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Fabrication of Fiber Reinforced Composite Material Using Bamboo Fiber, Glass Fiber and Polyester

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***Abstract:** Sheet Composites are essential for the aerospace, space, and automotive industry. In fact, a lot of structures and high-performance machines incorporate composites into their design. There are plenty of companies in India who perform composite analysis and manufacturing. Having knowledge and experience in the design and fabrication of composite material increases the employ-ability of an engineer. In this project, you are going to fabricate a composite material in which multiple materials will be used as fiber. This will help you gaining knowledge of composite material too.There are many processes to fabricate a composite material, such as hand lay-up, automated lay-up, spray-up, filament winding, protrusion, resin transfer molding etc. but hand layup method is easy and cost-effective. You will use this process to fabricate this composite material. After fabricating the sample, you need to perform the Tensile test and Compressive test by making standard specimens of your sample in Charpy impact test machine.*
***Keywords:** Bamboo Fiber, Glass fiber, Polyester, Hand Layup, Automated Lay-up etc*

I. INTRODUCTION

Composites are essential for the aerospace, space, and automotive industry. In fact, a lot of structures and high-performance machines incorporate composites into their design. There are plenty of companies in India who perform composite analysis and manufacturing. Having knowledge and experience in the design and fabrication of composite material increases the employability of an engineer. In this project, you are going to fabricate a composite material in which multiple materials will be used as fiber. This will help you gaining knowledge of composite material too.

Bamboo, Flex and Glass fiber are easily available materials and a great addition to the reinforcement phase of the composite material. Strengthening the reinforcement phase increases the strength of the composite significantly

There are many processes to fabricate a composite material, such as hand lay-up, automated lay-up, spray-up, filament winding, pultrusion, resin transfer molding etc. but hand layup method is easy and cost-effective. You will use this process to fabricate this composite material. After fabricating the sample, you need to perform the Tensile test and Compressive test by making standard specimens of your sample in Universal Testing Machine.

1) *Composite Material:* Materials like Iron, Steel are better in tension but poor in compression, similarly Wood, Cast Iron is better in compression but poor in tension. To gain the benefit of having more such properties in one material we combine two or more materials in some arrangement. These types of materials are called composite materials.
2) *Fibre Reinforced Composites:* Fibre reinforced composites have been widely successful in hundreds of applications where there was a need for high strength materials. There are thousands of custom formulations which offer FRP a wide variety of tensile and flexural strengths. When compared with traditional materials such as metals, the combination of high strength and lower weight has made FRC an extremely popular choice for improving a product's design and performance.
3) *Bamboo Fiber:* Bamboo fibre is a regenerated cellulosic fibre produced from bamboo. Starchy pulp is produced from bamboo stems and leaves through a process of alkaline hydrolysis and multi-phase bleaching.
4) *Flex:* Natural fibres are subdivided into different classes with flax being a bast fibre. Bast fibers bear the potential for industrial use based on their toughness and structural contribution. It has outstanding mechanical properties plus local availability. This will be a great addition to the reinforcement phase of your composite.
5) *Glass Fiber:* Glass fiber is also known as fiberglass. It is material made from the extremely fine fiber of glass Fiberglass is a lightweight, extremely strong, and robust material.

6) *Ployester:* The polyester materials, while less costly, have lower strength characteristics and are less heat and weather resistant. As such though, they are the most widely used in commercial products. The epoxy, bismaleimide, phenolic, and polyimide matrix materials exhibit superior mechanical properties and heat resistance quality.

II. STUDY AREA & COLLECTION

A. Study Area

Natural fiber reinforced polymer composites have raised a great attention and interest among scientists and engineers in recent years due to the consideration of veloping environmental friendly materials . They are high specific strength and modulus materials, low priced, recyclable and are easily available. It is known that natural fibers are non-uniform with irregular cross sections which make their structures quite unique and much different with man-made fibers such as glass fibers, carbon fibers etc .Various researchers have worked on the natural fibers containing polyolefins, polystyrene, polyester and epoxy resins. Properties like low cost, light-weight, high specific strength, free from health hazard are the unique selling points of these composites. Though the presence of hydroxyl and other polar groups in the natural fibers leads to the weak interfacial bonding between the fibers and the hydrophobic polymers, these properties can be significantly improved by interfacial treatment . Among the various natural fibers, bamboo fiber is a good candidate for use as natural fibers in composite materials. Jindal has observed that tensile strength of bamboo-fiber reinforced plastic (BFRP) composite is comparatively equivalent to that of the mild steel, whereas their density is only 12% of that of the mild steel. Hence, the BFRP composites can be extremely useful in structural applications. Jain and Kumar have investigated that a uniform strength can be achieved in all directions of the composites by using multidirectional orientation of fibers. Considerable interest has been generated in the manufacturing of thermoplastic composites due to their good fracture toughness and thermal stability With more stringent demands for recycling standards, thermoplastic polymers are substituting thermosetting polymers as matrix materials for high volume consumer-driven composites . Thermoplastic matrix composites materials offer an extended solution in different applications in automotive industry, construction, electrical appliances and home/urban furniture.

B. Collection

20*10*2cm (sample) =(400cc)

1) *Step-1(Reinforcement measure)*

5% Rainforcement (20cc)

Materials	Glass	Bamboo	Polyester
	1.4g/cc	0.6g/cc	1.38g/cc
Volume	2cm	1cm	1cm
	1.442+0.6+1.38=3cc		

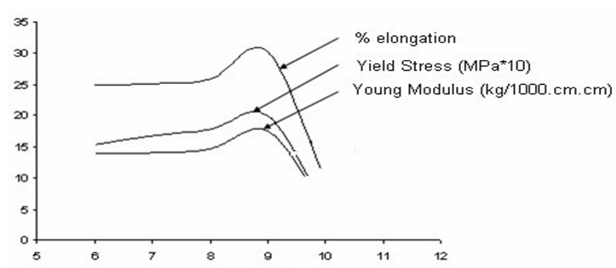
By volume(60:30:10)

Material	Glass	Bamboo	Polyester
Volume	12cc	6cc	2cc
Weight	168kg	3.6kg	2.7kg

2) *Step-2(Matrix = 380cc)*

Resin = 2/3*380 = 2508cc

Hardner =1/3*380 = 126.54cc



Effect of wt% of Hardener (Modi Tide) on Mechanical Properties

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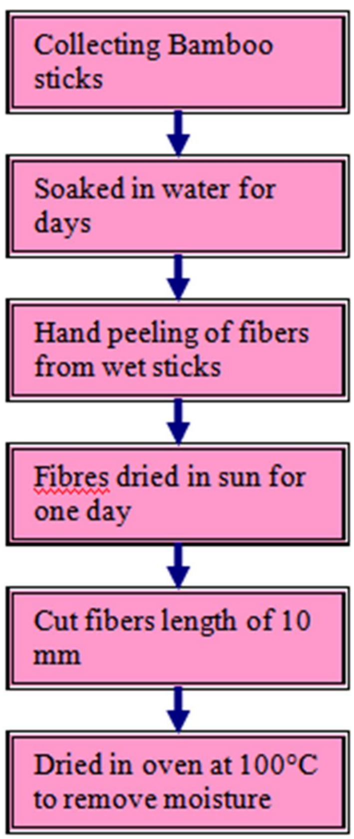
C. Methdology

1) To fabricate the composite first, you have to collect bamboo from your locality. Then you have to wash it thoroughly so that no impurities will be there
2) After completing the above process, you have to dry the Bamboo nearly a day to remove any moisture present in it. Then you have to perform alkali solution treatment to kill bacteria present in it
3) Then you have to cut alkali treated Bamboo into small fibers using the cutter
4) Make a square box with one side open, using wood or Cast iron with dimension 100*100*20mm. This box will be used as a mold for fabricating your composite.
5) Then use polyethylene at the bottom of the mold to get the good surface finish
6) Then start adding one layer of polyester and upon which put fibers layer by layer. Keep repeating this step, until you get desired thickness.
7) After this apply equal pressure throughout the mold so that both the material mixes together to form an effective composite material.
8) Then wait for few hours so that the mixture in the mold dries down and your composite is ready for tasting purpose.
9) Then make a few sample specimens for performing the various test. At least Make 3 standard specimen for each test.
10) Perform a tensile test using a UTM machine to find ultimate tensile strength, breaking strength, maximum elongation, and reduction in area. From these measurements, you can determine Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics.
11) Then perform the compressive test in the same machine to find out ultimate compressive strength, breaking strength etc.
12) Compare both ultimate tensile test and compressive test of your composite with the strength of parent materials.

D. Fabrication of Bamboo Fiber

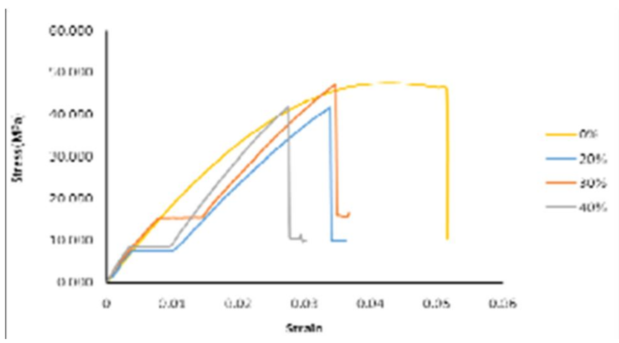


III. RESULTS AND DISCUSSIONS

A. Mechanical Properties

1) Tensile Test

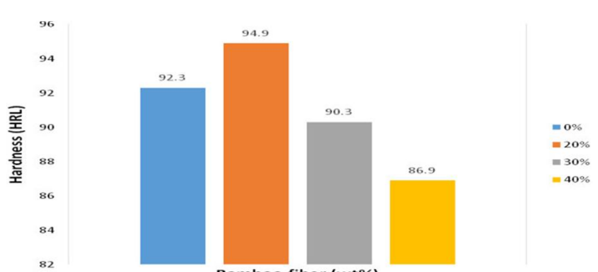
The tensile properties of the bamboo fiber filled epoxy resin composite material were determined by 100 kN universal testing machine at fixed strain rate 1 mm/min under displacement control mode. The results are presented in



The tensile stress-strain curve for unfilled epoxy resin (10 wt% HY-951 hardener and CY-230 resin) and bio composite material containing 20, 30 and 40 wt% bamboo fibers is shown in the figure 6. The variations in tensile strengths of the composites are shown in Fig.6. The tensile strength of the bamboo epoxy composites decreases at 40wt% fiber loading. This decrease in tensile strength is due to the maximum void contents and weak interfacial adhesion in case of composites i.e. when the material is stressed in tension test it tends to elongate and when the material elongates the bond between bamboo fibers and epoxy resin weakens and leads to the loosening of bamboo fibers and leads to fracture of material.

2) Hardness Test

In this study the hardness test have been conducted on L scale on Digital Rockwell hardness testing machine.

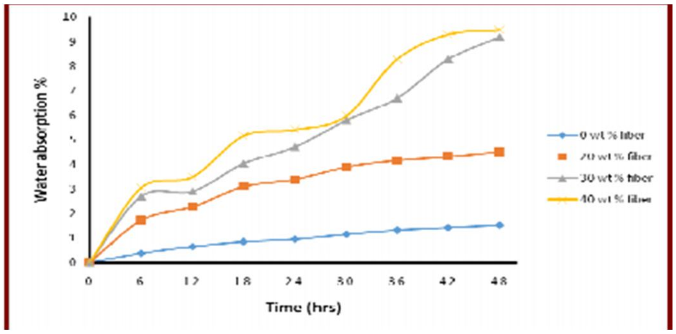


Effect of wt% of bamboo fibers on hardnes

This can be seen that hardness of bamboo fiber reinforced composite decreases with the increase in wt% of bamboo fiber. This may be due to the softness or low hardness of bamboo fiber.

B. Water Absorption Test

Water absorption is a very important test for natural particles and fibers reinforced composites to define their potential for outdoor working. The performance of these composites may suffer while they are exposed to environmental conditions for long time. The water absorption test provides information about the adhesion between the particles and the matrix in the interface region, as higher the adhesion between the matrix and the particles fewer will be sites that could store water and will lead to lower water absorption. Fig.13 shows the percentage of water absorbed at different time intervals.



Shows that the rate of water absorption increases almost linearly for neat (0 wt %) fiber and the water absorption increases for all wt % with water being absorbed by 40 wt % specimen being maximum. The rate of water being absorbed decreases with decreasing wt%. This may be because with the addition of bamboo fibers wt%, the voids and cavities in the materials increases. When the specimens are dipped in the water the water would enter into these locations and cause more absorption. The other reason may be that the bamboo fibers absorb water due to which the material is absorbing more water.

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IV. CONCLUSIONS

Bamboo fiber reinforced epoxy composites have been fabricated with varying fiber concentration. The experimental analysis has shown that bamboo fiber reinforcement in the epoxy matrix has improved the mechanical properties of composite structure. The composites have been fabricated using the hand-lay-up method, which is one of the simplest methods to fabricate the composites under normal conditions. The fabricated composites are of good quality with appropriate bonding between the fiber and resin. However the presence of voids is unavoidable in composite fabrication, particularly through hand-lay-up route. The presence of pores and voids in the composite structure significantly affect a number of mechanical properties and even the performance of the composites. Higher void contents usually mean lower fatigue resistance and greater susceptibility to water penetration. While studying the fiber variations, the increase in fiber loading has improved the hardness but reduced the tensile strength and flexural strength of the composites. This decrease is attributed to the inability of the fiber to support the stress transferred from the polymer matrix. Also the poor interfacial bonding generates partial spaces between the fiber and matrix material, hence resulting in a weak structure**.** Impact strength of composites also increased up to 20wt% fiber loading and then decreased at 30wt%fiber loading. Reduction of impact strength at 30wt% fiber loading was due to micro-spaces between the fiber and matrix polymer, and as a result causes numerous micro-cracks when impact occurs, which induce crack propagation easily and decrease the impact strength of the composites. Absorption of composites in water has been tested. Percentage absorption of chemicals in bamboo epoxy composite increased with increase in fiber content. Water absorption of composites increased with increase in fiber loading. The hydrophilic nature of bamboo fibers is responsible for water 161 absorption. Water absorption of particulate filled composites has been found to be less than the unfilled composites.

V. RECOMMENDATIONS

Manufacturers and engineers are always on the look for the new materials and improved processes to use in the manufacturing of better products, and thus increase their profit margin. The developed composites are a good substitute for a number of petroleum based products and form a very much sustainable resource. They have lot of advantages like low density, low price, recyclable, biodegradable, low abrasive wear, CO2 neutral and environment friendly. Natural fiber composites are being used in a large number of applications in automotive, constructions, marine, electronic and aerospace. These composite have a lot potential as a low cost polymeric composite material for tri bological applications also. Bamboo epoxy composites form a new class of bio-fiber reinforced composites, which may find potential applications in:

1) Conveyor belt rollers.
2) Passenger seat frames (replacing wood/steel) in railway coaches / automobiles
3) Pipes carrying pulverized coal in power plants
4) Pump and impeller blades
5) Household furniture and also as low cost housing materials.
6) Helicopter fan blades
7) Trim parts in dashboards
8) Door panels and Seat Cushions
9) Parcel shelves
10) Seat cushions 165
11) Backrests and Cabin linings.

VI. FUTURE SCOPE OF WORK

Bamboo-Epoxy composites have a lot of research potential, considering the present day environmental concerns.

The work of the present thesis can be extended by a number of different ways. Considering the raw materials, unidirectional short bamboo fibres has been used for fabrication of the composites in the present work. However bi-directional bamboo can also be used as reinforcement in the composites. Fiber length can be one of the

variables in the composite fabrication and their effect can be studied on the mechanical, chemical and erosive properties. Other thermosetting polymers like polyesters polyurethane and thermoplastics like polypropylene can also be used as resins in the bamboo based polymer composites. As far as the fabrication method is concerned, the hand up lay up method has been used for fabrication of composites in the present work. It is recommended

that the use of injection moulding to fabricate composites samples for testing is more precise and it reduces much of human errors. The chemical resistance and water absorption of composites have been studied in the present work; however the effect of temperature on the water absorption can be explored as future work. Effect

of chemicals on the mechanical properties of the composites can also be a good problem to study. Other chemical properties like Moisture absorption and swelling behavior of bamboo epoxy composites can also be studied wear behavior of composite can also be explored.

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If east LDR voltage is equal to west LDR
Positive Very Small (PVS):
If east LDR voltage is larger than west LDR
Positive Small (PS):
If east LDR voltage is much larger than west LDR
Membership function of ZE is triangular with the input range of -0.1 to 0.1 Volts. The experimental results show that at this value, each sensor receives solar radiation that almost the same or in other words that the PV panel is perpendicular to the sun. Accordingly, when the error is in the range then the movement of the motor will be stopped (STOP MODE) as shown figure 7. Meanwhile PVS has a trapezoidal membership functions, where the range is 0.1 - 0.3 volts. In this range, the position of the PV panel is nearly perpendicular to the sun. Thus the motor will move slowly for a clockwise direction (CW SLOW) so that the PV panel will return to its original position. PS has a trapezoidal membership functions, according to the experiments, error input is more than 0.4 Volt. In this case, the position of the PV panel is't perpendicular to the sun. This occurs when the start-up in the morning, where the position of the PV panel is facing west while the sun rise from the east. Therefore, the motor will move quickly in a clockwise direction to search the real position of the sun (CW FAST). As for membership functions of NVS is trapezoidal where the error is -0.1 - 0.3 volts. At this point, the position of the PV panel is almost perpendicular to the sun. It means the motor must move slowly counter-clockwise in order to keep the PV panels facing the sun (CCW SLOW). Whereas NS has a trapezoidal membership functions which the input error is less than - 0.4 volts. It is similar to the PS where its difference is the direction of rotary motors that move opposite to the clockwise (CCW FAST).

DC MOTORS

DC motor has the characteristics of low power consumption, large torque, low noise, small size, light weight, and easy to use. The DC motor used as actuator in the system has maximum angular speed of 5 rpm and 12 V of voltage supply. It is also equipped by gearbox as a speed reducer and it can move or rotate smoothly, as shown figure 9. Direction and speed of the DC motor represent plant outputs. In this case, the direction of DC motor can be set using the motor driver circuit, namely IC L298N. Moreover, the angular speed of the DC motor is controlled through a mechanism of PWM (Pulse Width Modulation). As stated previously that the DC motor in off -mode when the difference in the intensity of both two LDRs received are small (< 0.1 volt). This value is based onthe experiment results and is intended to avoid oscillation.

ASSEMBLING OF SOLAR TRACKING SYSTEM

The second stage is to integrate electrical and mechanical components as shown in fig 10 below, where according to experiments can be acquired that optimum angle of slope / tilt of PV panels is 30o for dry season (it is set based on date, month and latitude). The results of the testing of each component indicated that these have linear characteristics with the maximum hysteresis is less than 5.5%. In other word, that they have a reasonably good performance.

RESULTS AND DISCUSSIONS

To test the performance of the system was built, several experiments were carried out by comparing the output power generated by the PV panels of both fixed and tracking system where two PV panels used in the experiments have the same specifications and characteristics. The configuration of the experiments is shown in fig. 11 below
Figure ilustrates the comparison of output energy generated by two different systems (tracking vs. Fixed PV panel) for one-day i.e starting from 07.00 AM until 04.00 PM, the data are taken every 30 minutes, while the sky is clear with maximum illumination intensity, air temperature and the average wind speed are 110 600 lux, 36.3°C and 2 m/s, respectively. The location of the experiment is in surabaya –
Indonesia. Based on the experiment results, it can be known that the largest power increase achieved by the solar tracking system is 192.5% of the fixed PV panel which occurred at 09.00 AM. This shows that the radiation and temperature received by the tracking PV panel are more optimal than the other. The average power increase produced by using the tracking system for a particular day (one – day experiment), is over 47% compared with the fixed one

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5While the experiment results conducted for one month from 1 to 30 June 2013 are shown figure 13, where the environmental conditions including temperature, solar light intensity and wind speed are almost the same as the previous. The average power increase of the system is 47.16% compared to the fixed one. It means during the dry season that the prototype can improve the power efficiency over 47%, especially in Indonesia which is a tropical country with two seasons.

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CONCLUSIONS

Based on the experiment results we have concluded that the proposed fuzzy logic controller for a solar tracking system has worked properly. A fuzzy logic controller (one input – one output) was implemented on ATMEGA 8353 microcontroller to increase power gain of PV panels. The output power generated by the PV panels has been maximized, even to some extent it exceeded 47% compared to the fixed panel. Overall, the fuzzy logic controller based solar tracking system which is already built is an efficient system for renewable energy

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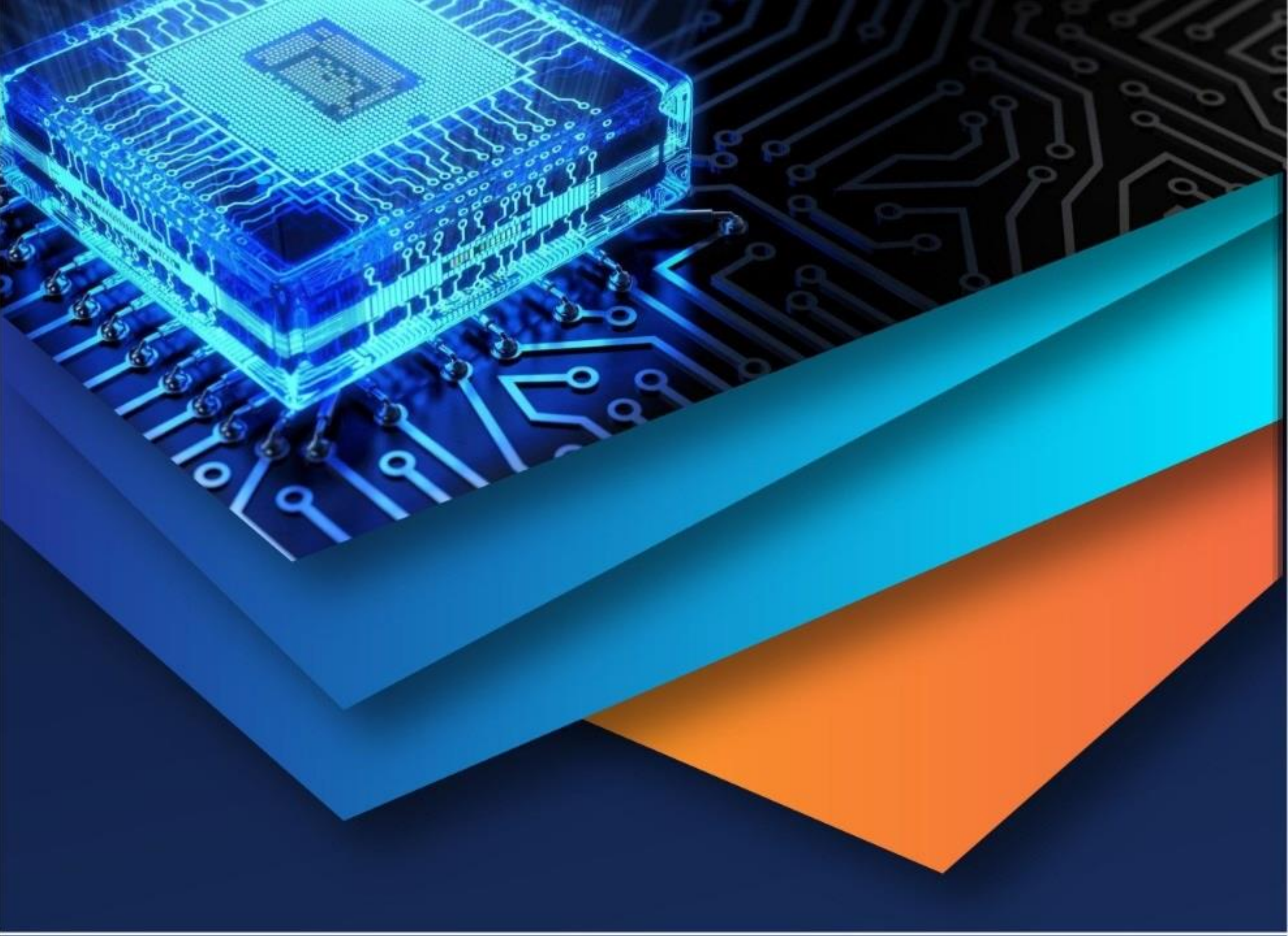

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