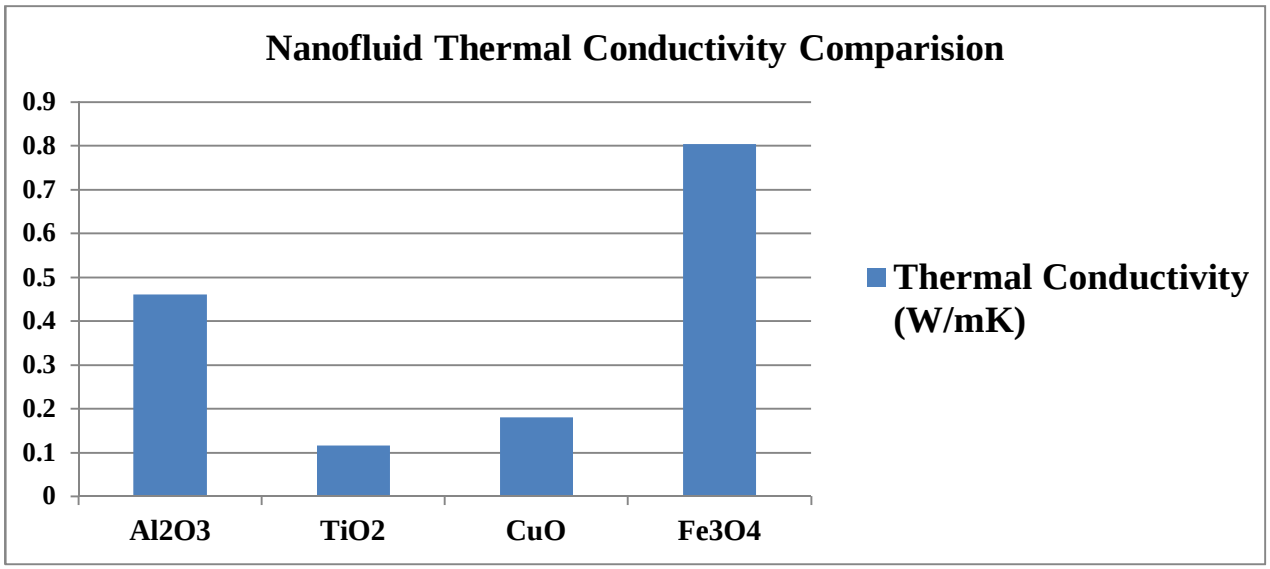
III. NANOFLUID

After comparative study of recent literature we found that Alluminium Oxide - Al_2O_3, is the supreme nanoparticle used by numerous researchers in their research because it possessed better heat transfer capability and economical to use in the long run. Countless efforts have been made to study the thermal conductivities of different Nanofluids and it is summaries in the bar graph[14] below.



Now that we selected the Alluminium Oxide - Al_2O_3 based nanofluid, we observed the literature to study it's Thermophysical properties. Our conclusions are listed in the table 2 below.

Table 1 - Thermophysical properties of Al_2O_3 Nanofluid[10]

Material Water + EG + Al_2O_3 (% conc)	PROPERTIES			
	Density (kg/m3) Specific	Heat Capacity (J/kg K)	Thermal Conductivity (W/m K)	Viscosity (kg/m s)
0.05	1156.10	3461.123	0.668	0.0019
0.15	1452.30	2685.322	0.874	0.0019
0.3	1896.60	1975.971	1.287	0.0019

Generally thermal conductivity of the nanofluids increases with increasing volume fraction of nanoparticles; with decreasing particle size, the shape of particles can also influence the thermal conductivity of nanofluids.

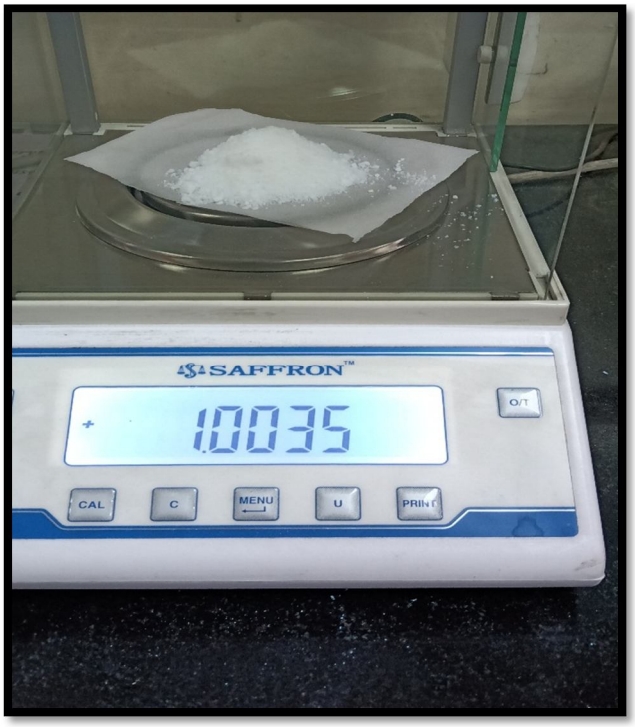
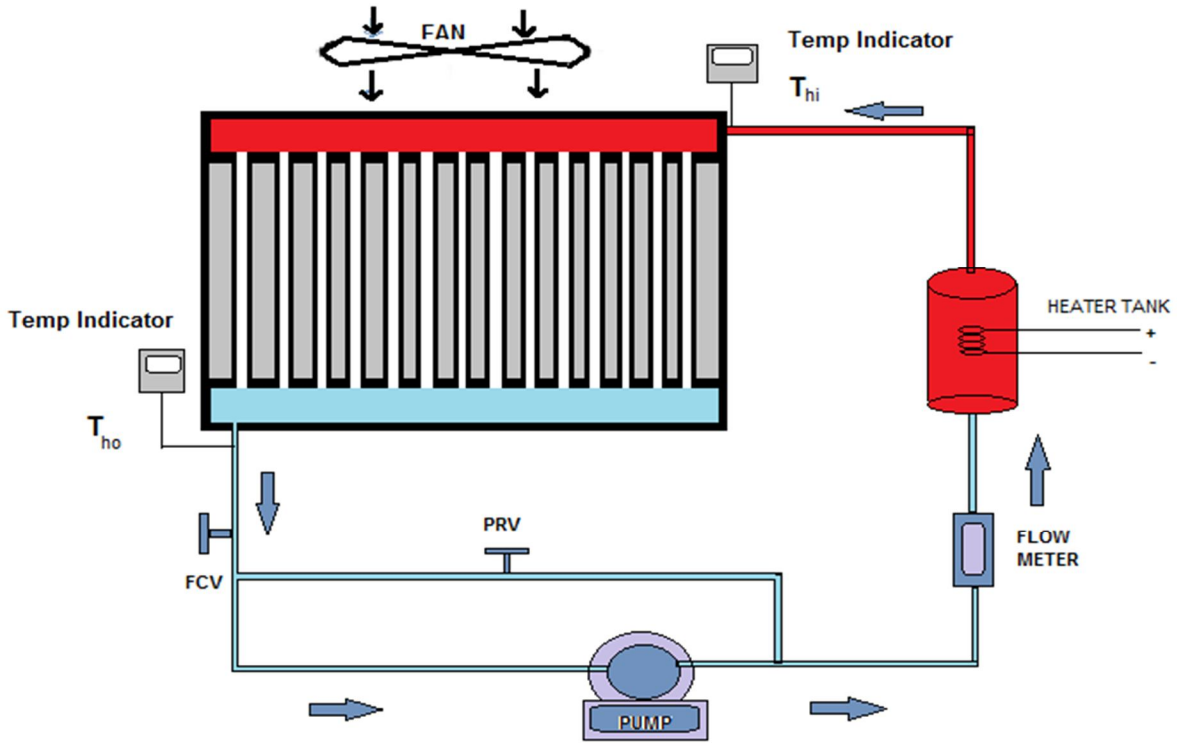


Figure 1 Al_2O_3 Nanoparticle measurement 1 gram

Figure 2 Nanofluid Solution

IV. EXPERIMENTAL SETUP



A. Calculation

As per the studied research paper and experimental set up we derive the four temperature by temperature indicator and name them as –

Tco	Temperature of cold fluid at inlet (*C)
Tci	Temperature of cold fluid at outlet (*C)
Tho	Temperature of hot fluid at inlet (*C)
Thi	Temperature of hot fluid at outlet (*C)

The temperature Difference

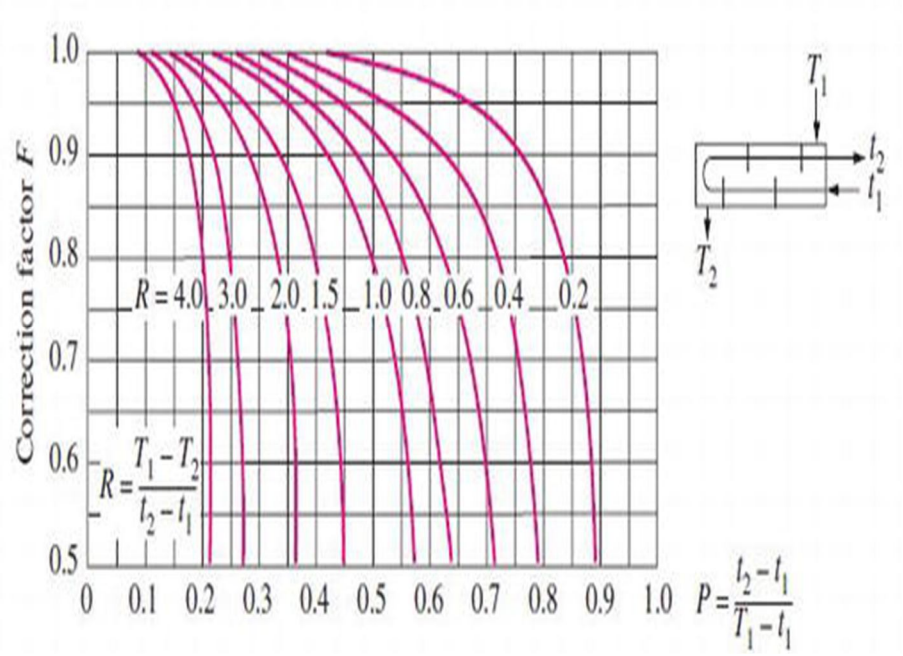
ΔT1	$= Th_{in} - T_{co}$
ΔT2	$= T_{ho} - T_{ci}$

Logarithmic mean temperature difference

ΔTm= ΔT1 - ΔT2/ ln(ΔT1 / ΔT2)

Correction factor should be found out in case of this radiator heat exchanger which is a cross flow heat exchanger and not counter flow.

*B. LMTD= F*ΔTm*



Rate of heat transfer Q= m*C_p*LMTD (kJ/s) where m=mass flow rate in kg/s

Velocity of flowing fluid V= discharge/area of cs = Q/A . (m/s)

Reynolds No Re= (p*V*Dh)/μ_f where p=density of fluid (kg/m^3), Dh=hydraulic diameter and μ_f=dynamic viscosity of fluid (Ns/m^2)

Nusselt no - Nu from range of Reynolds no i.e. if Re>500000 then

$Nu = 0.023 * (Re)^{0.8} (Pr)^{n}$ (n=0.3 for cooling and n=0.4 for heating) & Pr from table of Thermophysical properties of fluids

Heat transfer coefficient - $h = (Nu*k)/Dh$ (W/m^2K) where k=thermal conductivity (W/mK)

OR

Effectiveness of a Heat Exchanger

$\varepsilon = Th_{in} - T_{ho} / Th_{in} - T_{ci}$ This equation can be used to compare two heat exchanger.

V. CONCLUSION

By studying and analyzing various literature we studied that replacing of the conventional coolant by the modern NANOCOOLANT will definitely prove comparatively effective. The results which will be obtained by calculation studied above is the evidence of increase in the efficiency of the radiator. The following inferences can be drawn successfully after reviewing various research paper from reputed journal:

A. The heat transfer rate of nanofluid is greater than that of conventional coolant as the conductivity of the Alumina is higher than the simple coolant.

B. The size of the radiator is reduced in the case if we want same heat transfer rate as that of the conventional coolant.

C. Hence it becomes possible to improve the aerodynamic shape of the car which would reduce the air drag.

D. The reduced air drag, improved heat transfer rate, better engine cooling reducing the average fuel consumption.

E. The volumetric efficiency of the engine cylinder is also improved due to better and faster cooling.

F. The most important the NOx emission is also considerably reduced as the engine temperature is reduced below 110*C.

Thus we finally conclude that it is very beneficial in all-round aspects improving the overall vehicle performance and covering all important aspects.

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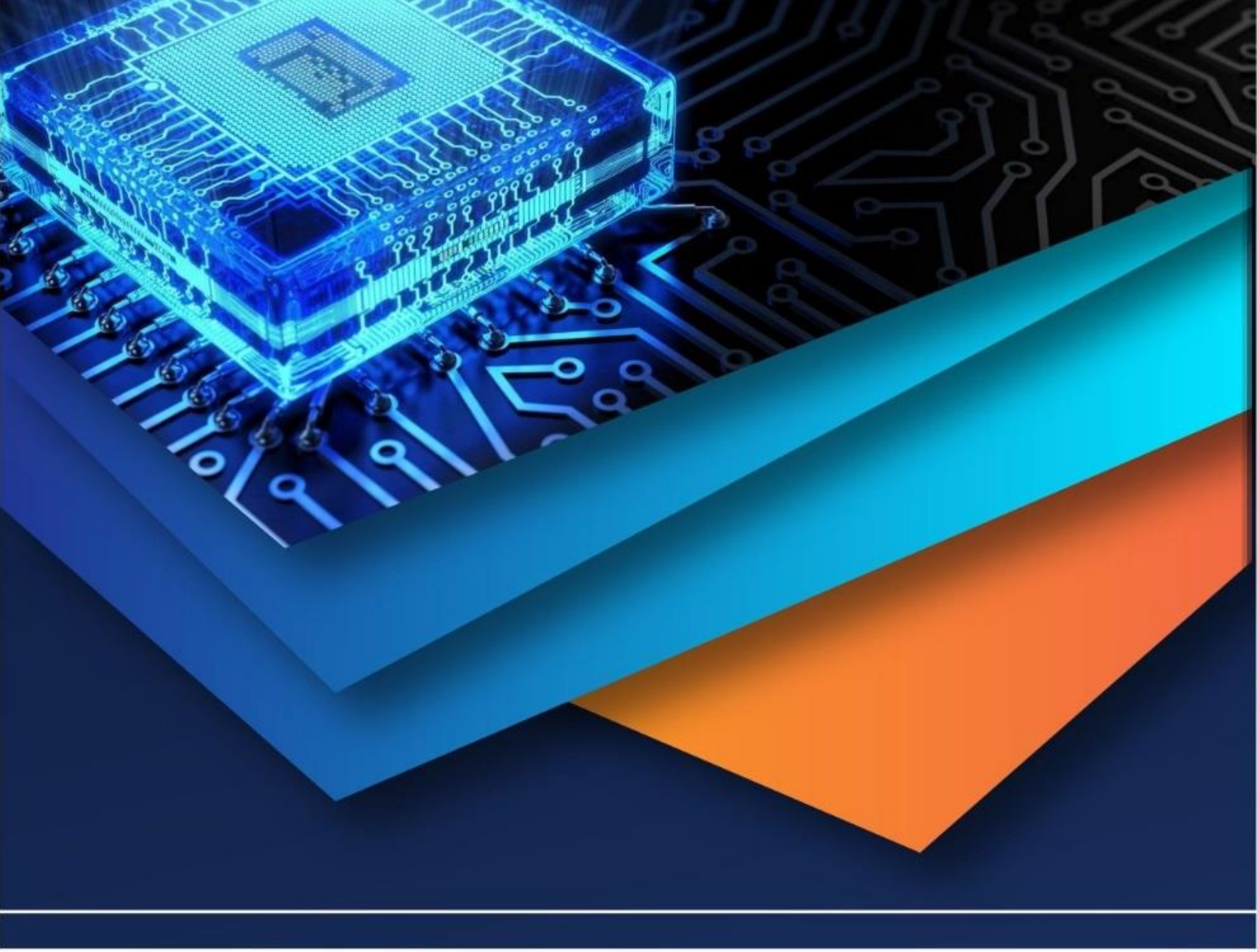

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