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An Experimental Investigation and Development Of Conventional Laminated GFRP And Al6061 Powder Reinforced Laminated GFRP For The Application Of Car Frontal Frames With fem - Crash Simulation Analysis

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Abstract :The project deals with the development of Aluminum reinforced GFRP (glass fiber reinforced plastic) which will serve as an effective replacement for conventional Aluminum A360 alloy, Structural Steel A36 & comparative study on GFRP used to manufacture safety frames in automobiles .Aluminum - glass fiber reinforced plastics (GFRP) sandwich panels are hybrid laminates consisting of GFRP bonded with resin epoxy mixed aluminum powder. Such sandwich materials are increasingly used in airplane and automobile structures. Laminates with varying aluminum thickness fractions, fiber volume fractions and orientation in the layers of GFRP were fabricated by hand lay-up method and evaluated for their impact performance by conducting Tensile Test, Compression Test and Wear Test. The impact energy required for initiating a crack in the outer aluminum layer as well as the energy required for perforation was recorded. Scanning electron micrographs were taken to visualize the crack and the damage zone. The bidirectional cross-ply hybrid laminate AL-GFRP has been found to exhibit better impact performance and damage resistance than the unidirectional hybrid laminate (GFRP). Introduction of aluminum powder along with GFRP and a greater extent of thickness fraction (Al_{tf}) and fiber volume fraction (V_f) resulted in an increase in the impact energy required for cracking and perforation. On an overall basis, the sandwich panels of AL-GFRP exhibited better impact performance than the monolithic aluminum supported with FEM Proof – Crash test analysis through ANSYS software.
Keywords: Aluminum Powder - glass fiber sandwich panels, Tensile, compressive Strengths,Impact resistance, Wear Resistance and ANSYSV16, Crash Test Simulations.

I. INTRODUCTION

In the wake of passenger safety becoming an important industry norm we propose to replace the traditional material Structural steel-A36 with Aluminum reinforced GFRP.The project focuses on the reinforcement of GFRP with Aluminum powder by Hand layup method for optimal energy absorbing properties.The latter part of the project focuses on testing the composite material laminate and applying the material properties(GFRP) to frontal frame model in ANSYS and studying the stress, strain and deformation to justify that AL-reinforced GFRP is an effective and better alternative to conventional A36 Steel.The material being economical and extremely reliable against fatigue can replace carbon fiber based composites in sports cars.Thus, safety norms can become less expensive and help save the consumer money without taking chances on safety. Composite materials has seen several civil engineering applications.Glass Fiber reinforced plastic(GFRP) has been used to strengthen structures such as beams and slabs. Our project focuses on application of a suitable light weight, high energy absorbing and high strength composite material for automobile safety frames–The frontal frame.The frontal frame being the most important impact dissipation safety feature in the car has to be extremely light and also should deform adequately to absorb the impact during collision.

In this paper car bumper is selected a bumper is a shield made of steel, aluminum, rubber, or plastic that is mounted on the front and rear of a passenger car. When a low speed collision occurs, the bumper system absorbs the shock to prevent or reduce damage to the car. In existing bumper the weight is more. In the present trends the weight reduction has been the main focus of automobile manufacturers. Less fuel consumption, less weight, effective utilization of natural resources is main focus ofautomobile manufacturers in the present scenario. The above can be achieved by introducing better design concept, better material and effective manufacturing process. Steel bumper have many advantages such as good load carrying capacity. In spite of its advantages, it stays back in low strength to weight ratio. It is reported that weight reduction with adequate improvement of mechanical properties has made composites as a viable replacement material for conventional steel. In the present work, the steel bumper used in passenger vehicles is replaced with a composite bumper made of glass/epoxy composites. The thickness of the composite bumper is calculated by bending moment equation and other dimensions for both steel and composite bumper is considered to be the same. The objective was to compare the stress, weight, and cost savings.

II. EXPERIMENTAL DETAILS

A. *Material selection*

Material selection is done on the basis properties required to facilitate good strength to the part for automotive by the literature survey, materials ware identified which may be suitable say aluminum, glass etc. Because of their mechanical properties and availability so these materials are selected for the analysis and manufacturing the part.

Aluminum has a unique and unbeatable combination of properties that make it into a versatile, highly usable and attractive construction material.

Table.1 PROPERTIES	
Tensile Strength	70-700 MPa depending on alloy
Elasticity (Young's Modulus)	70,000 MPa
Specific weight	2.7 g/m^3
Grade	Al 6061
Corrosion	Good resistance

Table.1 Properties of Al6061

Glass is one of the oldest known man-made materials; the practical strength of glass, however, has always been a limiting and puzzling Factor

Table .2 PROPERTIES	
Tensile Strength	430 MPa Standard Structure
Elasticity (Young's Modulus)	72,000 MPa
Specific weight	2.59 g/m^3
Grade	E-Glass
Corrosion	Good resistance

Table.2 Mechanical Properties of Glass Fiber

Table.3 EPOXY	
Resin	LY556
Hardener	HY951

Table.3.Epoxy-Mixture

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent products to form a very strong and relatively lightweight Hybrid Composite.

B. *Sample Preparation*

The fabrication of Al reinforced GFRP (Glass Fiber polymer Reinforced with Aluminum) by Hand lay-up technique, it is simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. Resins are impregnated by hand into fibers which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions.

1) *Advantages*
2) *Design Flexibility.* Tooling cost is low. Design changes are easily effected. Sandwich construction are possible.
3) *Disadvantages*: One molded surface is obtained. Low volume process.

Longer cure times required. Waste factor can be high

Table.4 Selection of materials:

Material	Type	Thickness in mm	Dimension in mm	QTY
Glass Fiber	Woven roving	3	300x300	12 No
Aluminium	Al6061	Power		50 gms
Resin	LY556			300 ml
Hardener	Hy951			30 ml

Figure.1Aluminium Power

Figure.2 Glass woven roving

Figure.3 Resin

Figure.4 Hardener

Figure.5

1) *Procedure*
   Glass fibers are cut with required dimension and numbers
2) Aluminum, Resin, Hardener are measured and taken as required.
3) .Hand Lay-Up Process - Initially wax is applied to a plastic sheet, then the mixture of resin is applied on the sheet and a layer of glass fiber is placed, again the resin is applied by brush to the fiber, the another layer is placed and the resin is applied. This steps are repeated till 6 layers is done. Finally another sheet which is waxed is placed on the final layer, the load is kept on the laminate and it is allowed to dry at room temperature.
4) Finally the component is obtained.

C. *Experiment*

Glass fiber reinforced aluminum is fabricated using Hand lay-up method the specimen is taken for testing like Tensile Compression and impact employing testing machines like UTM (Universal Testing Machine) and Impact testing machine (Charpy) the specification of these machines are shown below:

Figure.6 UTM

Table.5 EQUIPMENT DETAILS

Name of the equipment		Universal Testing machine
Sl.No		ML/MT/034
Model		WDW 100
Serial no		02 08 93
Make		TE
Range		(0-100)kN
Calibration due date		08.05.2017

Figure.7 Impact Testing Machine

Name of the equipment	Impact Testing machine
Sl.No	ML/MT/004
Model	IT-30
Serial no	81/993
Make	FIE
Range	0-300 J
Calibration due date	08.05.2017

Table.6 EQUIPMENT DETAILS

D. Specimen for testing

The fabricated specimen is cut into number of samples to carry out the testing as shown below

Figure.8Samples

1) *Tensile Test:* From the specimen two samples are chosen for conducting the tensile test with the parameters as shown below:

(a) Sample on Machine (b) Sample after testing
Figure.9

Table.7 Tensile Test Parameters

Test Parameters	Sample 01	Sample 02
Gauge Thickness (mm)	3.84	3.82
Gauge Width (mm)	23.22	22.96
Original Cross Sectional Area (mm^2)	89.16	87.71
Ultimate Tensile Load (kN)	29.52	29.08
Ultimate Tensile Strength(MPa)	331.09	331.55

2) Compression Test: From the specimen two samples are chosen for conducting the compression test with the parameters as shown below:

Figure.10 Sample mounted on Machine

Figure.11 Sample after compression test

Table.8 Compression Test Parameters

Test Parameters	Sample 01	Sample 02
Gauge Thickness (mm)	3.91	3.96
Gauge Width (mm)	22.82	23.03
Original Cross Sectional Area (mm)	89.23	91.20
Compression Load (kN)	1.35	1.26
Compression Strength(MPa)	15.13	13.82

3) Impact Test

From the specimen three samples are chosen for conducting the impact test with the parameters as shown below

Figure.12
Sample mounting on machine

Figure.13

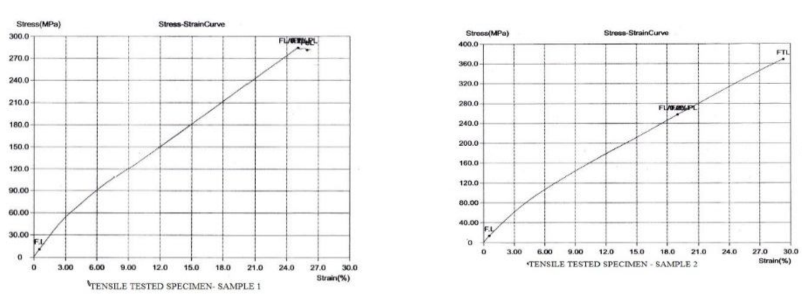
Table.9 Impact Test Parameters

Specimen size (mm)	3.5x10x80	
With out notch		
Test temperature	RT	
Sample	Absorbed Energy-Joules	
1	10	
2	08	
3	09	
Average	9	

III. RESULTS AND DISCUSSONS

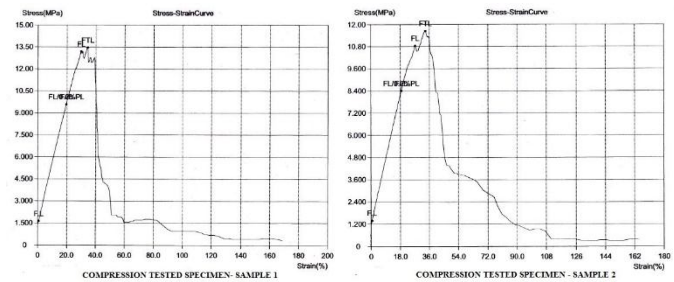
The tests are conducted as discussed above obtained results in the form of graph is plotted below and the values are compared with each other.

A. *For tensile test:*

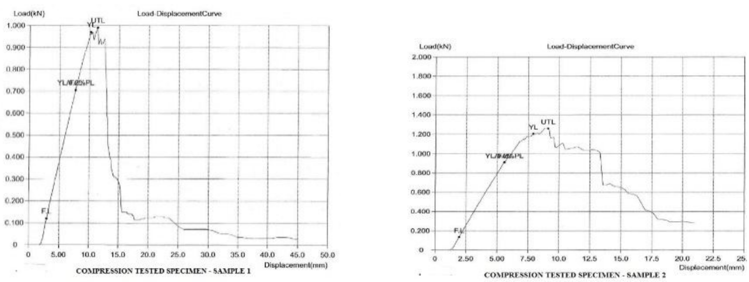


(a) (b)
Figure.14 Stress-Strain Curve

Figure.15 Load-displacement curve



B. For compression



(a) (b)

Figure.16 Stress-Strain Curve

(a) (b)

Figure.17 Load-displacement curve

C. Observations

Table.10

Materials Parameters	GFRP	AL+GFRP
ultimate tensile load (kN)	25.325	29.30
ultimate tensile strength (MPa)	326.34	331.32

(a)

Materials Parameters	GFRP	AL+GFRP
compressive load (kN)	0.995	1.305
compressive strength (MPa)	12.55	14.475

(b)

Materials Parameters	GFRP	AL+GFRP
Absorbed Energy - Joules	13	09

(c)

Comparison of GFRP and AL+GFRP is done as below:

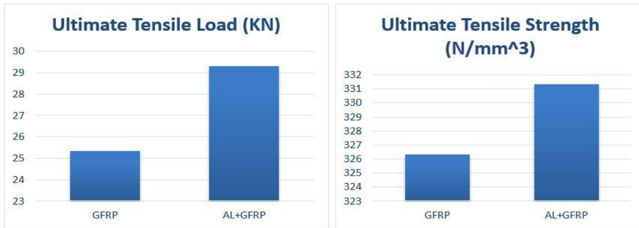


Figure 18 Ultimate Tensile

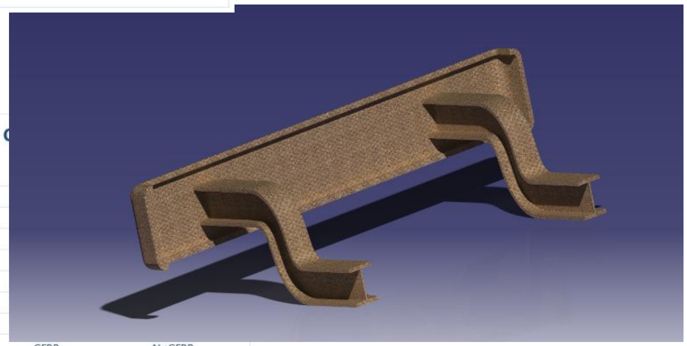


Figure19.Ultimate Tensile

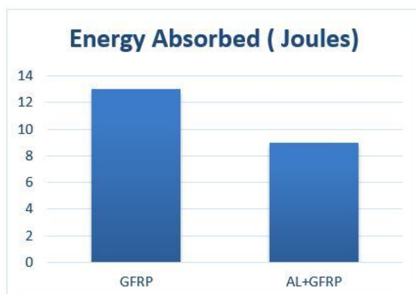


Figure.20 CompressionFigure.21 Compression

AL+GFRP exhibits superior strength in 4 aspects but due to uneven Epoxy+E-glass bonding the “Energy Absorbed” in AL+GFRP has been reduced.

IV. ANSYS WORK BENCH

A. Solution

Governing matrix equations.Solves for the displacements, strains and stresses. Alternatively explicit codes can be used, mostly for high strain rate engineering problems

B. Pre-Processing

Finite element mesh generation. Applies material properties, Boundary conditions and loads.

C. Post-Processing

Analyst obtains results usually in the form of deformed shapes, contour plots etc. which help to check the validity of the solution

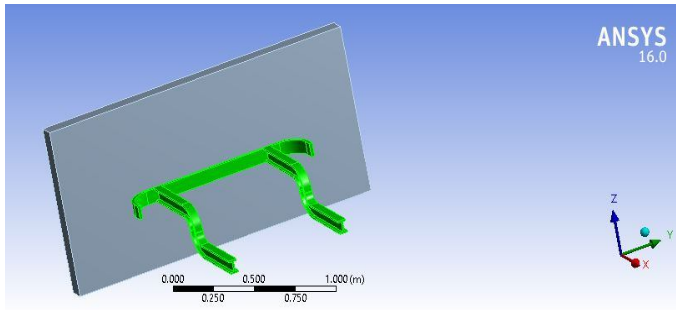


Figure.23Proposed Part ModelDesign [AL+GFRP] - CATIA

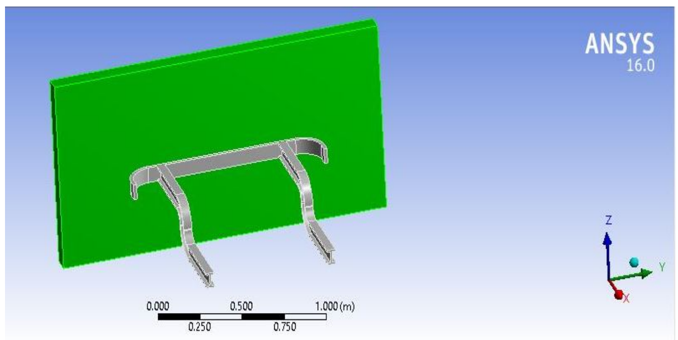


Figure.24 Part Model – Frontal Frame(Moving Part)

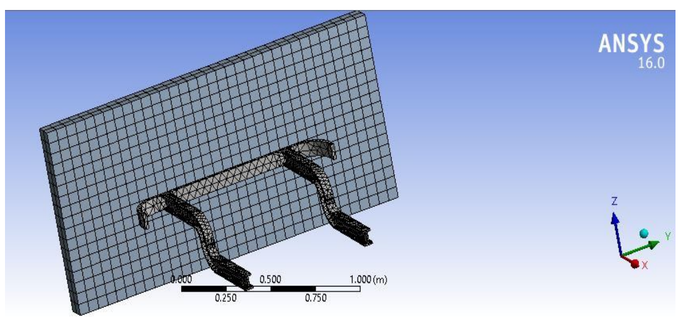


Figure.25 Part Model – Concrete Block (Fixed Support)

Figure.26Mesh Generation

The explicit dynamics method is used for the analysis with the following engineering data.

Table.11 Engineering Data

GFRP	Value
Density	1600 kg/m^3
Young's Modulus	1.5E+10 pa
Poisson's Ratio	0.21
GFRP with AL	Value
Density	2210 kg/m^3
Young's Modulus	3.15E+10 pa
Poisson's Ratio	0.237
CONCERTE	Value
Density	2400 kg/m^3
Young's Modulus	1.7E+10 pa
Poisson's Ratio	0.21

A. Result Obtained From The Software

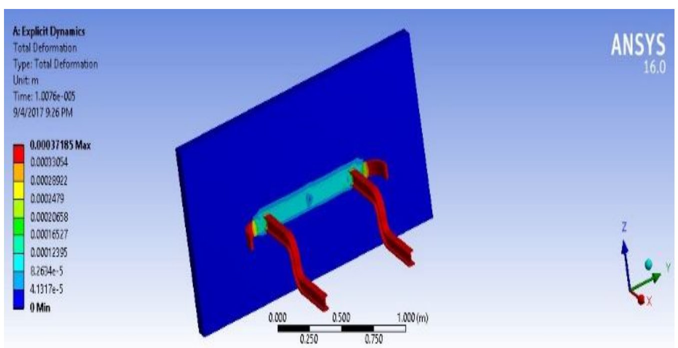


Figure.27 Part made of AL+GFRP

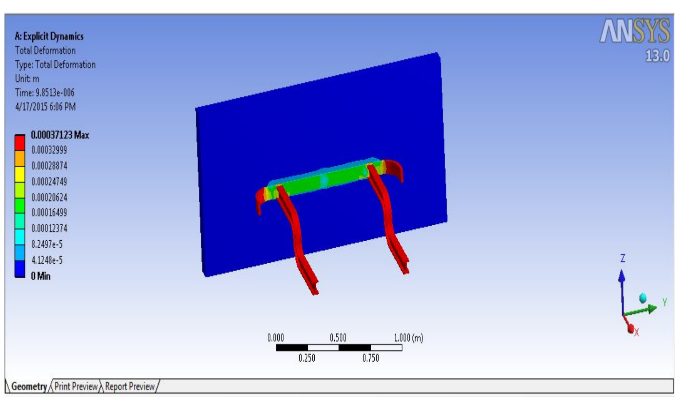


Figure.28 Part made of GFRP

From the below table, total deformation of GFRP with Aluminum is less when compared with GFRP alone.
The graph showing the comparison between the components made of GFRP and GFRP reinforced with Aluminum shown:
Fig.29 Total deformation

V. CONCLUSION

Analysis for GFRP and AL+GFRP is done using ANSYS Software& the result of total deformation is compared, It is clear that Glass fiber reinforced with Aluminum is much lesser than the GFRP. The experimentation is done for AL+GFRP which include Tensile, Compression, and Impact Test in which it is evident that the AL+GFRP is much better combination of material when compared with GFRP alone, because of the addition of Aluminum and E-glass fibre which made AL+GFRP material to enhance its mechanical properties. Thus making more suitable material for the frontal bumper part for any passenger cars by withstanding greater amount of impact force during any type of head on collision / accidents.

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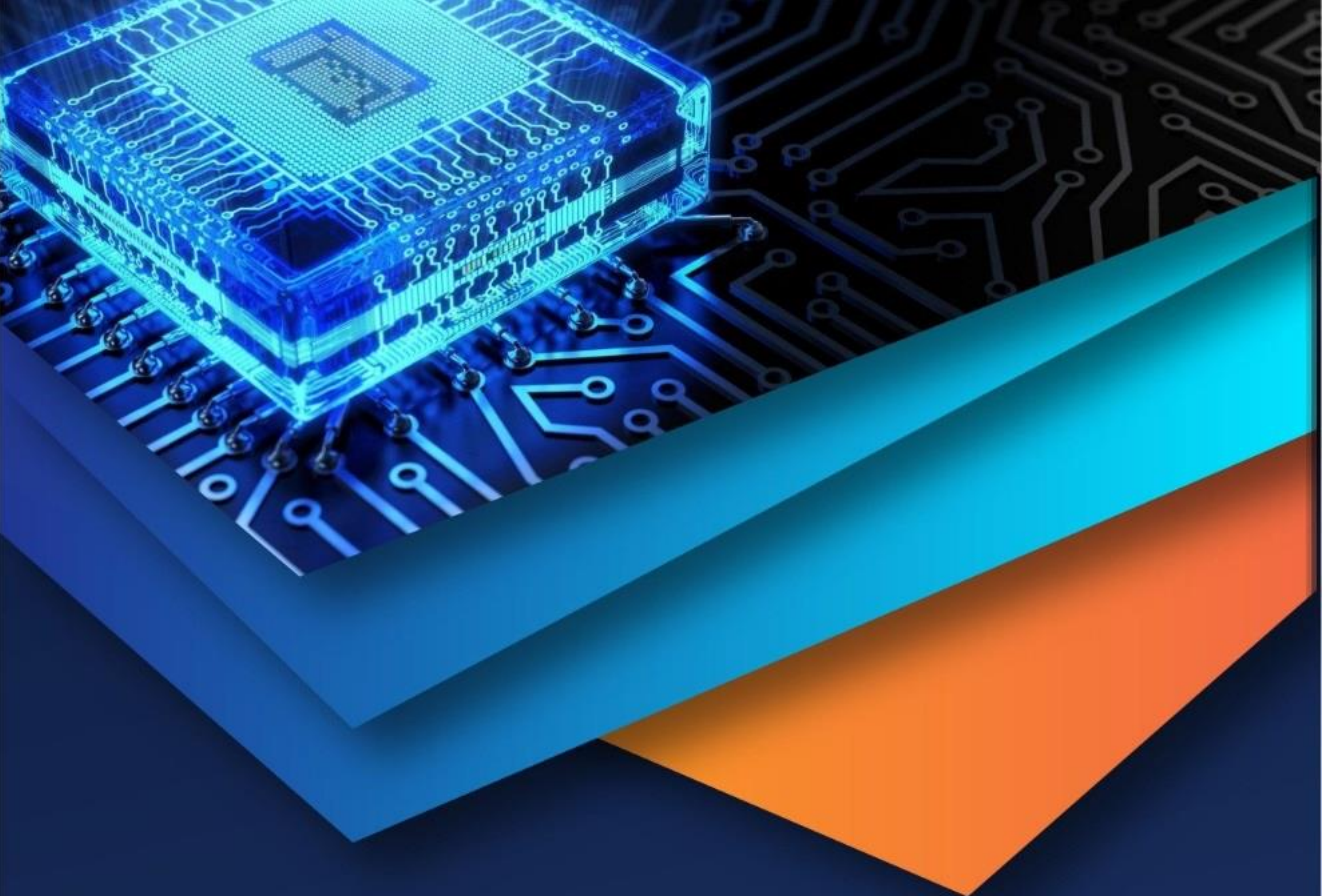

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