iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: II Month of publication: February 2022

DOI: https://doi.org/10.22214/ijraset.2022.40335

Synthesis and Characterization of Polyester and Rice Husk Fiber Reinforced Polymer Composites for Structural Applications

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***Abstract:** In current years composites have concerned considerable importance as a potential operational material. The composite materials are replacing the traditional materials, because of its superior properties such as low thermal expansion, high tensile strength, high strength to weight ratio ,Low cost, light weights, high specific modulus, renewability, and biodegradability are the most basic & common attractive features of composites that make them useful for industrial applications. The composite have generally minimal effort of creation, simple to create and better-quality contrast than perfect polymer tars. The developments of new materials are on the anvil and are growing day by day. In this study, Woven roving mats (E-glass fiber orientation (-45/45, 0/90, 45/45),UD450GSM) were cut in measured dimensions and a mixture of Polyester Resin, Methyl Ethyl Ketone Peroxide (MEKP), Cobalt and rice husk powder is used to manufacture the glass fiber reinforced composite by hand lay-up method. Mechanical properties such as tensile strength, impact are evaluated*
***Keywords:** Epoxy Resin, e-glass fibre, fly ash, Biodegradability, Mechanical Properties.*

I. INTRODUCTION

A. Background

Nature has provided composite materials in living things such as seaweeds, bamboo, wood, and human bone. The first reinforced polymeric based materials appear to have been used by the people of Babylonia around 4000-2000 B.C. The materials consisted of reinforced bitumen or pitch. Around 3000 B.C. evidences from various sources Bundles of papyrus reed embedded in a matrix of bitumen.

composites materials are using ever since several hundred years before Christand has been applied innovations to improve the quality of life. Contemporary composites resulting from research and innovation from the past few decades have progressed from glass fiber for automobiles bodies to particulate composites for aerospace and a range of other applications. The volume and number of applications of composite materials have grown steadily, penetrating, and conquering new markets relentlessly. Modern composite materials constitute a considerable proportion of the engineered materials market ranging from everyday products to sophisticated niche (hollow in a wall or statues) application. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective.

II. LITERATURE REVIEW

This section focuses on the research work that has already been carried out for testing the mechanical properties of the glass Fiber Reinforced Hybrid composites. Literature review of such work needs to be done in order to understand the background information available, the work already done and also to show the relevance of the current project. This chapter presents a general idea of the factors which affect the mechanical properties of hybrid fiber reinforced polymer composites in polymer composites, the matrix is the major load bearing component. In order to increase this load bearing capability, the reinforcements are introduced in the matrix. Currently, natural fibers and artificial fibers like glass, jute etc., are being widely used in polymer-based composites because of their high strength and stiffness properties

According to R. TAURINO & et.al worked on the new composite materials based in the glass waste and they found the advantage in using coarse glass particles in bi-layer composite was the energy saving in the glass manufacturing step, since no much more processing was required. The addition of waste glass fillers to the resin matrix resulted in a reduction of flexural strength, but an increase of elastic modulus and dynamic stiffness were obtained in the bi-layer composite.

According to METINSAYER& et.al worked on the Elastic properties and buckling load evaluation of ceramic particles filled glass/epoxy composites and he found that the elasticity moduli and load carrying capability of composites were significantly influenced by particle weight fractions, different particle sizes and different ceramic particles. In general, the addition of ceramic particles like glass particulates to composites increased the elasticity moduli and load carrying capability of composites. Accordingly, all composites with 10 weight% filler had maximum elasticity moduli values and the best ability to resist buckling load.

According to ERIC MINFORD & et.al worked on method of making hybrid composite structures of fiber reinforced glass and resin matrices and found that the fiber reinforcement in the resin matrix composite may comprise any fiber that exhibited a tensile strength greater than about 10×103 psi, a tensile modulus greater than about 10×106 psi, thermal stability at temperatures up to about 700° C. and is wet table by the matrix material.

According to A. A. IBRAHIM& et.al worked on flexural properties of glass particles filled polymer composites and he came to the conclusion that the hybrid composite reinforced with 10% glass particles presented the best overall flexural properties.

III. METHODOLOGY

Polymer Matrix Composite(PMC) is a composite material composed of a variety of short or continuous fibers bound together by an organic polymer matrix. PMCs are designed to transfer loads between fibers of a matrix.

These processing methods are classified into

1) Open mould process
2) Closed mould process

A. Open Mould Process

Open-mould processes involve a mould on which the product is made and that is not covered by a second mould or vacuum film (i.e. a flexible second mould) during the impregnation process . It is not possible to manipulate the pressure while wetting the fibers (impregnation). It is possible to start a manufacturing process as an open-mould process, and subsequently cover the product before curing and apply an over- or under-pressure to reduce superfluous resin or air inclusions (voids).

B. Hand lay-up Process

Hand Layup: This method is also known as contact-layup. It is carried out by manually applying loose plies onto a mould, and then wetting them with a roller or brush. This is a labor-intensive process, requiring measures to prevent the plies from shifting.It is a cost-effective process since it requires only simple tools and a small number of consumables.

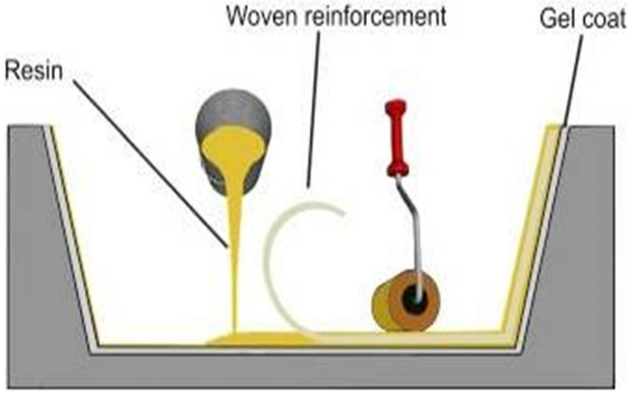

Fig 1: Hand Layup Process

C. Principle

The addition of glass Fiber mat in polyester composite helps to get required mechanical properties when compared with the only polyester. After a certain amount of addition of glass fiber mat, these properties do not get enhanced so, we are adding the rice husk powder as fillers to enhance the properties. E-glass is used because of their chemical resistance and relatively low cost. These FRCs are generally biocompatible, and their toxicity is not a concern.

IV. EXPERIMENTATION

Materials used are E-glass fiber, Rice-Husk, Polyster resin, Accelerator (Cobalt Octate), Catalyst (MEKP), E-GLASS: Woven roving glass made up of aluminosilicates. It is used where high strength, high stiffness, extreme temperature resistance, corrosive resistance is needed. E-Glass has a typical nominal composition of SiO_2 (65wt%), Al_2O_3 (25wt%), CaO(10wt%). E-glass does not actually melt, but softens instead, the softening point being the temperature at which a 0.55–0.77 mm diameter fiber 235 mm long, elongates under its own weight at 1 mm/min when suspended vertically and heated at the rate of 5 °C per minute. Having a density of 2.55 mg/m3.

A. Polyster Resin

Polyester resins are transparent, high-density polymers with excellent strength and water resistance with high usage in textiles and packaging. Polyster resin is superior to other types of resins because it has low shrink during cure, and excellent moisture and chemical resistance. It is impact resistant, it has good electrical and insulating properties, and a long shelf life. The various combinations of epoxy resins and reinforcements give a wider range of properties obtainable in molded parts.

B. Rice-Husk

Rice husk is one of the cheapest particulate which is obtained in rice grain, it is an outer layer of rice grain which is removed during the milling of rice. Rice husk contains silicon dioxide – 14.8%, ferrum (0.5%), plumbum (1%), and copper (0.4%).

C. Accelerator And Catalyst

The purpose of cobalt is to speed up the curing reaction of polyester resins and allow them to cure at room temperature. cobalt properties are heat proof, water proof, Non-corrosive and non-toxic.

Methyl Ethyl Ketone Peroxide (MEKP)helps to start the chemical reaction of the resin with the styrene monomer (present in the resin) allowing crosslinks to form between them.

D. Experimentation Process

Mould preparation, Preparation of artificial fiber samples, Preparation of polyester resin and glass fiber specimen , Curing, Finishing, Resulting.

E. Mold Preparation

In this process three moulds are to be prepared. Each mould is prepared by using tile and wood material. Each mould of 300mm×300mm in size, and thickness of 5mm should be prepared. After preparation of mould a release oil (grease) is to be applied to all moulds for quick and easy removal of specimen without any damage. A release sheet (mat) is also placed on the tile, so that it reduces the sticky nature between resin and mould.

Fig 2: Preparation of Mould

F. Fabrication Of Artificial Fiber Composites

A mixture of polyester resin and hardener is mixed in required proportions. For example, 1000ml of polyester resin is mixed with 3% of MEKP (methyl ethyl ketone peroxide) and 2% of cobalt.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

G. Preparation Of Polyester Resin And Glass Fiber Specimen

A mixture of polyester resin and hardener is prepared as explained in above. And a woven roving mat glass fiber is cut into required dimensions of 300mm*300mm.

H. Preparation of Artificial And Fly Ash Composites

Here we are using hand layup technique for preparing samples. A mixture of polyester resin and accelerator is mixed in different ratio for example if we take 100 ml of resin we have to take 10 ml of catalyst i.e., 10:1 ratio of resin and accelerator mixture is taken for each layer of specimen preparation. Then the prepared dough was transferred to the prepared moulds with care that the mould cavity should thoroughly filled. Levelling was done for uniformity of the layer.

While the process is going on first one layer of e-glass fiber is placed and then a layer of resin and catalyst, accelerator mixture is gently applied with the help of a roller. Next a layer of glass fiber is placed on the mould and a mixture of resin and hardener is applying on these layers. One layer after another is gently applied and the process goes on till, we obtain required thickness of the specimen as per standard dimensions with required ratio of jute fiber, glass fiber and resin, accelerator and catalyst mixture.

I. Curing

After the preparation of specimen for three slabs,wait for few hours at room temperature till the specimen is ready.

J. Demolding

That work pieces is removed carefully from mould and cut into pieces as per standard dimensions for testing

K. Cutting Of Laminates Into Samples Of Desired Dimensions

Wire hacksaw blade was used to cut each laminate into smaller pieces, for various experiments. tensile test- sample was cut into dog bone shape as per ASTM D-638(tensile), impact test- sample was cut into flat shape with notch at centre as per ASTM D-256(impact)

Fig 3: Resin Specimen for Tensile andImpact tests specimen

Fig 4: Resin and E-glass fiber Specimens for Tensile and Impact tests

Fig 5: Resin, E-glass fiber and Fly-ash Specimens for Tensile and Impact tests

L. Tensile Test

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the dog bone type. During the test a uni-axial load is applied through both the ends of the specimen. The dimension of specimen is per ASTM D638 (TENSILE). Typical points of interest when testing a material include, Ultimate Tensile Strength (UTS) or peak stress; Offset Yield Strength (OYS) which represents a point just beyond the onset of permanent deformation and the Rupture (R) or fracture point where the specimen separates into pieces. The tensile test is performed in the Universal Testing Machine (UTM) and results are analyzed to calculate the tensile strength of composite samples. Tensile strength is calculated by dividing the load at break by the original minimum crosssectional area. The result is expressed in mega Pascal's (MPa).

$$\text{Tensile Strength} = \frac{\text{(Load at break)}}{\text{(Original width)* (Original thickness)}}$$

Fig 6: UTM machine   Fig 7: Specimens after Tensile Test

M. Impact Test

Impact strength, is the capability of the material to withstand a suddenly applied load and is expressed in terms of energy. Often measured with the Izod impact strength test or Charpy impact test. Low velocity instrumented impact tests are carried out on composite specimens. The tests are done as per ASTM D256 using an impact tester. The Charpy/Izod impact testing machine ascertains the notch impact strength of the material by shattering the V-notched specimen with a pendulum hammer, measuring the spent energy, and relating it to the cross section of the specimen

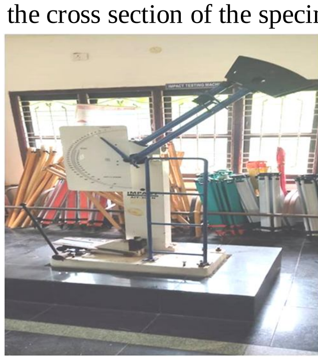

Fig 6: Impact testing machine   Fig 7: Specimens after Impact Test

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

This presents the mechanical characterization of the class of Polymer matrix composites developed for the present investigation. They are Unsaturated polyster resin mixture filled is 100 weight percentage. Glass fiber is 40% and polyster resin mixture filled is 60 weight percentage. Rice husk is 20% and polyster resin is 40% and E-glass fiber 40 weight percentage. The results of various characterization tests are reported here. They include evaluation of tensile strength, impact strength.

Table 1: Resin properties

Properties	Specimen-1	Specimen-2
Load at yield	0.75KN	0.62 KN
Elongation at yield	3.69 mm	3.55 mm
Yield Stress	6.5 MPa	6.48 MPa
Load at peak	1.25 KN	1.2 KN
Elongation at peak	9.1 mm	8.95 mm
Tensile strength	12.87 MPa	10.89 MPa
Load at break	0.150 KN	0.145 KN
Elongation at break	9.65 mm	9.6 mm
Breaking strength	0.9 MPa	0.85 MPa

Table 2: Resin and fiber properties

Properties	Specimen-1	Specimen-2
Load at yield	2.72 KN	2.7 KN
Elongation at yield	5.62 mm	5.6 mm
Yield Stress	28.4 MPa	28.21 MPa
Load at peak	5.320 KN	5.30 KN
Elongation at peak	9.3 mm	9.1 mm
Tensile strength	56.45 MPa	56.12 MPa
Load at break	0.515 KN	0.52 KN
Elongation at break	10.7 mm	10.59 mm
Breaking strength	4.83 MPa	4.79 MPa

Table 3: Resin, Fiber and Rice husk properties:

Properties	Specimen-1	Specimen-2
Load at yield	5.35 KN	5.20 KN
Elongation at yield	8.31 mm	7.95 mm
Yield Stress	56.32 MPa	55.98MPa
Load at peak	6.73 KN	6.52 KN
Elongation at peak	9.31 mm	9.25 mm
Tensile strength	70.12 MPa	69.93 MPa
Load at break	0.090 KN	0.095 KN
Elongation at break	11.7 mm	11.3 mm
Breaking strength	0.25 MPa	0.23 MPa

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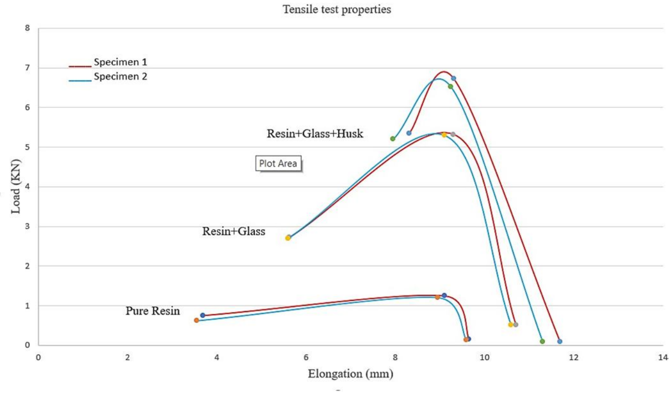
N. Graphs obtained for Tensile Test:

Graph1: Tensile test properties



O. Tensile Test Properties

The mean value of the tensile strength of the glass fibers with various specimensis 11.52 Mpa for 100%resin and 56.25 Mpa for 40% glass fiber and 60% resin and 70.02Mpa for 40%resin, 40%fiber and 20%rice husk. It seems that increase in fiber percentage will increase in tensile strength. The test results shown in table seems that composite with rice husk and glass fiber has more tensile strength in artificial fiber composites.

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications. The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength or tensile strength at break. The rate at which a sample is pulled apart in the test can range from 0.2 to 20 inches per minute and will influence the results. Theanalogous test to measure tensile properties in the ISO system is ISO 527. The values reported in the ASTM D638 and ISO 527 tests in general do not vary significantly andeither test will provide good results early in the material selection process.

Table 4: observations for impact test

Composition	Impact strength(joules)
Resin (S1)	6
Resin (S2)	6
Resin +Fiber (S1)	141
Resin +Fiber (S2)	143
Resin +Fiber+ Rice husk (S1)	159
Resin +Fiber+ Rise husk (S2)	163

P. Impact Test Properties

The mean value of impact energy of the glass fibers with varying percentages is6 J for 100% resin and 142J for 40% glass fiber and 60% resin and 161J for 40% resin,40% glass fiber and 20% rice husk. Though there may change in the values with increasein fiber percentage but it seems there is major difference with rice husk percentage. Thetest results shown in the table seems that different compositions has more impact energyin hybrid fiber composites.

The impact properties, which indicate a material's toughness, can be determinedfrom the potential energy difference resulting from striking the material with a pendulum hammer. The impact properties include the notched impact strength, as determined with a V-shaped notch, and the un-notched impact strength. In determiningthe un-notched impact strength, the entire test piece receives the impact energy caused by the hammer striking, whereas in determining the notched impact strength, breakage is promoted by concentrating the impact energy on the notch.

V. CONCLUSION

This experimental investigation on polyester composites filled with woven roving composite mat has led to the following specific conclusions:

A. The polymer matrix composite based on the woven roving glass mat with polyester resin and hardener [-$45^0/45^0$, $0^0/90^0$,-$45^0/45^0$]. With three layers were successfully prepared by using hand lay-up technique and cured process under room temperature.

B. After making laminated plate, we have cut the laminates into Standard Test specimen using ASTM (American society of Testing Materials) table. Test specimens are drawn from that Glass fiber laminate, after that test specimens are tested in the Universal Testing Machine (UTM) and impact testing machine.

C. The experimental investigation on the Evaluation of mechanical properties of artificial and hybrid fiber reinforced polymer composites were conducted. Properties such as the Tensile strength, Impact energy were evaluated from various experiments. The experiments lead us to the following conclusions obtained from this study:

D. The successful fabrications of a new class of polymer based composites reinforced with artificial and natural fibers have been done.

E. The maximum tensile strength among hybrid fiber reinforced composites is 70.02Mpa whose composition is 40% fiber, 40% resin and 20% Rice husk.

F. The maximum impact strength among hybrid fiber reinforced composites is161 J whose composition is 40% fiber, 40% resin and 20% Rice husk.

Possible use of these composites such as pipes carrying coal dust, industrial fans, helicopter fan blades, desert structures, low cost housing etc. is recommended. However, this study can be further extended in future to new types of composites using other inorganic materials/fillers and the resulting experimental findings can be similarly analyzed.

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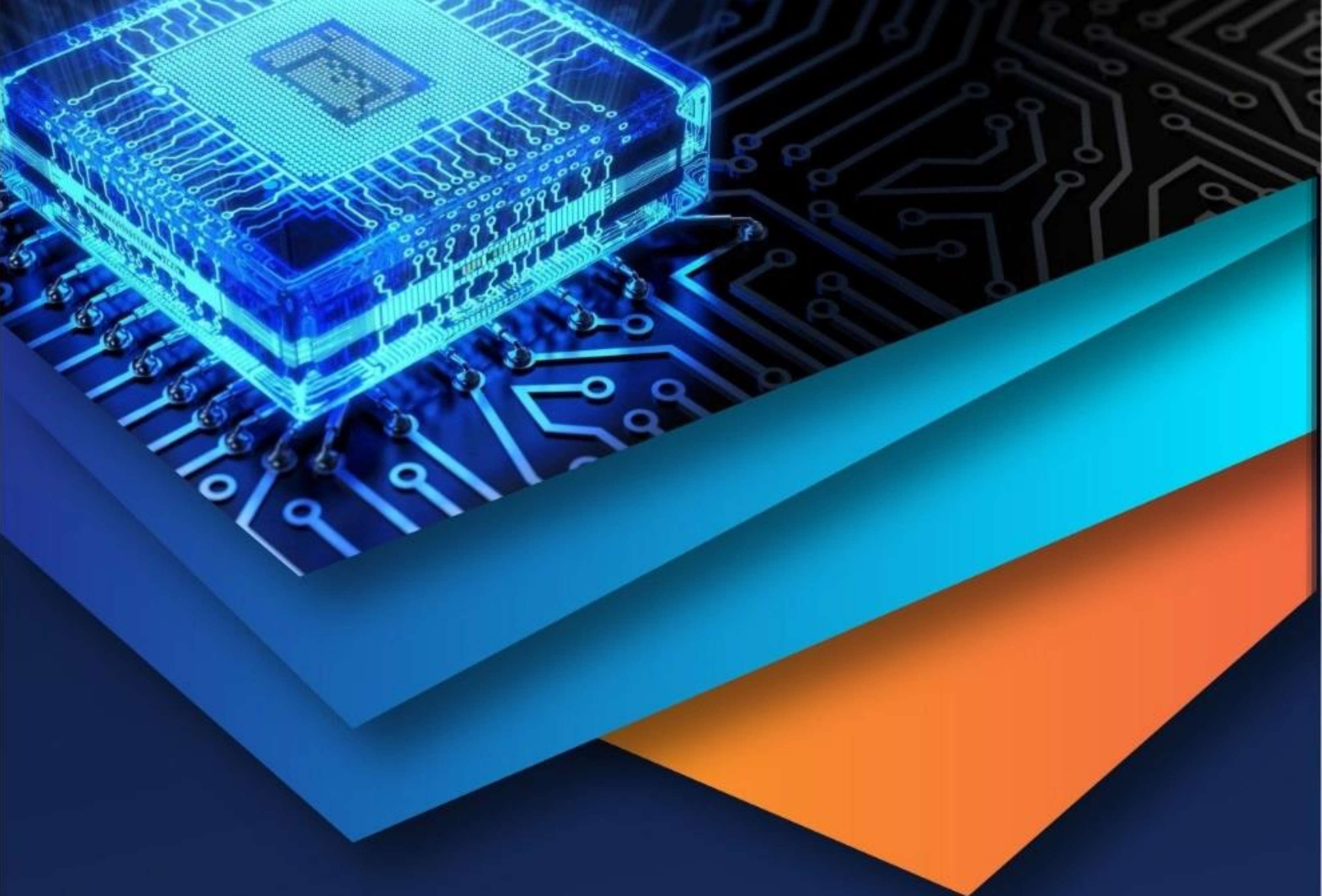

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