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# Manufacturing and Mechanical Properties Testing of Hybrid Natural Fibre Reinforced Polymer Composites

Rahul Bhedasgaonkar[1], Sunil Jamadade[2], Pratik Bhole[3], Aniket Narake[4], Akash Jadhav[5], Aditya Humbare[6], Ruturaj Deasi[7]

*[1, 2]Assistant Professor, Dept. of Mechanical Engineering, Kolhapur Institute of Technology's College of Engineering (Autonomous), Kolhapur, Maharashtra, India*

*[3, 4, 5, 6, 7]U.G. Student, Dept. of Mechanical Engineering, Kolhapur Institute of Technology's, College of Engineering (Autonomous), Kolhapur, Maharashtra, India*

***Abstract: A composite material is a materials system made up of two or more micro or macro elements with different forms and chemical compositions that are largely insoluble in one another. It basically comprises of two phases: matrix and fiber. Polymers, ceramics, and metals such as nylon, glass, graphite, Aluminium oxide, boron, and aluminium are examples of fibres. In the present research work epoxy is used as matrix and Bamboo, Sugarcane Bagasse and Coconut fibre are used as fibres for preparing the composites. In the preparation of specimen, the fibre as taken as a continuous fibre. The fibre is treated with NaOH solution. Hybrid natural fibre reinforced composites of bamboo, sugarcane baggase and coconut coir has been prepared using hand lay-up process of composite manufacturing. These hybrid composites were tested for determining their tensile and impact strengths. Results of mechanical testing reveals that the tensile strength of Bamboo- Bagasse hybrid composite is more compared to other composites. Taking into consideration of enhanced tensile and impact strength of bamboo-bagasse hybrid natural fibre polymer composite, we recommend the use of hybrid bamboo-bagasse composite in manufacturing of automotive bodies. Because of their unique characteristics of recyclability, waste utilization, biodegradability, good strength, and a viable alternative to plastics, these composites can be used for a variety of applications.***

***Keywords: Natural Fibre, Bamboo, Sugarcane Bagasse, Coconut Coir, Epoxy***

## I. INTRODUCTION

The development of new products in today's modern world necessitates the use of more efficient materials. Composites play an important part in this since they have a strong load-bearing material encased in a weaker material. Reinforcement helps and supports the structural load by providing strength and rigidity. Although polymer matrix composites are widely employed, their mechanical characteristics are insufficient for many structural applications. In comparison to ceramics and metals, their strength and stiffness are very low. These problems are solved by using polymers to reinforce other materials. Natural fibres are being used as reinforcing materials in polymer composites in a variety of studies. A composite is made up of two or more materials. Composites have better qualities, such as strong flexural, tensile, and impact strength, as compared to its core components. A mixture of components is used to produce three-dimensional effects. This required attribute can't be shown by any of the components on their own. Workplace, strength, high stiffness, heat resistance, chemical resistance, and insulation are all desirable features of matrix elements. Surface energy, surface conditions, and polarity of natural fibres may all be affected by hydroxyl group reactions. Natural fibres provide a number of distinct characteristics, including acceptable specific strength qualities, high toughness, excellent thermal properties, and environmental friendliness. Because of the increased usage of natural fibre composites in the automotive industry, energy consumption in the manufacture of motor vehicles is decreasing and day-to-day fuel efficiency is improving.

Synthetic polymer composite materials are widely used in numerous industrial industries to meet light-weight and high-strength requirements. Environmental concerns such as trash disposal, waste disposal services, and incinerator pollution must be handled promptly as the worldwide supply of synthetic polymer materials develops. Natural fibers have numerous advantages over synthetic fibers, including low cost, low density, unlimited supply, biodegradability, renewability, environmental friendliness, and recyclability. Natural fibres have a significant potential for chemical treatment due to the presence of hydroxyl groups in lignin and cellulose.

## II. LITERARURE REVIEW

From the literature review of the research papers mentioned in references section of this paper, it has been found that fibre Reinforced Composites have been used by a variety of individuals since antiquity. Due to the limitations of traditional synthetic fibres, FRCs (Fibre Reinforced Composites) are considered, and many young scientists are encouraged to pursue additional study in the area of NFRCs (Natural fibre reinforced Composites). In today's composites, we use a range of natural fibres as reinforcement [1]. New approaches for characterising the mechanical characteristics of various composites and using such composites for further use have been created as a result of advancements in science and technology. Jute, sisal, banana, rice husk, elephant grass, and other popular natural fibres have been chosen for the investigation of mechanical [2] characteristics. Natural fibres have a number of advantages, the most notable of which is that they are renewable. This overview looks at the many kinds of fibres that are accessible, as well as the current state of research on natural fibre reinforced composites. This review article includes a number of references to recent work on NFRCs, their mechanical characteristics, and processing. The nature of the matrix may be used to classify composites. The physical and chemical qualities of the matrix and reinforcing fibres are also taken into consideration throughout the fabrication process.

1) *Polymer Matrix Composites (PMCs):* PMCs are the most widely used composites nowadays. A thermoplastic polymer is used in these composites. They are inexpensive, have excellent strength, and may be produced using a simple procedure.
2) *Metal Matric Composites:* As the name implies, these composites are made up of metal matrices. Magnesium, aluminium, and titanium are among the metals used in the matrix. The elastic stiffness and strength of a material may be improved by utilising this sort of composite.
3) *Carbon-Carbon Composites:* Carbon fibres are employed in this form of composite. Carbon-carbon composites are employed in high-temperature applications. They outperform other composites by a factor of 20. Thermosetting Plastics have mostly been utilised to create Natural Fiber Reinforced Composite.

From the extensive literature review, it has been found that less work has been reported on natural fibres like sugarcane baggase,bamboo and coconut coir. So, there is need to develop a hybrid natural fibre polymer composite using these natural fibres which has been done in this research work.

## III. PREPAERATION OF HYBRID NATURAL FIBRE REINFORCED POLYMER COMPOSITES

### A. *Selection of Natural Fiber Reinforced Polymer Composites*

According to the research gap identified with extensive literature review, in this research work natural fibres like sugarcane baggase,bamboo and coconut coir have been selected to prepare hybrid natural fibre reinforced polymer composite.

### B. *Bamboo Fibre*

Bamboo is natural cellulose regenerated biodegradable textile material that is also environmentally friendly. It is not only a green fibre, but it also possesses antibacterial and UV protection properties, making it a unique eco-friendly textile material in the twenty-first century. Due to its high tensile strength, durability, and stability, it is not only employed in traditional textile but also in high-performance end uses as a composite material.

### C. *Coconut Coir*

Coconut fibre is produced from the husk of the coconut fruit and is one of the natural fibers plentiful in tropical climates. It's also known as coir fiber. The outer shell of a coconut is used to obtain coconut fibre.

### D. *Sugarcane Bagasse*

Bagasse is the fibrous material left over after sugarcane has been crushed to get its juice. Sugarcane bagasse is a fibrous waste remaining after sugarcane is crushed in sugar and alcohol plants. It is one of the major cellulose-based agricultural industrial byproducts. It is now employed as a biofuel and a renewable resource in the production of pulp and paper goods, as well as construction materials.

Bagasse is also utilized in the production of bio-based goods and as a source of renewable energy. It contains a mixture of hard fiber with a high hygroscopicity, soil, wax, and residual sugars, among other things. Using dry (or) wet chemical processing, bagasse can be turned into soft boards, medium density fibre boards or particle boards, as well as high density hard boards. Figure 1 shows the photographs of preparation of selected fibres.

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Bamboo fibre Coconut coir Sugarcane bagasse fibre

Fig. 1 Photographs of preparation of selected fibres

### *E. Chemical Treatment of Natural Fibres*

Bamboo, bagasse, and coconut coir fibres were treated with 5% NaOH for 6 hrs. After that, the fibres are completely cleaned with distilled water. The fibres are then dried in the sun to remove any remaining moisture.

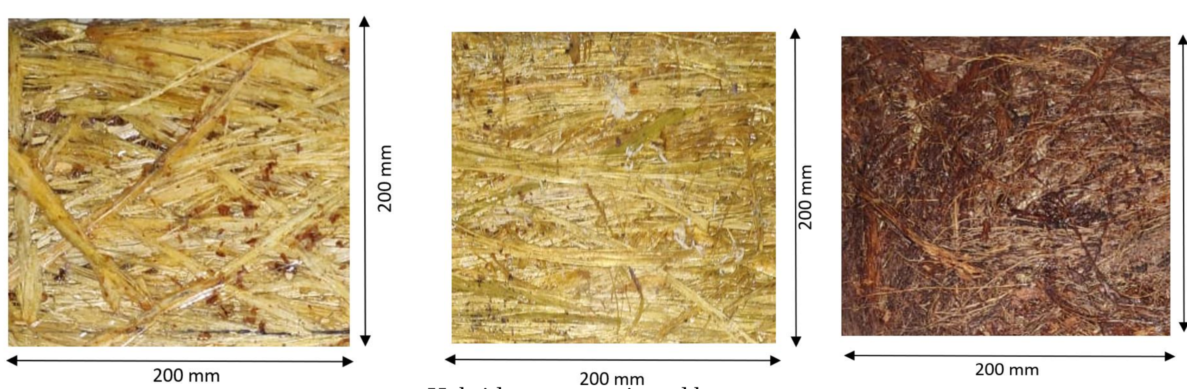
The composite plate is made with LY556 epoxy (density 1.15–1.20 g/cm3) and HY951 hardener (density 0.97–0.99 g/cm3). Epoxy and hardener are mixed at a 10:1 weight ratio. At 250°C, it has a viscosity of 10-20 poise.

### *F. Fabrication of Composite*

Mould Preparation

This work's mould is made of plywood with dimensions of 200 mm X 200 mm X 50 mm. The hand lay-up technique was used to manufacture the composite material. The top and bottom plates cover and compress the fiber once the epoxy has been applied. During the curing process, they also keep debris out of the composite pieces. Out of various methods of fabrication of composites, hand lay-up method has been adopted in this research work. Because it involves the least amount of equipment, hand lay-up is the most popular and least expensive open-molding method. Hand-placed fibre reinforcements in a mold, then resin is applied with a brush or roller. Large and tiny goods, such as boats, storage tanks, baths, and showers, are made using this method.

Hand lay-up technique is used to produce the composites. Before applying epoxy, the molds are cleaned and dried. The mold was filled with plastic paper. A coat of epoxy was applied to the plastic paper, and the fiber was layered into the mold at the desired ratio. The epoxy mixture is then uniformly poured over the fiber and squeezed for 24 hour with a load of 5kg. For comparison, Bamboo-Bagasse, Bagasse-Coconut Coir, and Bamboo-Coconut Coir composites were made under similar processing conditions. The prepared composites were now cut for testing to ensure that they conformed to the specimen's dimensions according to ASTM specifications. Figure 2 shows photographs of fabricated sheets of hybrid natural fibre polymer composites (taking 50-50 % composition of each selected natural fibre)




Hybrid bamboo and bagasse composite Hybrid coconut coir and bagasse composite Hybrid bamboo and coconut coir composite

Fig. 2 Photographs of fabricated sheets of hybrid natural fibre polymer composites (taking 50-50 % composition of each selected natural fibre)

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## IV. MECHANICAL TESTING OF HTBRID NATURAL FIBRE REINFORCED POLYMER COMPOSITES

Two different types of tests were conducted on the composites, namely tensile strength test and Izod impact test .The details of these tests are given below.

### A. *Tensile Test (ASTM D-638)*

One of the most significant and commonly evaluated qualities of materials used in structural applications is their capacity to withstand failure under tensile stress. The ultimate tensile strength, or tensile strength, is the force per unit area in MPa necessary to break a material in this way. The tensile characteristics of a material describe how it will respond to tension forces. A tensile test is a basic mechanical test that involves loading a well prepared specimen in a highly controlled way and measuring the applied load in different zones, as well as the specimen's elongation or change in length and area. Tensile tests are used to measure tensile strength, yield point, yield strength, and other tensile parameters such as modulus of elasticity, elastic limit, elongation, proportional limit, and decrease in area.

### B. *Charpy Impact test (ASTM D-256)*

The charpy impact test, sometimes called the charpy v-notch test, is a standardised high strain-rate test that assesses how much energy a material absorbs during fracture. This absorbed energy is a measure of specimen material toughness and may be used to investigate the temperature-dependent ductile-brittle transition. It is commonly used in industry since it is simple to perform and has speedy results. The fact that the findings are comparative is a huge drawback. A pendulum axe (hammer) swings against a notched specimen in this contraption.

By measuring the height of the hammer before and after the impact, the amount of energy delivered to the material may be calculated. The impact test findings are influenced by the notch in the specimen and the size of the specimen. As a result, the notch must have uniform size and shape.

The specimens were cut as per ASTM Standards.
For Tensile Test the specimen was cut as per ASTM D638.
The dimensions of the specimen are 165 mm ×15 mm ×15 mm
For Impact Test the specimen was cut as per ASTM D256.
The dimensions of the specimen are 65 mm ×15 mm ×15 mm
The cutting process was carried out by using Horizontal Band Saw Cutting Machine.
Figure 3 shows photographs of testing machines and test specimens.

Universal Testing Machine

Tensile testing specimens


Impact testing machine

Impact testing specimens

Fig.3 Photographs of testing machines and tested specimens

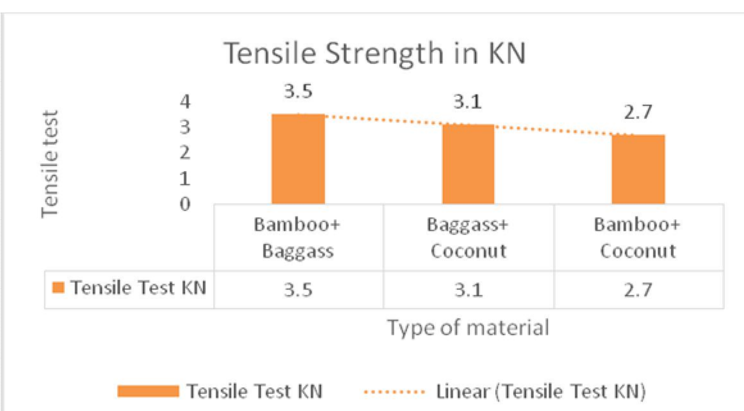
## V. RESULTS AND DISCUSSIONS

### A. *Tensile Properties*

The tensile strength capabilities of Bamboo-Bagasse, Bagasse-Coconut Coir and Bamboo-Coconut Coirare determined by testing in the UTM. The tensile properties of the composites are listed in Table1. From table we can see that tensile strength of Bamboo-Bagasse hybrid composite is more than the other two types of hybrid composites composites.

Table 1 Results of tensile testing

| Specimen | Dimensions | Tensile Strength |
|---|---|---|
| Bamboo-Bagasse Composite | 165 mm ×15 mm ×15 mm | 3.5 KN |
| Bagasse-Coconut Coir Composite | 165 mm ×15 mm ×15 mm | 3.1 KN |
| Bamboo-Coconut Coir | 165 mm ×15 mm ×15 mm | 2.7 KN |



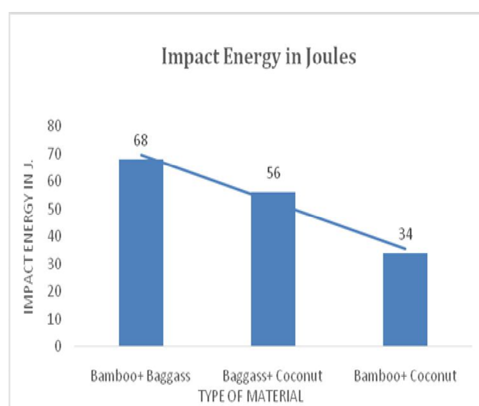




Fig. 4 Graph of tensile strength Vs type of material

### B. *Impact Strength Properties*

The impact strength capabilities of Bamboo-Bagasse, Bagasse-Coconut Coir and Bamboo-Coconut Coir are determined by Charpy Impact testing machine and have been listed in Table 2. From table we can see that Impact strength of Bamboo-Bagasse is more than the other two composites.

Table 2 Results of Impact Testing

| Sr. | Type of Test | Type of Material | Dimensions of Test Specimen | | | Position of Notch | Angle of Fall of Hammer ⁰ | Wt. of Hammer in Kg. | Loading Position |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | B | D | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | | | | |
| 1 | CHARPY | Bamboo+ Baggass | 165 | 15 | 15 | At the Centre | 140 | 25 | Simply Supported |
| | | Baggass+ Coconut | 165 | 15 | 15 | At the Centre | 140 | 25 | Simply Supported |
| | | Bamboo+ Coconut | 165 | 15 | 15 | At the Centre | 140 | 25 | Simply Supported |

| Sr. | Type of Test | Type of Material | Final Reading Joules | Frictional loss if any in Joules | Impact Energy in Joules ( 12-13 ) | Type of Failure | Comments about Impact Strength |
|---|---|---|---|---|---|---|---|
| | | | 12 | 13 | 14 | 15 | 16 |
| 1 | CHARPY | Bamboo+ Baggass | 72 | 4 | 68 | Broken | High |
| | | Baggass+ Coconut | 60 | 4 | 56 | Broken | Medium |
| | | Bamboo+ Coconut | 38 | 4 | 34 | Broken | Low |

- From the above tables, the tensile strength of Bamboo- Bagasse hybrid composite is more compared to other composites. This is because Bamboo fibre is stronger and more resilient.
- The existence of void contents significantly affects the tensile and impact properties of composites. Hence, the voids in composites should be as less as possible in order to obtain desirable mechanical properties up to the expected value.
- The Impact and Tensile strength decrease as we reduce the length. The fibre length of Bamboo and Bagasse is more. So, Impact strength of Bamboo- Bagasse specimen is more than other two specimens.
- Taking into consideration of enhanced tensile and impact strength of bamboo-bagasse hybrid natural fibre polymer composite, we recommend the use of hybrid bamboo-bagasse composite in manufacturing of automotive bodies.

## VI. CONCLUSIONS

In this research paper, an attempt has been made to develop and manufacture hybrid natural fibre composites. From the literature review, we came to know that very less work has been done on natural fibres like coconut coir,sugarcane bagasseand bamboo fibre. Hence, we selected these three fibres for preparation of hybrid composite.To extract water content i.e., is moisture from these fibres we put all these fibre in NAOH solution. After this chemical treatment, we prepared mixture resin and hardener in the proportion of 2:1. We prepared 3 hybrid composites. First one is bamboo fibre and sugarcane bagasse, second is bamboo fibre and coconut coir and third is sugarcane bagasse and coconut coir. Above all these hybrid composites has 50%-50 % content of each fibre. Hybrid composites were manufactured by hand lay – up method. According to the ASTM standards, specimens were cut. Then mechanical properties were determined by performing tensile test on UTM machine and Impact test on Impact testing machine. Results of mechanical testing reveals that, the tensile strength of Bamboo- Bagasse hybrid composite is more compared to other composites. This is because Bamboo fibre is stronger and more resilient. The Impact and Tensile strength decrease as we reduce the length. The fibre length of Bamboo and Bagasse is more. So, Impact strength of Bamboo- Bagasse specimen is more than other two specimens. Hence according to application, we can use this hybrid composite in automobile industry. Taking into consideration of enhanced tensile and impact strength of bamboo-bagasse hybrid natural fibre polymer composite, we recommend the use of hybrid bamboo-bagasse composite in manufacturing of automotive bodies.

## VII. ACKNOWLEDGMENT

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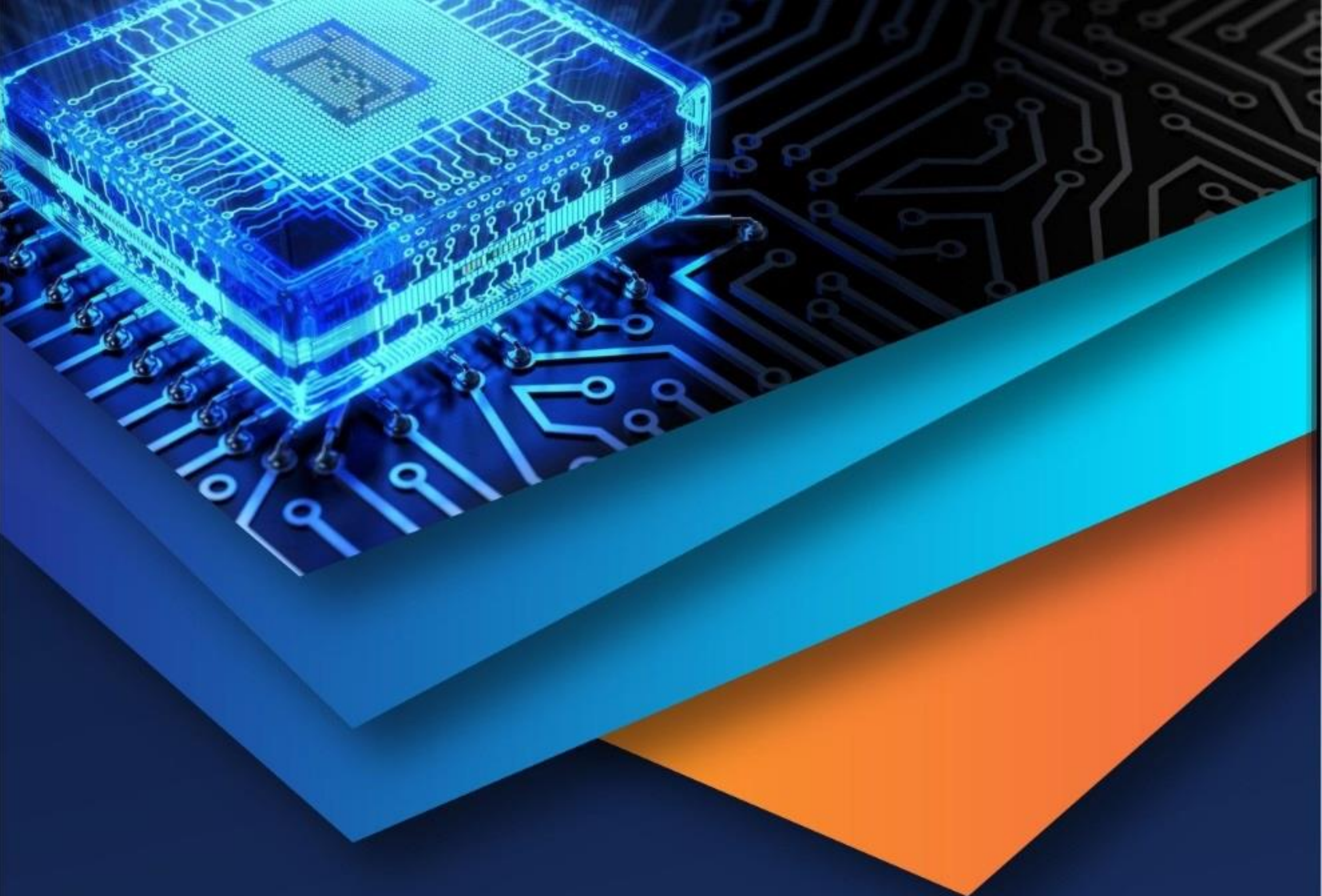


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