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Development of Carbon Fiber Composite Impact Absorber with Integrated Hydraulic Damper

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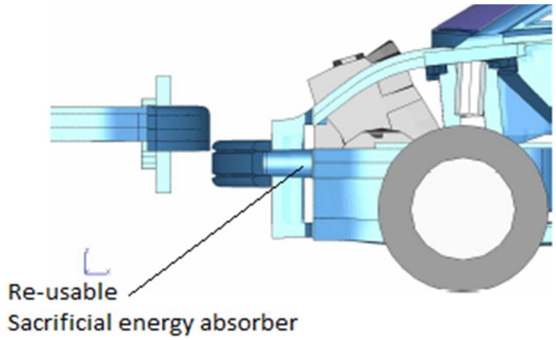
***Abstract:** In case of vehicle accidents, the frontal impacts are seen to be fatal and crash protection is necessary. Crumple zones developed through rigid flat barrier is common to passenger vehicle bodies and these through testing have proved to improve passenger cell although do not provide complete safety in case of frontal impacts. The problem of accident of speeding vehicles in highway transportation is common but very crucial. Traffic accident leads to loss of life and property. We cannot avoid accidents completely but we can reduce by applying safety measures, safety instrument in the form of Carbon fiber composite vehicle crash energy absorber -damper. In this project we aim to develop a composite safety device where in the outer member of the impact damper will be made of carbon fiber which will absorb close to 60 percent of the kinetic energy after impact whereas the hydraulic damper will take 20to 25 percent of the remaining energy there by reducing the vehicle speed to well within safe limit thereby protecting human life. The project aims at design development and analysis of carbon fiber composite damper and hydraulic damper of the above said system to take 20 percent of the energy with suitable energy scale prototype of the said damper. Components of the damper will be modelled using Unigraphics NXR whereas the analysis has been will be done using Ansys Work bench 16.0. The experimental test of the damper has been done using test rig.*

***Keywords:** Frontal impact, Hybrid, Composite damper*

I. INTRODUCTION

Crumple zones work by managing crash energy, absorbing it within the outer parts of the vehicle, rather than being directly transferred to the occupants, while also preventing intrusion into or deformation of the passenger cabin. This better protects car occupants against injury. This is achieved by controlled weakening of sacrificial outer parts of the car, while strengthening and increasing the rigidity of the inner part of the body of the car, making the passenger cabin into a "safety cell", by using more reinforcing beams and higher strength steels. Impact energy that does reach the "safety cell" is spread over as wide an area as possible to reduce its deformation. All the research review significantly does not provide any immediate solution to vehicle impact problem more over no significant research is found in the field of rechargeable impact damper. The application of the composite damper although done earlier was a standalone type and no integration with hydraulic damper was found. Hence considering the passenger safety of utmost importance there is a need to develop a composite impact shock absorber with hydraulic damper. The project work involves the design development , analysis and performance evaluation of the carbon fiber shock absorber with integrated hydraulic damper with pressure relief so that on impart the partial kinetic energy will be absorbed by the carbon fiber composite bumper and the partial energy will be absorbed by the hydraulic damper there by the resultant kinetic energy after impact is reduced to minimum and thereby reduce the severity of the accident. The potential for energy absorption within the front structure of a passenger vehicle may be optimized for specific loading e.g. high-speed rigid flat barrier impact. In many vehicles' energy absorption is provided by the axial collapse of longitudinal frame members. These structural members work well when loaded as intended but may not always perform so effectively in vehicle crashes on the road. In the study described here the controlled bending rather than axial collapse of the main longitudinal members has been used to reliably manage the energy from frontal impact.



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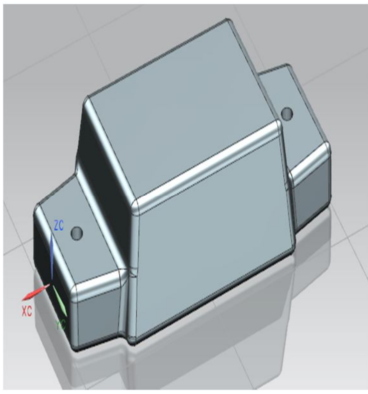
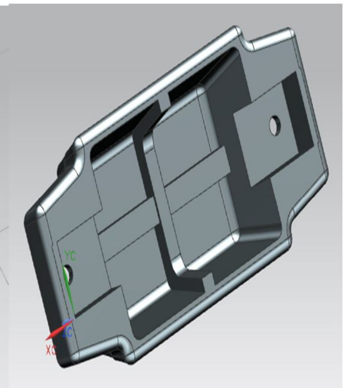
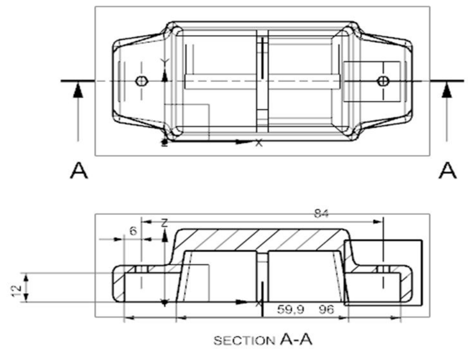






Material selection.

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
STD CF fabric	600	480

A. Direct Tensile or Compressive Stress Due to an Axial Load

Piston force = Pressure x area = 0.3 x (π /4) 28^2 = 184

$$fc_{act} = \frac{W}{A}$$

Considering maximum impact f

$$fc_{act} = \frac{1100}{40x1.5}$$

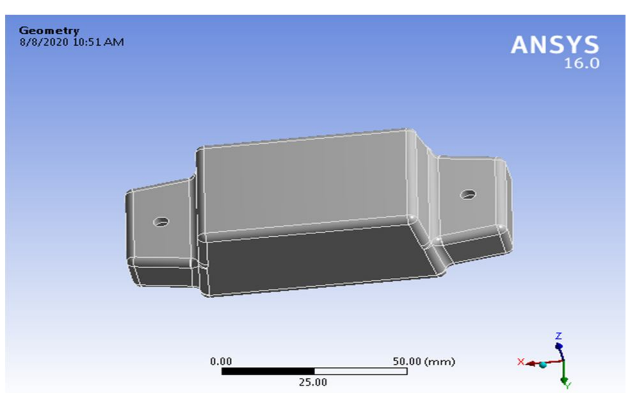
fc_{act} =18.33N/mm^2

As $fc_{act} < fc_{all}$; The bumper is safe in compression.

II. ANALYSIS OF BUMPER

A. Geometry

Geometry was developed using Unigraphics Nx-8 software and the step file was used as input to Ansys



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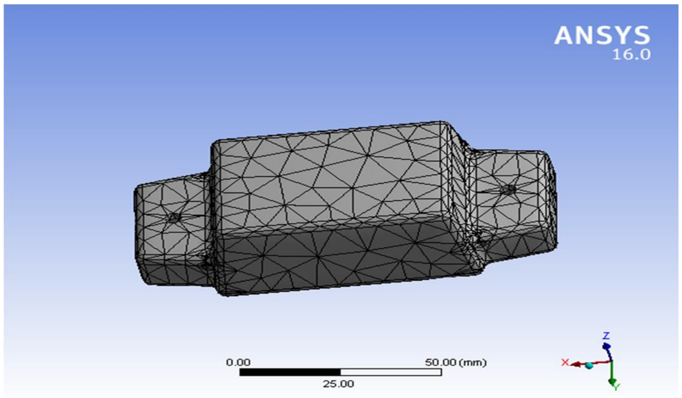
B. Meshing

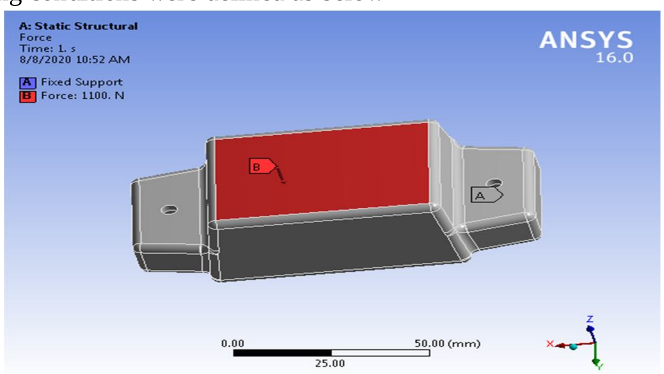
Meshing was done using Ansys free masher and mesh details are as follows



Statistics	
Nodes	8483
Elements	4561
Mesh Metric	None

C. Boundary Conditions

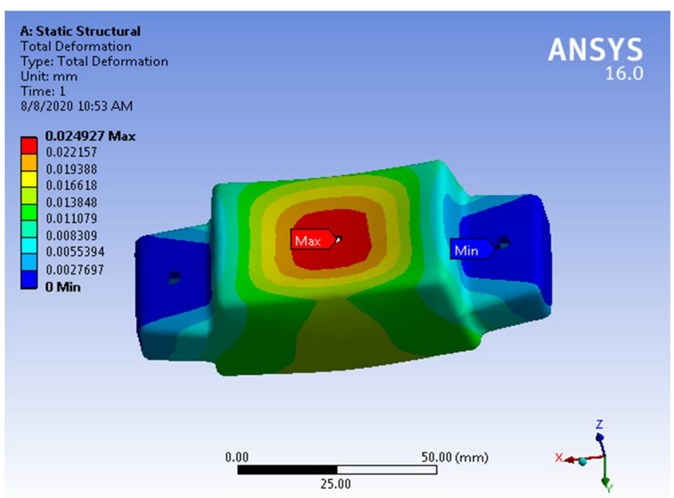
The boundary conditions and loading conditions were defined as below



D. Von-mises Stresses

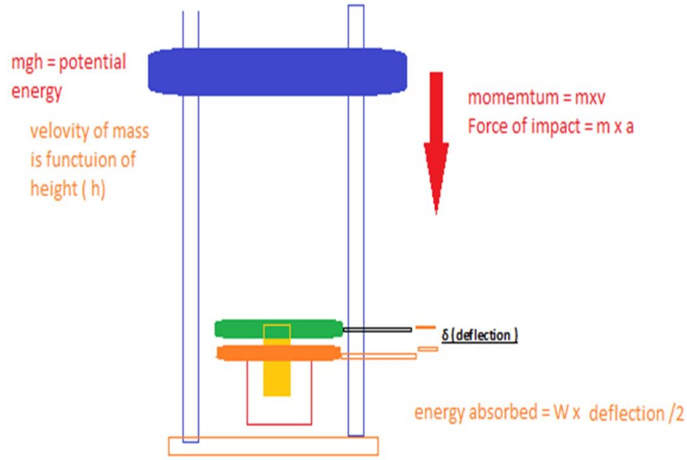
265582 MPa which is far below the allowable value 204 MPa hence the part is safe under given loading conditions.

Maximum deformation



The maximum deformation in the part is 0.029mm, which is very negligible hence the part is safe.

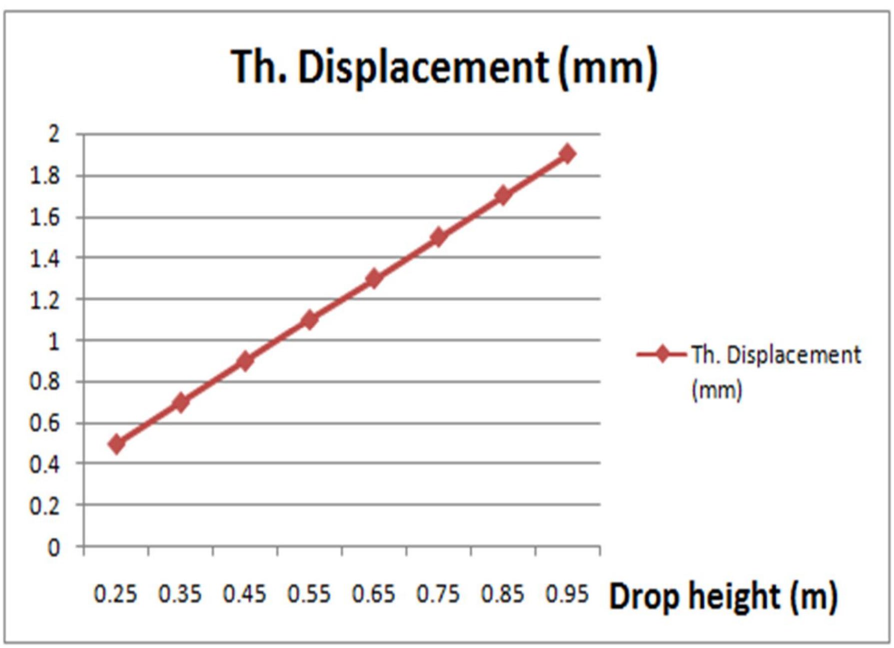
Test and trial on Carbon fiber composite impact absorber with integrated hydraulic damper.



III. EXPERIMENTAL PROCEDURE

1) Place the damper in the damper mount.
2) Load the 5 kg weight on the mass pan.
3) Raise the mass pan to the specified drop height.
4) Release the mass pan from specified drop height.
5) Measure the deflection of the bumper after impact.
6) Calculate actual energy absorbed after impact.
7) Calculate the percentage safety
8) Calculate the distance travelled after impact.
9) Repeat the procedure steps 2 to 8 for various drop height
10) Plot the graph of parameters vs drop height.

A. Graph of theoretical deflection Vs Drop ht.



The theoretical displacement is seen to increase with the drop height as the impact force increases

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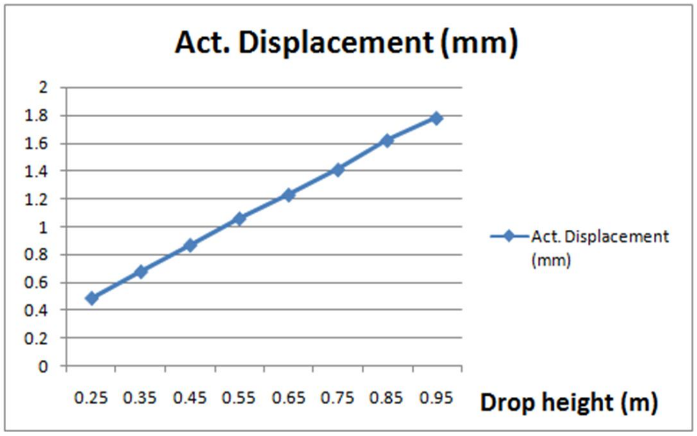
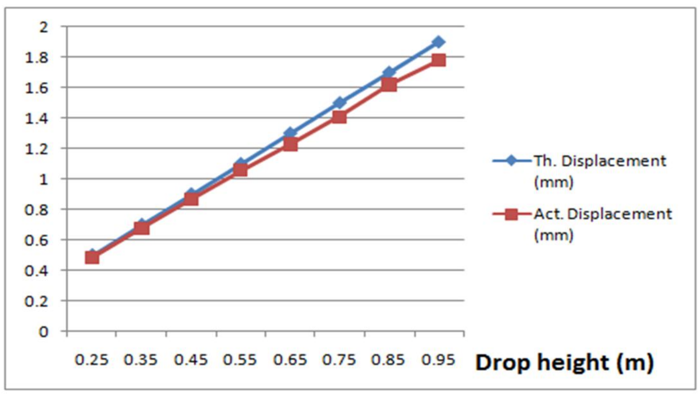
B. Graph of Actual deflection Vs Drop ht.



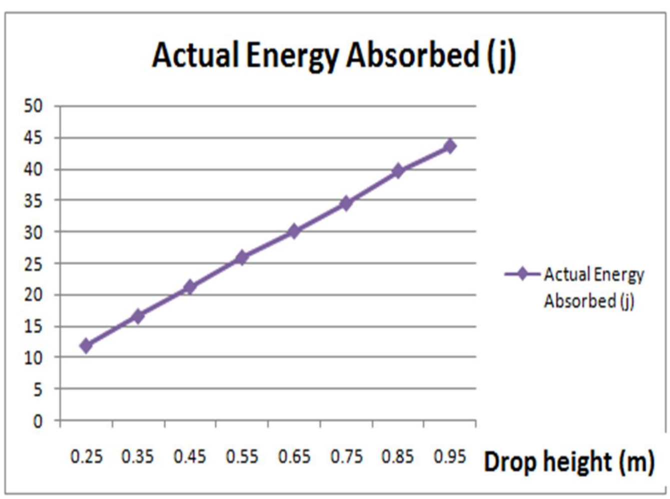
The actual displacement is seen to increase with the drop height as the impact force increases

C. Comparison of Theoretical and Actual Deflections



From the graph above it is clear that the actual deflection is leser than the theoretical values indicating slight inefficiency of device however this is limited below 6 percent of the theoretical value thereby validating the design of the damper.

D. Graph of Energy Absorbed vs Drop Ht.



The graph indicates that the damper absorbs maximum energy equivalent to 43.65 Joule before cracking pressure is attained.

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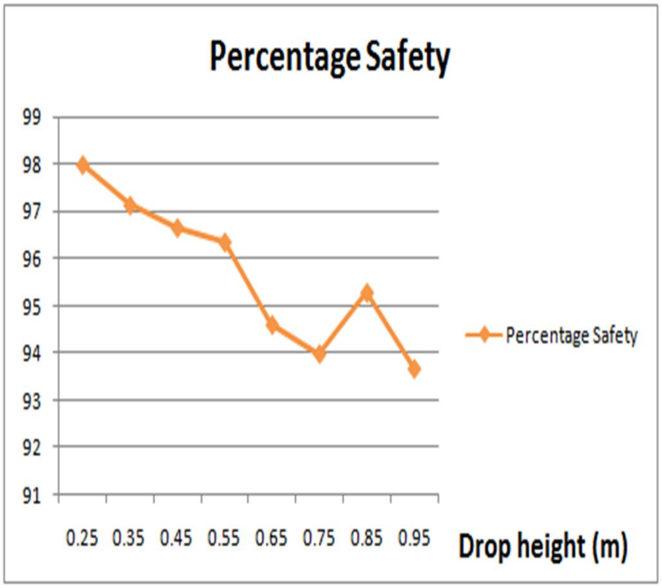
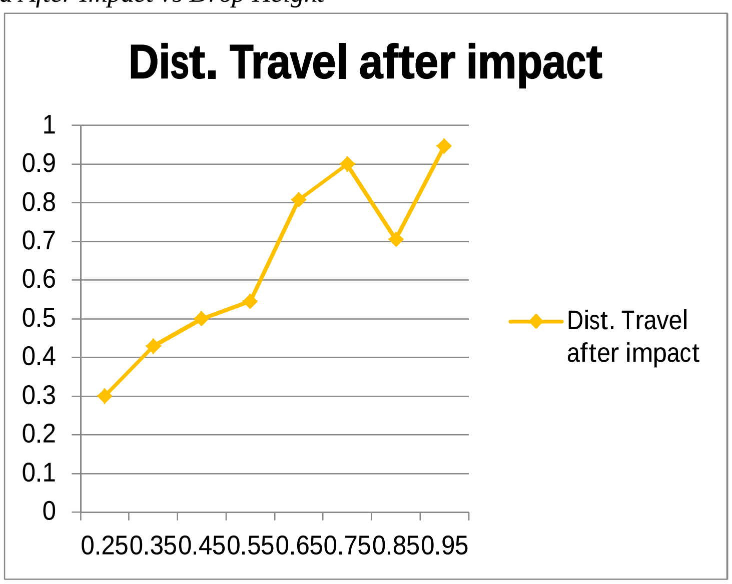
E. Graph of Percentage Safety vs Drop Height.



The graph of percentage safety indicates that the maximum safety attained is 98 percent and minimum safety is 93.6 percent.

F. Graph of Distance Travelled After Impact vs Drop Height



The maximum distance travelled is less than 1mm indicating maxium safety provided by the damper.

IV. RESULT AND DISCUSSION

A. The theoretical displacement is seen to increase with the drop height as the impact force increases
B. The actual displacement is seen to increase with the drop height as the impact force increases
C. The actual deflection is leser than the theoretical values indicating slight inefficiency of device however this is limited below 6 percent of the theoretical value thereby validating the design of the damper.
D. The damper absorbs maximum energy equivalent to 43.65 Joule before cracking pressure is attained.
E. The maximum safety attained is 98 percent and minimum safety is 93.6 percent**.**
F. The maximum distance travelled is less than 1mm indicating maxium safety provided by the damper.

V. CONCLUSION

The sizing, design analysis critical components of Carbon fiber composite damper is successfully done and the dimensions of the components have been determined. Estimation of the maximum stress induced in the components of the system have being determined by both theoretical method as well as using Ansys Work bench and the results indicate that the maximum stress values are well below the permissible limit hence the parts are safe under given system of loads. The theoretical displacement is seen to increase with the drop height as the impact force increases The actual displacement is seen to increase with the drop height as the impact force increases The actual deflection is leser than the theoretical values indicating slight inefficiency of device however this is limited below 6 percent of the theoretical value thereby validating the design of the damper.The damper absorbs maximum energy equivalent to 43.65 Joule before cracking pressure is attained. The maximum safety attained is 98 percent and minimum safety is 93.6 percent.

The maximum distance travelled is less than 1mm indicating maxium safety provided by the damper.

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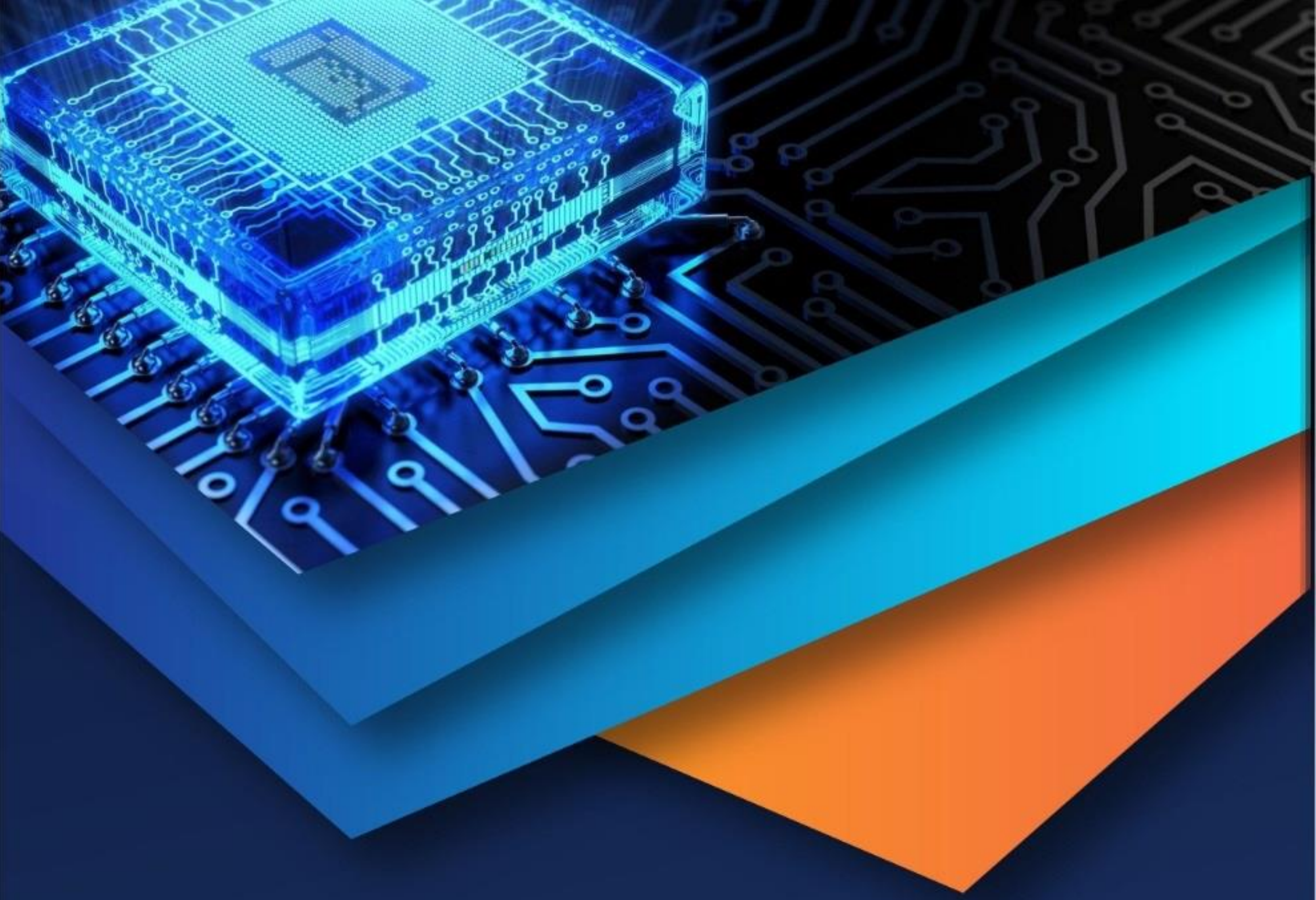

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