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Comparision and Mechanical Characterization of Graphite Insert in different Aluminium Alloys

M. Beniyel[1], S. Selva prabhu[2], S. A. A. Jude[3], A. Syed Mydeen[4], M. Nisanth[5], G. Paul Suresh[6], Sasi Kumar[7]
[1, 2]Research Scholar, Mechanical Engineering, PSN College of Engineering and Technology.
[3]Assistant Professor, Mechanical Engineering, PSN College of Engineering and Technology, Tamilnadu
[4, 5, 6, 7]U.G Student, Mechanical and Automation Engineering, PSN College of Engineering and Technology

Abstract: ***Aluminium is the lightest of all metal elements and therefore is an excellent choice for engineering applications to design element. In this paper processes for fabrication of aluminium-alloy composites containing a particulate dry lubricant, of these composites, their microstructures, their friction and wear behaviors and their mechanical properties are described It is strong, has good heat dissipation and is readily available. The use of pure aluminium is rare due to its volatility at high temperatures and it is extremely corrosive. Therefore the use of aluminium alloys when designing parts is critical. Specific alloys are better for certain applications and often also need graphite Embedded to provide the longest life of the Friction developing part. The wear behaviour of the aluminium alloy specimens and aluminium alloy Graphite insert specimens was studied using a pin-on-disc type machine with under different load, velocity, Sliding Distance. It was shown that composites containing some amounts of non-metals exhibit excellent wear resistance In this project we deal about the alloy of aluminium with Graphite insert specimens and analyze its mechanical properties of Microstructure, Hardness, wear, friction and its application in lubrication fewer drives.***
Keywords: (Size 10 & Bold) Key word1, Key word2, Key word3, etc (Minimum 5 to 8 key words)…

I. INTRODUCTION

A. Aluminium

Aluminium is the world's most abundant metal and is the third most common element comprising 8% of the earth's crust. The versatility of aluminium makes it the most widely used metal after steel. Aluminium is derived from the mineral bauxite. Bauxite is converted to aluminium oxide (alumina) via the Bayer Process. The alumina is then converted to aluminium metal using electrolytic cells and the Hall-Heroult Process.

Table-1: Aluminium properties

Sl. No	Properties	Values
1	Atomic Number	13
2	Atomic Weight	26.98 (g/Mol)
3	Crystal Structure	FCC
4	Melting Point (^{O}c)	660.2
5	Boiling Point (^{O}c)	2480
6	Density (g/cm^3)	2.68

B. Physical Properties of Aluminium

1) *Density of Aluminium:* Aluminium has a density around one third that of steel or copper making it one of the lightest commercially available metals. The resultant high strength to weight ratio makes it an important structural material allowing increased payloads or fuel savings for transport industries in particular.
2) *Strength of Aluminium:* Pure aluminium doesn't have a high tensile strength. However, the addition of alloying elements like manganese, silicon, copper, and magnesium can increase the strength properties of aluminium and produce an alloy with properties tailored to particular applications.
3) *Corrosion Resistance of Aluminium:* When exposed to air, a layer of aluminium oxide forms almost instantaneously on the surface of aluminium. This layer has excellent resistance to corrosion. It is fairly resistant to most acids but less resistant to alkalis.

4) *Thermal Conductivity of Aluminium:* The thermal conductivity of aluminium is about three times greater than that of steel. This makes aluminium an important material for both cooling and heating applications such as heat-exchangers. 1.2.5
5) *Electrical Conductivity of Aluminium:* Along with copper, aluminium has an electrical conductivity high enough for use as an electrical conductor. Although the conductivity of the commonly used conducting alloy (1350) is only around 62% of annealed copper.
6) *Reflectivity of Aluminium:* From UV to infra-red, aluminium is an excellent reflector of radiant energy. Visible light reflectivity of around 80% means it is widely used in light fixtures. The same properties of reflectivity make aluminium ideal as an insulating material to protect against the sun's rays in summer while insulating against heat loss in winter.

C. Aluminium Alloys

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin, and zinc. There are two principal classifications, namely casting alloys and wrought alloys.
7068 aluminium alloy's composition is zinc (7.3–8.3%), magnesium (2.2–3.0%), copper (1.6–2.4%) and zirconium (0.05–0.15%), with traces of silicon, iron, manganese, chromium, titanium.
7075 aluminium alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than a half percent of silicon, iron, manganese, titanium, chromium, and other metals.

1) *Cast Alloy:* Casting aluminum alloys undergo a catastrophic loss of mechanical properties (tensile, impact, shear strength etc.) in the temperature range from 520 to 590 degrees C. In comparison,
2) *Wrought Alloys:* Wrought aluminum alloys retain their mechanical properties and remain ductile within this temperature range.

D. Graphite

Graphite is structurally composed of planes of polycyclic carbon atoms that are hexagonal in orientation. The distance of carbon atoms between planes is longer and, therefore, the bonding is weaker.
Graphite is best suited for lubrication in the air. Water vapour is a necessary component for graphite lubrication. The adsorption of water reduces the bonding energy between the hexagonal planes of the graphite to a lower level than the adhesion energy between a substrate and the graphite. Because water vapour is a requirement for lubrication, graphite is not effective in a vacuum.[3] Because it is electrically conductive, graphite can promote galvanic corrosion. In an oxidative atmosphere, graphite is effective at high temperatures up to 450 °C continuously and can
Graphite is characterized by two main groups:

1) Natural
2) Synthetic.

Synthetic graphite is a high temperature sintered product and is characterized by its high purity of carbon (99.5−99.9%). Primary grade synthetic graphite can approach the good lubricity of quality natural graphite.
Natural graphite is derived from mining. The quality of natural graphite varies as a result of the ore quality and its post-mining processing. The end product is graphite with a content of carbon (high-grade graphite 96−98% carbon), sulfur, SiO_2, and ash. The higher the carbon content and the degree of graphitization (high crystalline) the better the lubricity and resistance to oxidation.
For applications where only a minor lubricity is needed and a more thermally insulating coating is required, then amorphous graphite would be chosen (80% carbon).

E. Dry Lubricants

Dry lubricants or solid lubricants are materials that, despite being in the solid phase, are able to reduce friction between two surfaces sliding against each other without the need for a liquid oil medium.
The two main dry lubricants are graphite and molybdenum disulfide. They offer lubrication at temperatures higher than liquid and oil-based lubricants operate. Dry lubricants are often used in applications such as locks or dry lubricated bearings. Such materials can operate up to 350 °C (662 °F) in oxidizing environments and even higher in reducing /non-oxidizing environments (molybdenum disulfide up to 1100 °C, 2012 °F). The low-friction characteristics of most dry lubricants are attributed to a layered structure on the molecular level with weak bonding between layers. Such layers are able to slide relative to each other with minimal applied force, thus giving them their low friction properties.

II. METHODOLOGY

A. The Aluminium alloys have a poor wear resistance it has been analysed from the literature study.
B. Initially Materials fabrication process were done by using mechanical methods
C. after that the aluminium alloy surface properties analysed by
D. Surface analysis (Optical Microscope & SEM)

(The specimen is prepared for surface analysis, the specimens were polished abrasive paper up to 2500 Grit and polish by the velvet cloth with diamond paste)

E. Hardness (Vickers Hardness Test)

(The specimen is prepared for Hardness test, the specimens were polished abrasive paper up to 1500 Grit for clear indentation marking visibility) and then the tribological studies were done by

F. Wear Test (Pin-on-Disc Wear apparatus)
G. Wear Specimen analysis (SEM)

III. EXPERIMENTAL DETAILS

A. Surface Properties

1) Optical Microscope: The first step in the metallographic analysis is to select a sample that is representative of the material to be evaluated. This step is critical to the success of any subsequent study. The second, equally important step is to correctly prepare a metallographic specimen. The region of the sample that is of interest must be sectioned from the component. For example, if a failure occurred because a steel pipe leaked during service, the metallographic analysis would probably involve at least three samples: one removed from the pipe such that a portion of the leak is contained in the sample, another removed near the leak, and a third taken far from the leak. Each of the samples would be mounted to facilitate handling. Selected surfaces would then be ground flat, polished, and etched to reveal the specific structure or structures of interest.

a) Sectioning of a metallographic sample must be performed carefully to avoid altering or destroying the structure of interest (see the article "Sectioning" in Volume 9 of the 9th Edition of *Metals Handbook).* The most widely used sectioning device is the abrasive cutoff machine, ranging from units using thin diamond-rimmed wafering blades to those using wheels that are more than 1.5 mm (1/16 in.) thick, 30 to 45 cm (12 to 18 in.) in diameter, containing silicon carbide particles. Heat is generated during abrasive cutting, and the material just below the abraded surface is deformed. To minimize burning and deformation, a lubricant or coolant is typically used. Wet cutting yields a flat relatively smooth surface.

b) Mounting facilitates handling of the specimen. A procedure that does not damage the specimen should be selected. Because large specimens are generally more difficult to prepare than small ones, specimen size should be minimized. Standard or typical specimen mounts are right circular cylinders 25 to 50 mm (1 to 2 in.) in diameter. Mounting mediums should be compatible with the specimen regarding hardness and abrasion resistance. Two common mounting materials are thermosetting phenolics, such as Bakelite, and thermoplastic materials, such as methyl methacrylate (Lucite).

c) Grinding is generally considered the most important step in specimen preparation. Care must be taken to minimize mechanical surface damage. Grinding is generally performed by the abrasion of the specimen surface against water-lubricated abrasive wheels (assuming water does not adversely affect the metal). Grinding develops a flat surface with a minimum depth of deformed metal and usually is accomplished by using progressively finer abrasive grits on the grinding wheels. A typical sequence might begin with 120- or 180-grit papers and proceed to 240, 320, 400, and 600 grits. Scratches and damage to the specimen surface from each grit must be. Removed by the next finer grinding step.

d) Polishing of the metallographic specimen generally involves rough polishing and fine polishing. In rough polishing, the cloth covering on a wheel is impregnated with a fine (often as small as 1 txm) diamond paste or a slurry of powdered or-A1203 in water, and the specimen is held against the rotating wheel. The cloth for rough polishing is frequently napless, providing easy access of the polishing abrasive to the specimen surface. Fine polishing is conducted similarly, but with finer abrasives (down to 0.05 ~m in diameter) on a napped cloth. Although often automated, polishing can be performed by hand.

e) Etching includes any process used to reveal the microstructure of a metal or alloy. Because many microstructural details are not observable on an as-polished specimen, the specimen surface must be treated to reveal such structural features as grains, grain boundaries, twins, slip lines, and phase boundaries. Etchants attack at different rates areas of different crystal orientation, crystalline imperfections, or different composition. The resulting surface irregularities differentially reflect the incident light, producing contrast, coloration, polarization, etc.

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B. Hardness

1) *Vickers Hardness Testing:* Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation. More simply put, when using a fixed force (load) and a given indenter, the smaller the indentation, the harder the material. The Vickers method is based on an optical measurement system. The Micro hardness test procedure, ASTM E-384, specifies a range of light loads using a diamond indente**r** to make an indentation which is measured and converted to a hardness value. It is very useful for testing on a wide type of materials, but test samples must be highly polished to enable measuring the size of the impressions. Typically loads are very light, ranging from 10gm to 1kgf, although "Macro" Vickers loads can range up to 30 kg or more.

C. Wear Testing with a Pin-on-Disk

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principal areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined. The values stated in SI units are to be regarded as standard

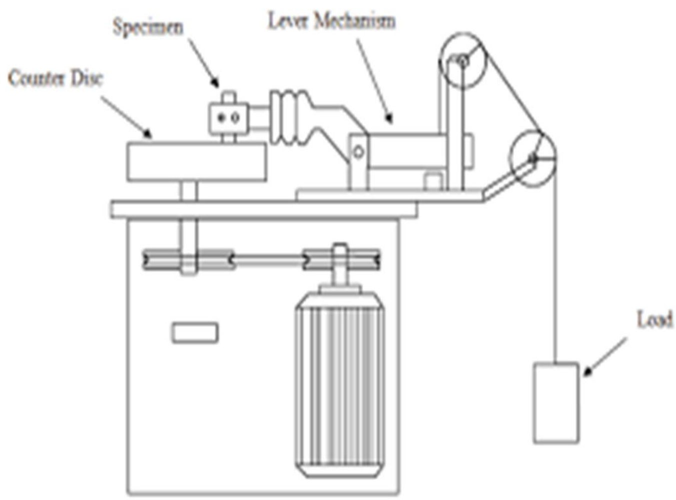

Fig 1. Pin On Disk Apparatus

1) *Procedure*

a) Immediately prior to testing, and prior to measuring or weighing, clean and dry the specimens. Take care to remove all dirt and foreign matter from the specimens. Use non-chlorinated, Non-film-forming cleaning agents and solvents. Dry materials with open grains to remove all traces of the cleaning fluids that may be entrapped in the material. Steel (ferromagnetic) specimens having residual magnetism should be demagnetized. Report the methods used for cleaning.
b) Measure appropriate specimen dimensions to the nearest 2.5 µm or weigh the specimens to the nearest 0.0001 g.
c) Insert the disk securely in the holding device so that the disk is fixed perpendicular (61°) to the axis of the resolution.
d) Insert the pin specimen securely in its holder and, if necessary, adjust so that the specimen is perpendicular (61°) to the disk surface when in contact, in order to maintain the necessary contact conditions.
e) Add the proper mass to the system lever or bale to develop the selected force pressing the pin against the disk.
f) Start the motor and adjust the speed to the desired value while holding the pin specimen out of contact with the disk. Stop the motor.
g) Set the revolution counter (or equivalent) to the desired number of revolutions.
h) Remove the specimens and clean off any loose wear debris. Note the existence of features on or near the wear scar such as protrusions, displaced metal, discoloration, micro cracking, or spotting.
i) Remeasure the specimen dimensions to the nearest 2.5 µm or reweigh the specimens to the nearest 0.0001 g, as appropriate.
j) Repeat the test with additional specimens to obtain sufficient data for statistically significant results.

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IV. RESULT AND DISCUSSION

A. Vickers Hardness

Sl No	Specimen (Al 7075)	Hardness (Hv)
1	Trial 1	67
2	Trial 2	67
3	Trial 3	68

Sl No	Specimen (Al 7068)	Hardness (Hv)
1	Trial 1	51
2	Trial 2	53
3	Trial 3	50

The hardness and compressive properties of as-extruded Aluminium alloys Al7075 and Al7068 are better than those of the original homogeneous state. Micro-hardness and compressive strength are greatly improved after extrusion, but the total strain-to-fracture declines a little compared to the homogeneous state. In regard to the effect on the total strain-to- fracture, the theoretical strain-to-fracture decreases with the extrusion temperature and the grain size increases gradually. But at the same time, strain-to-fracture has a certain relationship with the uniformity of structural stress and heat stress. The structural stress is rather high owing to the less homogeneous structure, thus it's more easily to generate pileup of dislocation and stress concentration, which lead to the overall plasticity and toughness decrease.

B. Wear Parameter

Sl No	Specimen	Load (N)	Velocity (m/s)	Distance
1	D1	30	1	1500
2	D2	50	1	1500
3	G1	30	1	1500
4	G2	50	1	1500

Dry sliding wear tests were performed with a pin-on-disc-type wear apparatus at a room temperature of 25◦C. Wear test specimens of 10 × 10 mm length were machined from as-cast Al 7075 & 7068 alloy ingots. Specimen surfaces were thoroughly degreased by acetone and dried before the commencement of each wear test. The counterface disc was made of high-carbon chromium steel. The diameter of the disc was 150 mm. The surface hardness of the disc was 570 HV. Both pins and counterface discs were polished to 0.4 μm *Ra* and cleaned in a methanol solution before each wear test.

The wear tests were carried out in a sliding speed range of 1 ms−1 and a load range of 30 and 50 N. The sliding distance was 1500 m. At each sliding speed, the wear tests were conducted by increasing the applied load until the occurrence of surface melting or the highest experiment load of 50 N

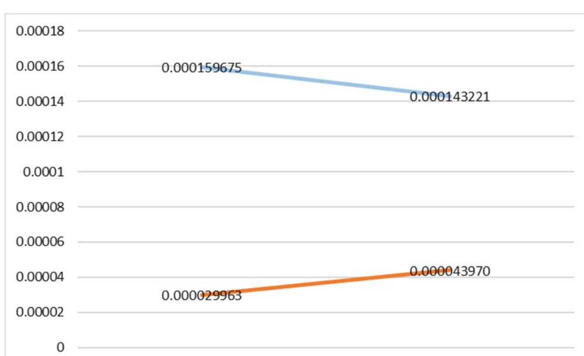

Fig: 3.1 Wear Comparison between Al-7075 and Al-7068

Specimens were weighed on a single-pan electrical balance that gave readings to a 0.1 mg, before and after each wear test. The mass losses were calculated from the differences in weight of three specimens before and after the sliding tests and transformed into volume losses by dividing by the density of the Al-7075 and Al -7068 alloy. Volumetric wear rates were calculated by dividing the volume losses by the sliding distance. The worn surfaces of the wear pins were examined with a scanning electron microscope (SEM) equipped.

V. CONCLUSIONS

Reviewed the Aluminium alloy and its composites Physical and mechanical Material properties of aluminium alloys of Al7075 and Al7068.Interpretation studies of the Aluminium alloy and its composites by Different Testing methods and its applications

Physical properties of aluminium alloys of Al7075 and Al7068 will be observed by Optical Microscope methods. A hardness of aluminium alloys of Al7075 and Al7068 alloys will be determined by Vickers Hardness testing methods. The hardness improves the wear resistance.

Tribology of various aluminium alloys of Al7075 and Al7068 alloys will be determined by Pin- on – Disc testing methodology. The Wear analysis will be studied by Scanning Electron Microscope absorbs. The Topographical surface and chemical composition variations and wear mechanism will be studied for both alloys. Microscopy analysis, Mechanical Testing results, and Mechanisms will be deeply characterized, discussed

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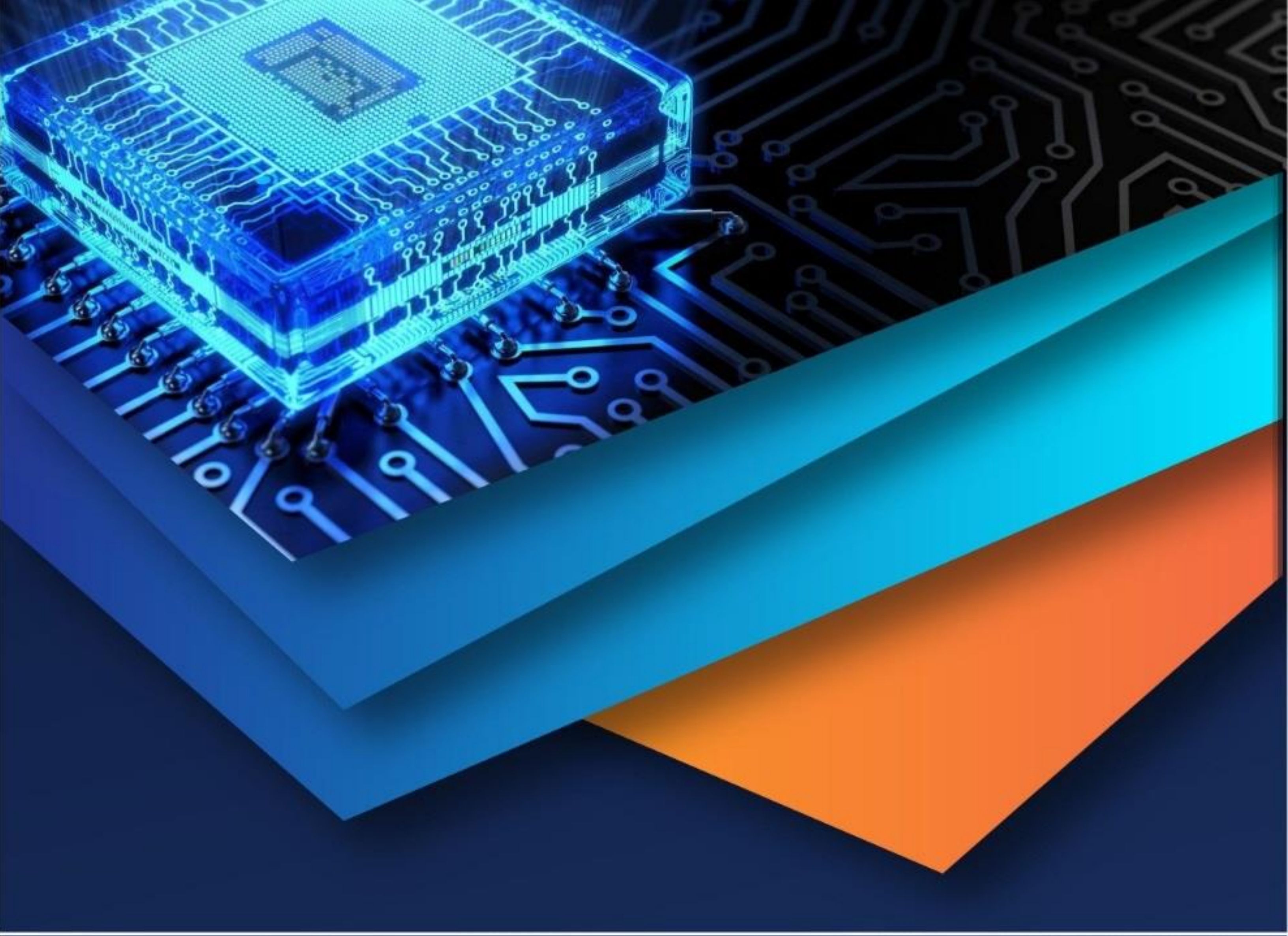

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