iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: I Month of publication: January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1478

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Preparation and Mechanical Optimization of Composite Laminates

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Abstract: Composite materials reinforced with synthetic fibers such as glass, carbon, and aramid provide Advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. wood, concrete, and steel. But replace of synthetic fiber of composite Material to natural fibers like Kenaf, jute, etc and improve the properties of natural and compare to other synthetic fiber as well as now used material and prepared for Kenaf and jute fiber and e-glass fiber compare the properties as tensile test and water absorption and pressure test and manufacturing of composite pipes of Kenaf, jute and composite pipe of E-Glass are finding the best properties of composite material will be compare.
Keywords: Composite Materials (kenaf, jute, E-Glass), Resins

I. INTRODUCTION

In the past few decades, research and engineering interest has been shifting from monolithic materials to fiber-reinforced polymeric composite materials. These composite materials (notably aramid, carbon and glass fiber reinforced plastics) now dominate the aerospace, leisure, automotive, construction and sporting industries. Glass fibers are the most widely used to reinforce plastics due to their low cost (compared to aramid and carbon) and fairly good mechanical properties. However, these fibers have serious drawbacks. The shortcomings have been highly exploited by proponents of natural fiber composites. Carbon dioxide neutrality of natural fibers is particularly attractive. Attempts have been made to use natural fiber composites in place of glass mostly in non-structural applications. So far a good number of automotive components previously made with glass fiber composites are now being manufactured using environmentally friendly composites.

II. PREPARATION OF SPECIMEN

A. Hand Lay-Up Method

Chopped strand glass fiber mat is the reinforcement most commonly used in contact moulding, though the use of woven and various combination materials has grown considerably over the years. The preparation of reinforcement ‘packs’, specifically tailored to the mould being used, saves time and reduces wastage.

The amount of resin required for a laminate can be calculated by weighing the reinforcement to be used. Resin to glass ratios of approximately 1 to 1 (50% glass content) are normal for woven roving, whilst those achievable with combination reinforcements will vary depending on the construction of the particular fabric used.

Once the Resin has cured sufficiently, a liberal coat of resin is applied as evenly as possible. The first layer of glass is then pressed firmly into place and consolidated using a brush or roller. This action will enable the resin to impregnate the glass mat and dissolve the binder which holds the fibers together.

Fig 1: E-Glass lamina, roller and cavity and E-Glass lamina

The reinforcement will then conform readily to the contours of the mould. Once the first layer of mat is fully impregnated, further resin can be added, if necessary, before applying subsequent layers of reinforcement. It is important that the first layer is as free of air bubbles as possible, as any air trapped immediately behind the Resin could lead to blistering, should the moulding be exposed to heat or water during its working life. Impregnation of the reinforcement can be carried out using a brush, or a mohair or polyester roller. If a brush is used, it should be worked with a stippling action, as any sideways brushing motion will displace the fibers and destroy their random nature. The use of rollers is advantageous when working on large moulds and they are available with long or short pile. Long pile rollers pick up more resin than short pile ones, but care needs to be taken to accurately control resin to glass ratios.

Fig 2: Weight on the mould cavity, E-Glass laminate

Consolidation of the laminate is more effective if carried out using a roller and several types have been developed for the purpose. Metal paddle, disc or fin rollers are available, and of these, thin fin types have proved particularly effective in removing air bubbles trapped in the resin. Subsequent layers of resin and reinforcement are applied until the required thickness has been achieved, ensuring that each layer is thoroughly impregnated and properly consolidated. As per ASTM D5868-01 standard tensile specimens of different orientation are cut from the fabricated laminates using hacksaw frame and to maintain good surface finish as shown in

Fig 3: Test laminate of kenaf fiber

III. SPECIMEN PREPARATION AND TESTING

The mechanical testing methods that are carried out were based on American Society for Testing and Materials (ASTM).There are below tests to be perform, Water Absorption Test(ASTM D570),Tensile test(ASTM D5868-01).

A. Tensile Test Specimen of Kenaf Fiber

Specimens for tensile test are cut from Laminates as per ASTM D 790standard.

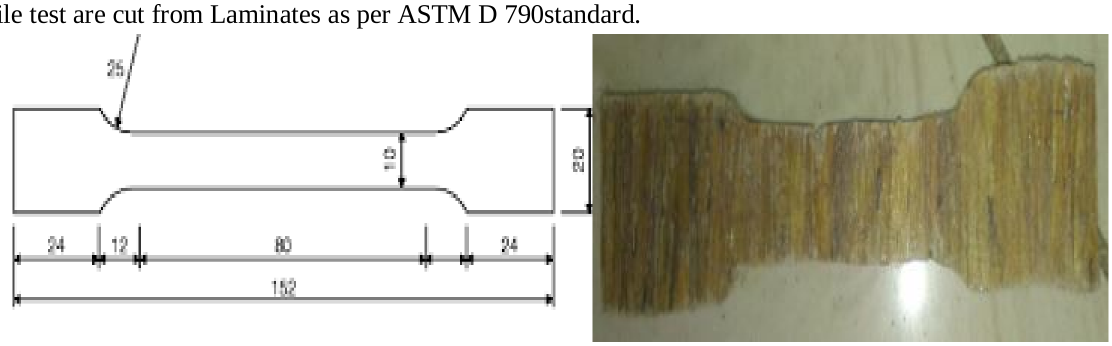

Fig 4: Tensile Test standard dimensions and Test Specimen

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The load vs displacement curve was plotted by using experimental results. The X-axis indicates displacement value and Y-axis indicate load value

Fig 5: Kenaf specimen

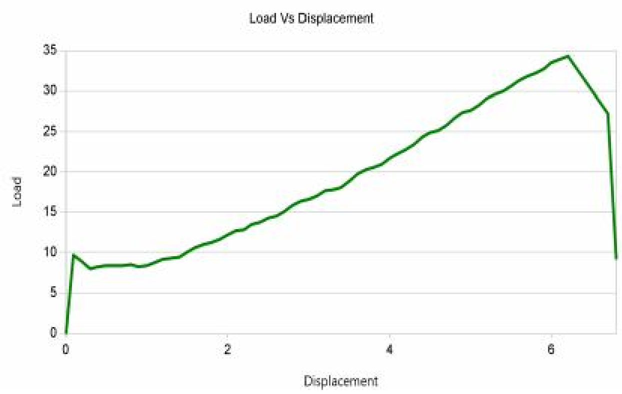

Fig 6: Load and displacement graph

Load (KN)	Displacement (mm)	Stress (N/mm^2)	Strain
0	0	0	0
4	0.08	78.43	0.001
8	0.3	156.86	0.00875
12	2	235.294	0.025
16	2.8	3.13.725	0.035
20	3.6	392.15	0.045
24	4.6	470.588	0.0575
28	5	549.01	0.0625
32	5.75	627.45	0.0718
34.34	6.2	673.33	0.0775
28	6.9	549.01	0.08625
12	7.2	235.294	0.09

Table 1:Stress-Strain Values

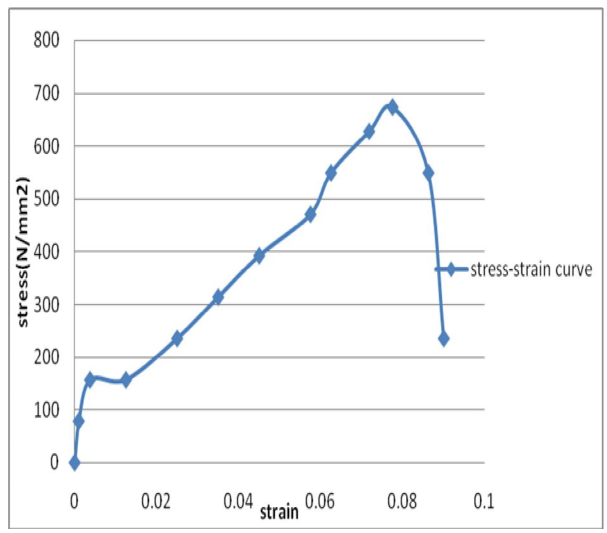

Fig 7: Stress-strain graph

B. E-Glass Fiber

The load vs displacement curve was plotted by using experimental results. The X-axis indicates displacement value and Y-axis indicate load value

Fig: 8 E-glass specimen

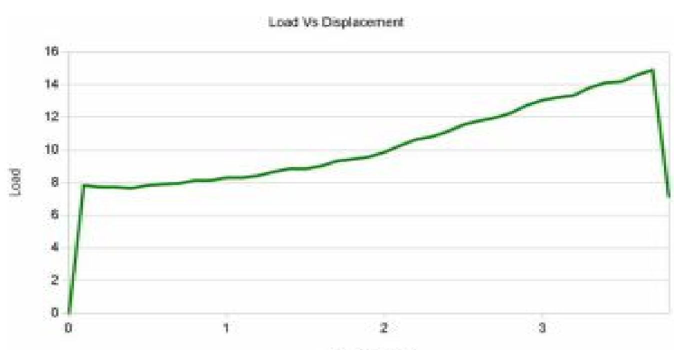

Fig:9 load and displacement graph

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Load (KN)	Displacement (mm)	Stress (N/mm^2)	Strain
0	0	0	0
2	0.004	41.4.7	0.0005
4	0.008	82.815	0.001
6	0.14	124.22	0.00175
8	1.82	165.63	0.02275
10	3	207.039	0.0375
12	4	248.44	0.05
14	5.75	289.855	0.0718
16	5.9	323.809	0.07375
6	6.2	124.22	0.0775
10	6	207.039	0.075

Table 2: Stress-Strain Values

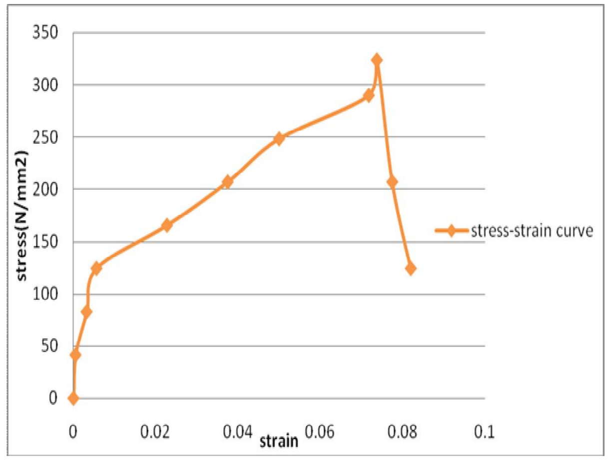

Fig 10: stress-strain

C. Jute Fiber

The load vs displacement curve was plotted by using experimental results. The X-axis indicates displacement value and Y-axis indicate load value

Fig11: jute specimen

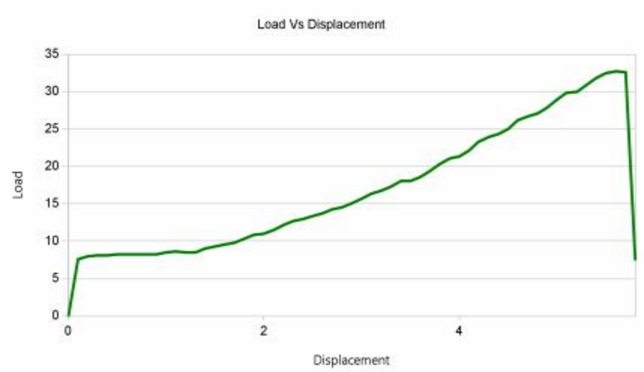

Fig12: load and displacement graph

Load (KN)	Displacement (mm)	Stress (N/mm^2)	Strain
0	0	0	0
4	0.09	57.14	0.001125
8	0.4	114.28	0.005
10	1.8	142.85	0.0225
12	2.2	171.42	0.0275
16	3.08	228.57	0.0385
20	3.9	285.71	0.04875
24	4.2	342.85	0.0525
28	5.3	400	0.06625
32	5.48	457	0.0685
20	5.5	285.71	0.06875
28	5.56	400	0.0695
24	5.6	342.85	0.07
10	5.7	142.85	0.07125

Table 3: Stress-Strain Values

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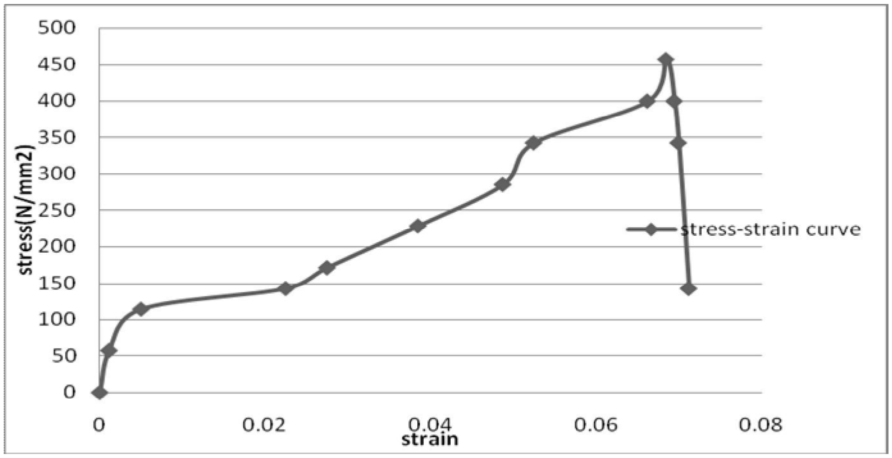

Fig:13stress-strain graph

IV. RESULTS AND DISCUSSIONS

A. *Tensile Test Results*

Table 4: Modulus of Elastic of Different Types of Fiber Composites

s.no	Type of composite	Thickness of laminate (mm)	Modulus of Elastic(E_X) N/MM^2 10^5	Modulus of Elastic(E_Y) N/MM^2 10^5	Modulus of Elastic(E_Z) N/MM^2 10^5
1	Kenaf	4	3.316	1.08	1.08
2	Jute	4	3.31	1.286	1.286
3	E-glass	4	5.2	6.39	6.39

Table 5: Rigidity Modules of Different Types of Fiber Composites

s.no	Type of composite	Thickness of laminate (mm)	Rigidity Modules (G_X) Gpa	Rigidity Modules(G_Y) Gpa	Rigidity Modules (G_Z) Gpa
1	Kenaf	4	1.1758	0.42	0.42
2	Jute	4	2.36	0.53	0.53
3	E-Glass	4	2.08	2.36	2.36

Table 6: Poisson Ratio and Different Types of Fiber Composites

s.no	Type of composite	Thickness of laminate(mm)	Poisson Ratio (μ_X)	Poisson Ratio (μ_Y)	Poisson Ratio (μ_Z)
1	Kenaf	4	0.41	0.26	0.26
2	Jute	4	0.33	0.21	0.21
3	E-Glass	4	0.25	0.35	0.35

Table 7: Ultimate Strength and Breaking Load for kenaf

Type of composite	Thickness of laminate (mm)	Breaking load (KN)	Ultimate strength (KN/mm^2)
Kenaf	4	34.34	0.673
Jute	4	20.8	0.546
E-Glass	4	17.18	0.318

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Table 8:Ultimate Strength and Breaking Load and strength to Weight ratio

Type of composite	Laminate Thickness (mm)	Breaking load (KN)	Ultimate strength (KN/mm^2)	strength to Weight ratio
1.kenaf	4	34.34	0.673	122.69
2.E-Glass	4	14.92	0.324	65.15
3.Jute	4	20.58	0.572	104.28

Table 9:Hoop Stress & Longitudinal Stress and Max Pressure

S.No	Material	Hoop Stress (N/mm^2)	Longitudinal Stress (N/mm^2)	Max Pressure (N/mm^2)
1	Kenaf	1509.27	754.63	455.63
2	Jute	1125.96	562.98	339.91
3	E-Glass	770.91	385.45	232.73

B. Water Absorption Test Specimen

Specimens for Water Test are cut from laminas as per ASTM D 570 standards.

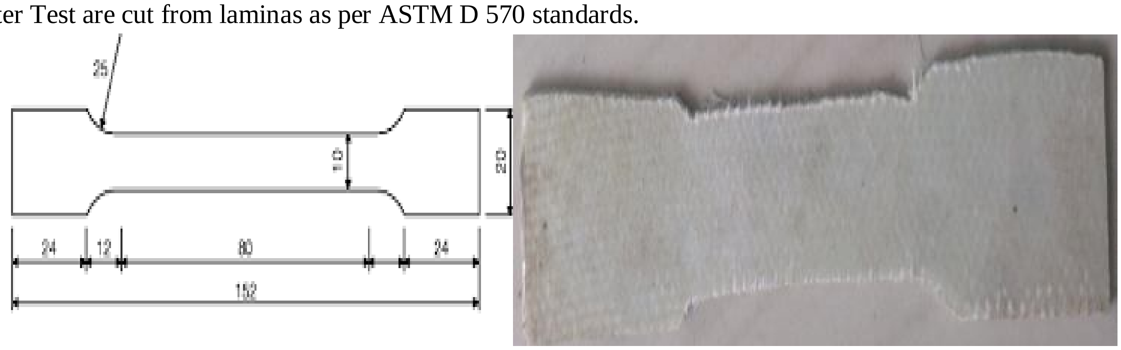

Fig 14: Water Absorption Standard Dimensions and Test specimen

S.no	Type of composite	Conditioned weight(gms)	Wet weight(gms)	Re conditioned weight(gms)	% increase in wt of specimen	% amount of soluble mater lost
1	kenaf	44.000	42.800	43.751	1.56	0.46
2	E-Glass	44.840	43.940	44.41	2.52	0.79
3	Jute	44.600	43.500	44.250	2.04	0.41

Table 10: Water Absorption Test Result

V. CONCLUSION

In the present work, one artificial and three natural fibers are used. The materials selected were fully characterized in terms of their mechanical properties. The data obtained on the single lamina prepared with that natural fibers (i.e Kenaf fiber) has good properties, when compared to the other fibers (Jute and E-glass). Experiments were conducted on the prototype model by simulating the real working conditions of tensile test & Water absorption test confirmed that kenaf Fiber only can withstand the real working conditions.

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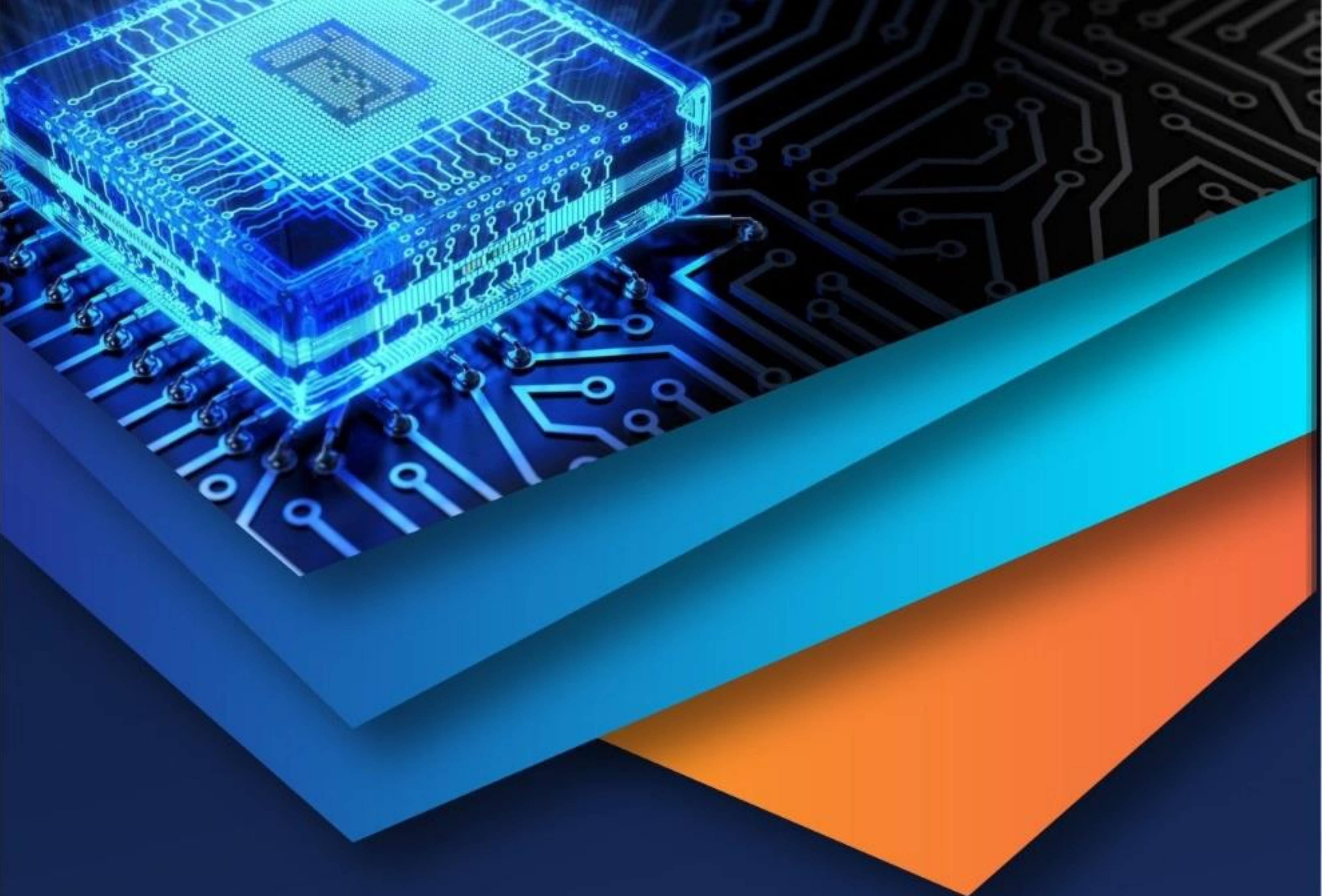

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