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Investigation on Mechanical Characterization of Aluminium-6063 MMC'S with Reinforcements of Silicon Carbide, Titanium Di-Oxide, Zinc Chloride by using Stir Casting

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***Abstract:** As part of my research work probe the mechanical properties of aluminium-6063 reinforced with Silicon Carbide, Titanium dioxide, Zinc Chloride particles were fabricated through Stir casting process which is extremely effective technique. The reason behind choosing the technique is to avoid clusters and non-homogenous dispersion which allows perfect mixing of reinforcement and the base metal. By varying the percentage of the reinforcement in the base metal matrix, the composite was casted and the samples were prepared, by simple turning process for subjected to various tests to determine the mechanical properties. The reinforcements i.e. Titanium Dioxide, Silicon Carbide and Zinc Chloride weight percent of pure, 1 %, 2% and 3 % resulted in increasing ultimate tensile strength and average hardness with increasing concentration of reinforcement, while the Density decreased with the increasing composition of reinforcement. Hence, it can be concluded that as the percentage of Reinforcement increases the properties show enrichment due to the development of strong bonding between the particles of reinforcement and the base matrix*

***Keywords:** Aluminium-6063, Silicon Carbide, Titanium Dioxide, Zinc Chloride, Stir casting Process, Mechanical properties.*

I. INTRODUCTION

"Design" concerns Innovation and Renovation in all areas of scientific issues. As an Engineer the main aspect to fulfil is, minimizing of cost, maximizing the span of life and reliable for work. If it is satisfy these things the design has value, if not regulates these aspects the design is failed.

While coming to the main stream of research, composites has specific importance in today's environment. Before designing of any component selection of material plays vital role. Convectional material gives less benefit than the composite materials. These composite materials are dividing into different matrix composites according to the area of application. The main purposes of these composites are improving the properties of the materials which lead to high performance and acceptable quality of material. MMC'S have some good properties like high strength, specific modulus, damping capacity, stiffness, good wear resistance and weight saving.

Aluminium metal matrix composites acquires most interest because of having some effective properties comparative to the other alloys. While seeing according to the strength, stiffness and tribological property it has significant improvement by addition of reinforcements.

The choice of reinforcement among the wide range of materials available in outside is a big task. Selection of material should be adaptable to manufacturing process for their applications.

There are different process techniques which are used in manufacturing process. Among those I adapted Stir Casting technique cause of some features like easy to install, high efficiency etc. Most of the industries are using this process for manufacturing the composite materials.

Mixing of reinforcement in liquid base mental is not an easy task to accomplish, by stir casting it made easy and regulating the casting defects also.

II. RELATED WORK

1) *Title:* Characteristic Behaviour of Aluminium Metal Matrix Composites: A Review

a) *Authors:* Manish Shukla[a], S.K. Dhakad[b] Pankaj Agarwal[c]M.K Pradhan[d]

b) *Conclusion:* In this review paper the author is used stir casting technique for manufacturing. And Also studied the different weight percentage characteristics present in the composite like Microstructure, hardness, tensile strength. The SiC content distribution is partially homogeneous, varying content of SiC in Al matrix increases the hardness and tensile strength of AMCs compared with unreinforced. The porosity was increased in percentages of the reinforcement where as the density of hybrid of composites decreases and also silicon carbide addition decreases the ductility. The main important property of Al-SiC is referred to the aerospace industry cause having good properties than mild steel. The author thinks that more research has been carried out for aluminium matrix composites [AMC] expecting Titanium, Magnesium and Copper MMC still have yet ample scope for research. Stir casted have scope of highly precise microprocessor based electronics control panels for control of stirrer RPMs, Vibration, Timing.

2) *Title:* An Experimental Study and Analysis of the Mechanical Properties of Titanium Dioxide Reinforced Aluminum Al-5051 composite.

a) *Authors:* Surabhi Lata[a,*], Ankur Pandey[b], Labhansh[b], Ankit Sharma[b], Kuldeep Meena[b], Ramakant Rana[c], Roop Lal[d]

b) *Conclusion:* In this paper author conducted a research on an aluminium based composite where AA 5051 was used as matrix alloy and titanium dioxide (TiO_2) as reinforcing material. Three compositions were casted with three different percentages of TiO_2 particles viz. 5%, 10% and 15%. The composite was manufactured through casting technique. After doing the tests conducted on casted specimens they concluded that, the strength and hardness of the composite increases with the variation of reinforcement i.e. TiO_2 in comparison to the pure base matrix. The tests also stated that there exist an optimized percentage of reinforcement which increases the mechanical properties. The optimized percentage of the reinforcement i.e. TiO2 in the AA 5051 base matrix has been inferred as 15%. This composite can effectively serve as the promising material for the automobile, manufacturing, architectural buildings and aerospace industries.

3) *Title:* Experimental Analysis of Mechanical Properties of Al6063 and SIC Composite.

a) *Authors:* Manoj Kumar Yadav1, Bijender Saini2, Ashu Yadav3.

b) *Conclusion:* In this experimental approach the author concludes, Yield strength and Ultimate tensile strength increases by increasing of weight percentages of silicon carbide. Total elongation decreases with the increase of weight percentage of silicon carbide. Hardness of the Al-SiC composite increases by varying amount of silicon carbide. In the microstructure studies finds the uniform distribution of SiC composite in the matrix system.

4) *Title:* Experimental Investigation on Mechanical Properties of Hybrid Metal Matrix Composite Reinforced With Alumina, Graphite and Silicon Carbide.

a) *Authors:* Nagisetti Dileep Kumar1, Dr. B. Amar Nagendram2

b) *Conclusion:* In this investigation, Hybrid Metal-matrix composite of Al6063 alloy reinforced with graphite (Gr),alumina(Al2o3) and silicon carbide (SiC) are fabricated successfully. Tensile strength of casted specimens are done successfully and noticed that composition of Al+5% Sic+5%Al2o3+5%Graphite is having high tensile strength of 133MPa while compared to the other compositions. And also hardness of the composites were tested successfully and concluded that material having the composition of Al+5% Sic+5%Al2o3+5%Graphite is possessing high hardness of 49.6 HBW compared to the other compositions.

5) *Title:* Effect of double thermal ageing treatment on the mechanical properties of Al–Cu–Mg/3% rice husk ash composite.

a) *Authors:* O.B. Umaru [a], , M. Abdulwahab [b], A. Tokan [a], A.M. Bello [a], H.A. Umar [a].

b) *Conclusion:* In this paper the authors stated some important information about the reliability. An energy saving and cost reduction point of view, researchers are focusing on investigating the possibility of reducing the heat treatment cycle without losing mechanical properties to a great extent. In this research, the variation in ageing time of the DTAT samples has highly increased the properties of the composite by a good percentage. Based on the above statement, the following conclusions are made;

DTAT treatments with varying ageing which allows the increasing of hardness, impact values and tensile properties of the composition.

Through these obtained the highest values of hardness and impact strength.

III.EXPERIMENTAL

A. *Materials*

1) *Aluminium-6063:* Aluminium has generally good mechanical properties and is heat treatable and weldable. It allows complex shapes to be formed with very smooth surfaces. In my work the base metal is Aluminium-6063 was selected as the chemical composition of the matrix metal is shown in below table 1.

Table: 1 The chemical composition of Aluminium 6063:

Constituent	Al	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn
% wt	97.5	0.1	0.1	0.35	0.9	0.1	0.6	0.1	0.1

The above table gives the clarity about the wt% of different chemicals associated in Al-6063. Including the Al there are another eight more chemicals present in Al-6063. A higher composition is Al having 97.5% and rest of the chemical shares varies weight ratio in whole composition.

a) *Applications:* The main reason behind the choosing of Aluminium metal is, it plays a good and reliable role. Major areas like Electrical conductors, Transport, Packaging, Building and Architecture, Miscellaneous applications, High pressure gas cylinders, Machined components, Ladders and access equipments, Sporting equipments, Roads barriers and signs, Domestic and office furniture's and Lithographic plates are employed by the aluminium.

2) *Silicon Carbide (SiC):* Silicon carbide also called as carborundum, and it is a semi-conductor consists of silicon and carbon. It is liberated in nature as the extremely rare mineral moissanite. Synthetic SiC powder has been used for mass-production since 1893 as an abrasive.

Fig: 1 SiC Powder.

. The table gives clarity about the composition of SiC:

Table:2 chemical composition of SiC

Constituent	SiC	Si	SiO_2	Fe	Al	C
% wt	98.5	0.3	0.5	0.08	0.1	0.3

The above table shows the percentage of contents present in SiC Along with the SiC there are five more chemicals. The major proportion is SiC having 98.5 and the rest of the proportion is shared by the remaining contents Si, SiO_2, Fe, Al and C.

a) *Uses of SiC:* Being the hardest material, it is used in different areas for increasing the life of the product. Abrasive and cutting tools, Structural materials, Automobile parts, Foundry crucibles, Electrical systems, Electronic circuits elements, Power electronic devices, LED'S, Astronomy, Thin filament pyrometer, Heating elements, Nuclear fuel particles and Cladding, Jewellery, Steel production, Quantum physics.

3) *Titanium di-oxide (Tio_2):* Titanium dioxide also known as titanium(IV) oxide or titania, is the naturally appearing oxide of titanium, chemical formula Tio2.When used as a pigment, it is called titanium white, pigment white or CI 77891.probably, it is sourced from ilmenite, rutile and anatase. It has vast range of applications, including paint, sunscreen and food coloring. When used as a food coloring, it has E number E171. While compared to other titanium metals, this titanium dioxide is cheaper. As per cost bases and other criteria's the adaption of titanium di-oxide is done.

4) *Zinc Chloride ($Zncl_2$)*

a) Zinc chloride is the name of chemical compounds with the formula $Zncl_2$ and its hydrates.

b) Zinc chlorides, of which nine crystalline forms are known, are colorless or white, and are highly soluble in water.

c) Samples should therefore be protected from sources of moisture, including the water vapor present in ambient air.

d) Zinc chloride finds application in textile processing, metallurgical fluxes and chemical synthesis.

Fig: 2 Tio_2 Powder

Fig: 3 $Zncl_2$ Powder

B. Experimental Procedure

1) *Stir-Casting Technique:* Perfect mixing of two or more metals into single composite is a great task to do effectively. Past few decades researchers done a great job on it, and finally find the solution i.e.; none other than STIR CASTING. Stir Casting is employed in every industry due to their easy of adoption and installation. In Stir casting, base metal is melted above the melting point and after complete melting of metal, we have to add the reinforcement material slowly into the molten metal. Before we adding the reinforcement in the machine we sholud pre-heat it below melting temperature to remove the wettability in it. Allow the Stirrer to rotate after adding the reinforcement, to mix both base metal and reinforced metal into a Metal Matrix Composite.

Fig – 4: Bottom pouring stir casting machine

C. Composition of Reinforcements in AMC'S

composition	Al-6063 (grams)	SiC (grams)	Tio_2 (grams)	$Zncl_2$ (grams)
pure	1020	-	-	-
1%	1011	3	3	3
2%	1002	6	6	6
3%	993	9	9	9

These are the variation of weight percentages of the base metal and the reinforcements. According these proportions mixed the metals and after that casting had done through Stir Casting Machine. The below figure show the pictorial view of casting.

Fig: 5 Casted Specimens

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IV. EXPERIMENTAL SETUP

A. Tensile Strength

This test is also called as tension testing, it is a basic material science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uni-axial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. Some materials use biaxial tensile testing. It was performed using computerized UTM testing machine. The test was conducted using strain rate of 0.2mm/rev at 25 degrees room temperatures. As cast Al and composite tensile test specimens were prepared using lathe machine and shaper machine according to the dimensions.

The following figure is the test specimens for tensile strength. These are machined as per the ASTM E8 standards.

Fig: 6 Tensile testing Specimen.

B. Density Testing

Density is defined as, mass of a substance per unit volume. Mathematically it is donated as mass divided by volume. Theoretical density of aluminum 6063 is 2.69 g/cm^3. It is useful to check the Density of various liquids and material weighting up to 99.99gm measure of this by following three methods:

1) *In Water:* Solid sample testing in water
2) *In Liquid:* Solid sample testing in another liquid
3) *Of Liquid:* Liquid sample testing with known solid sample micro controller based unit.

Fig – 7: Density measuring instrument.

C. Vickers Hardness Testing

Digital Micro Vickers Hardness Tester made with a unique and precise design in the fields of mechanics, optics and lights source is able to produce a clearer indentation and hence a more precise measurement. By means of a 20 X lens and a 40 X lens the tester has a wider measurement field and a broader usage range. The tester has such features as the direct reading of the measurements, the easy change of the hardness scales. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The hardness number is find out by the load over the surface area of the indentation and not the area normal to the force, and is therefore not pressure. The hardness test were conducted on the specimens which in different weight proportion of reinforcements which are micro polished for getting better results. The results are appeared digitally when diamond shaped indenter point the specimen having load of 1kg and the value was averaged of three reading taken at three different locations.

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Fig – 8: Hardness measuring instrument.

V. RESULTS AND DISCUSSIONS

A. Tensile Strength

The below chart, shown the relation between tensile strength and wt. % of reinforcements of fabricated composites. From the tensile test results, it is observed that the tensile strength of AMCs is greater than unreinforced Al. Increase of tensile strength in AMCs can be attributed due to the applied tensile load transfer to the strongly bonded reinforcements in Al matrix, increased dislocation density near matrix-reinforcement interface, and grain refining strengthening effect.

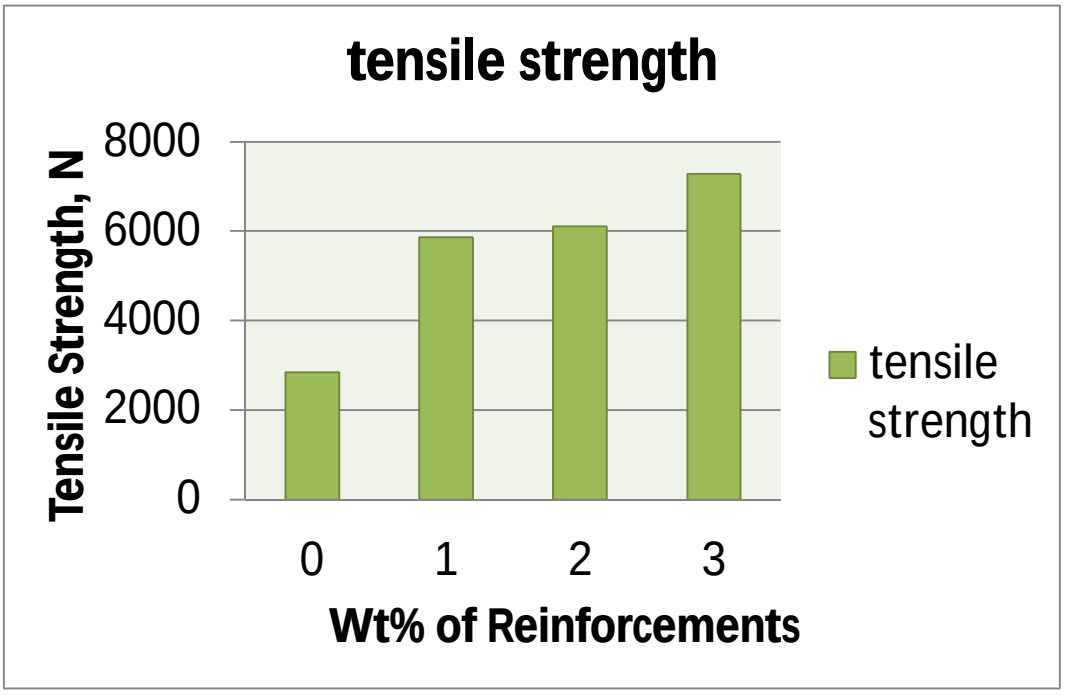

Fig: 9 Tensile Strength Results.

B. Density Testing

Following chart shows, the relation between Density and wt. % of reinforcements of fabricated composites. From the Density results, it is observed that the Density of AMCs is lesser than unreinforced Al. Decreasing of Density in AMCs can be Attributed due to the strongly bonded reinforcements which are less in weight.

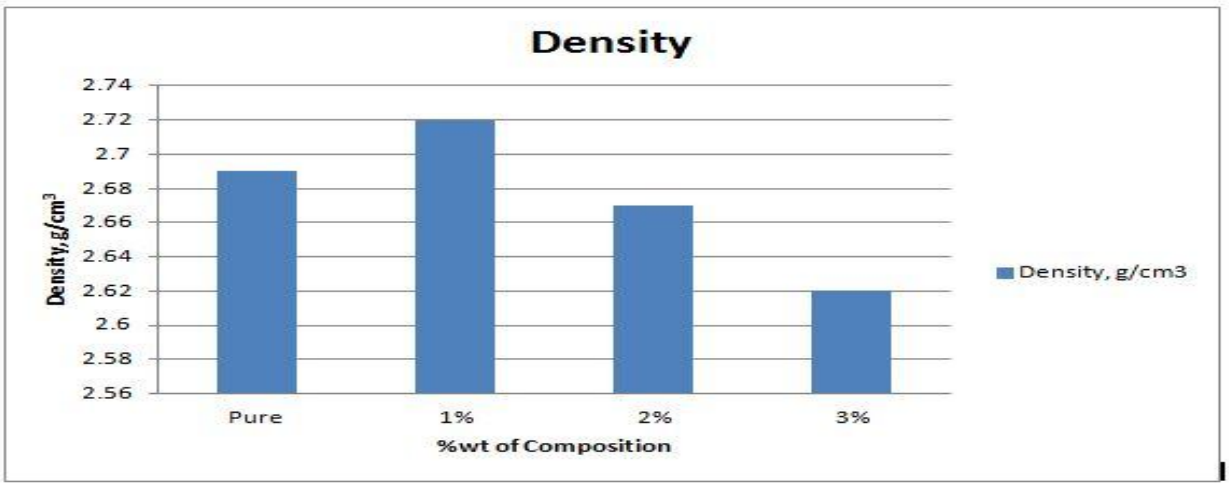

Fig: 10 Density Results.

C. Vickers Hardness Testing

Below chart shows, the relation between Hardness and wt. % of reinforcements of fabricated composites. From the Hardness results, it is observed that the Hardness of AMCs is greater than unreinforced Al. Increasing of Hardness in AMCs can be attributed due to the bonding between reinforcements and the base mental.

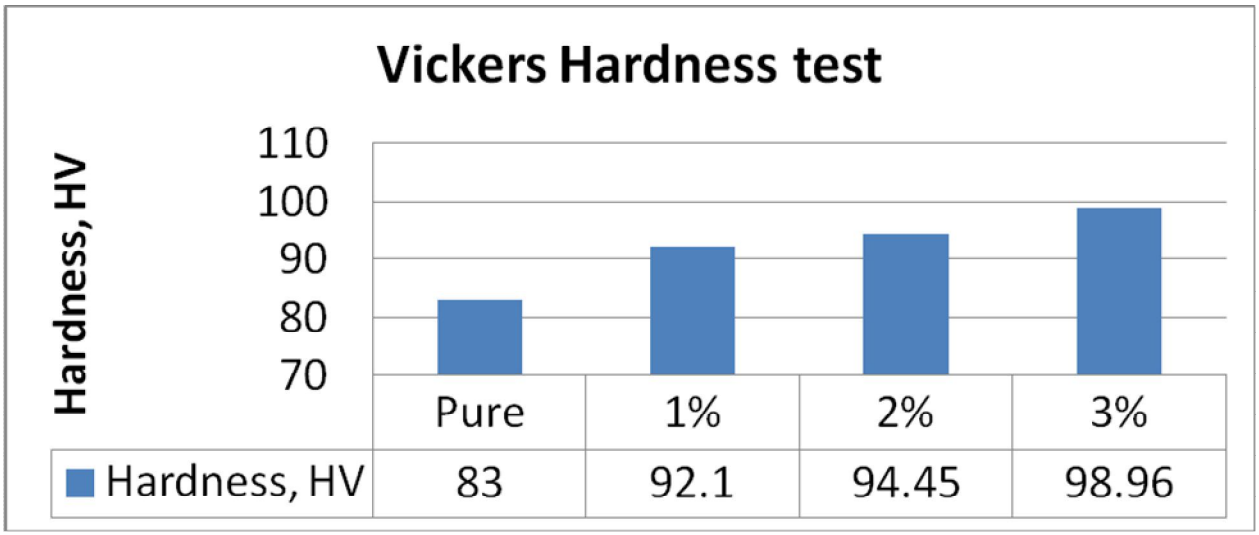

Fig: 11 Micro Hardness Results.

VI. CONCLUSIONS

The reinforcements were synthesized successfully under required micro size for perfect bonding with the base metal. The fabrication of AMC'S was done effectively by using Stir Casting technique. Through this technique casting defects like clustering and non-homogenous dispersion was avoided. After casting the casted parts were machined according to the dimensions of ASTM. Tensile strength, Hardness test and Density test were conducted on the machined specimens.

A. Tensile strength was increased by increasing of weight percentage of the reinforcements. The tensile strength of Al-6063 is 2845N. The maximum tensile strength attained at 3% of the fabricated composites i.e.7271.5 N.

B. Density of the fabricated specimen decreased with an increase weight percentage of reinforcement. The minimum density observed at 3% i.e. 2.62 g/cm^3.

C. Hardness of the pure Al-6063 is 83HV. The hardness was increased by varying of weight percentages of the reinforcements and that is noticed at 3% having 98.96HV.

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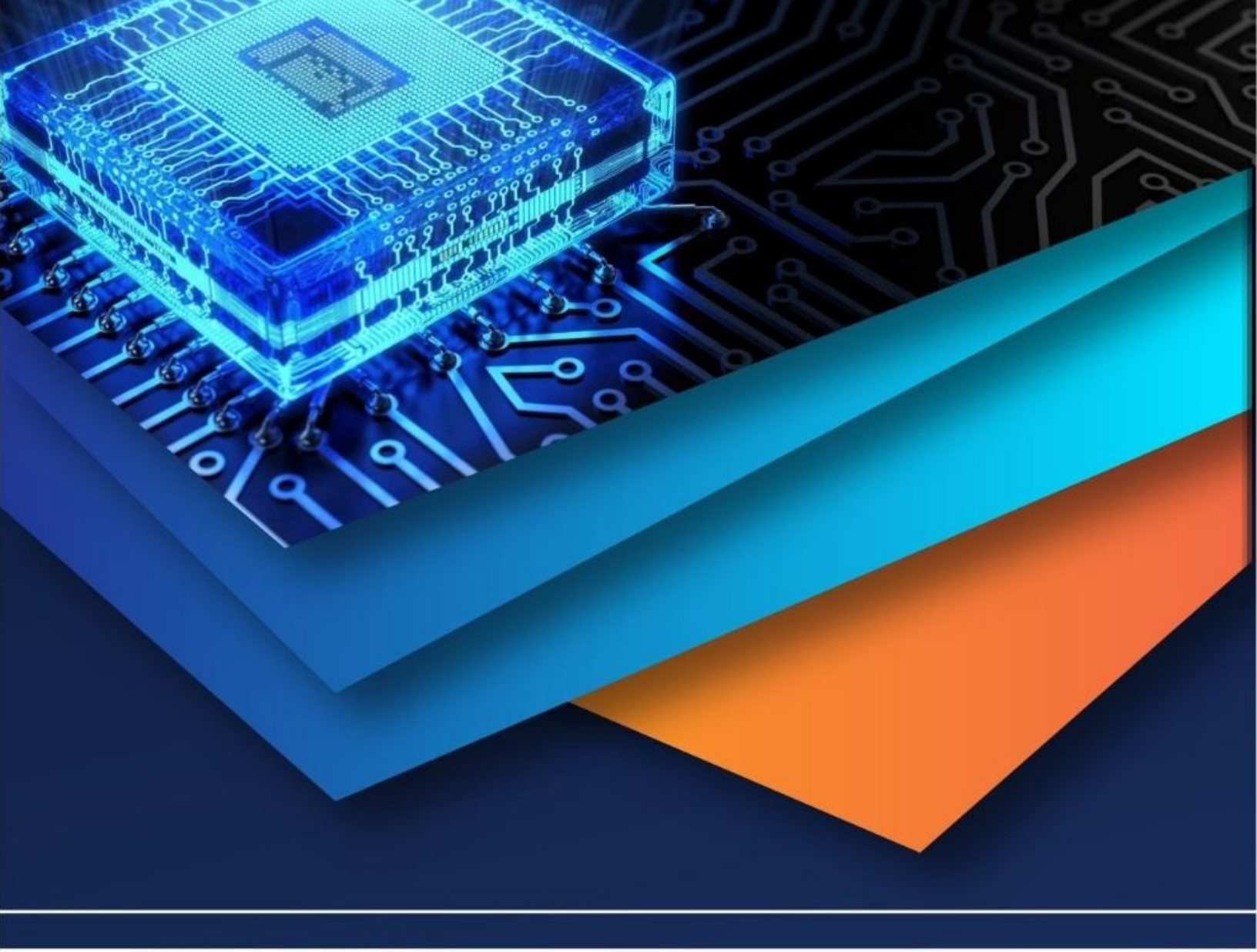

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