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Design and Analysis of Chassis with Loading Condition and with Weight Optimization Solution

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***Abstract:** The chassis frame is an important part in a Vehicle and it carries the whole load acting on the truck as well as different parts of the automobile. So it must be strong enough to resist the shock, twist, vibration and other stresses. Maximum stress and maximum deflection are important criteria for design of the chassis. There are several types of chassis frames available and they are much strength full. But the direct major or minor impacts on chassis frames in accidental cases may cause the dynamic unbalancing, chassis misalignment and other problems which affect the vehicle performance as well as the appearance. Due to large and sudden jerks during running conditions may create the vibrations inside the chassis which cause the prior failure in chassis members. The objective of this paper is to improve the design of chassis by using different cross sections and material. Also the weight of chassis is suggested to enhance the vehicle performance. For this purpose entire design work is carried out in CATIA V5R19 software. Both cross sections (C section and I sections are considered) with different materials are analysed for stresses and deformation in ANSYS 14.5 software. Based on the comparative study of obtained results the best chassis cross section and design will be suggested.*
***Keywords:** Heavy duty chassis, FEA of Chassis, Structural behavior of Chassis, Design of Chassis , Chassis Analysis , Deformation analysis of Chassis , Design improvement in chassis , Weight Optimization, ANSYS 14.5*

I. INTRODUCTION TO HEAVY DUTY CHASSIS

There are many industrial sectors using this Vehicle for their transportations such as the logistics, agricultures, factories and other industries. If any of the excitation frequencies coincides with the natural frequencies of the Vehicle chassis, then resonance phenomenon occurs. The chassis will undergo dangerously large oscillations, which may lead to excessive deflection and failure. The vibration of the chassis will also cause high stress concentrations at certain locations, fatigue of the structure, loosening of mechanical joints, creation of noise and vehicle discomfort. To solve these problems, study on the truck chassis dynamic characteristics is thus essential. The torsion stiffness and modal parameters were determined experimentally and then used to validate the finite element model and finally the chassis was optimized to increase the structural stiffness. It was noted that the torsion mode dominated the natural frequency. A **chassis** consists of an internal framework that supports a man-made object in its construction and use. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted). If the running gear such as wheels and transmission, and sometimes even the driver's seat, are included then the assembly is described as a rolling chassis.

II. OBJECTIVES OF STUDY

- *A.* Virtual Design of C-section and I-section Chassis.
- *B.* Determination of Stress and deformation in chassis frame.
- *C.* Study of Finite Element Method and its applications.
- *D.* Study of CAD and FEA Package.
- *E.* Comparative study of chassis with different materials and cross sections.

III. OUTCOMES FROM LITERATURE SURVEY

- *A.* Vibrations due to sudden jerks are to be studied well. Focus needed on vibrations.
- *B.* FEA Analysis is best suitable method for chassis experimentation and testing.
- *C.* Stresses are induced in the rear members of chassis.
- *D.* Different chassis materials are studied rarely.
- *E.* Combination of structural, vibration and shape optimization analysis will provide deep study of chassis deformation and stresses.

IV. CAD MODEL DEVELOPMENT

To prepare the CAD model of chassis several commands from sketcher module and part module are utilized. We have two types of chassis which is to be modeled. One of them has C type cross section and other have I type cross section. Following Figure 3.9 shows the chassis with C type cross section. And figure 3.10 shows the chassis with I type cross section.

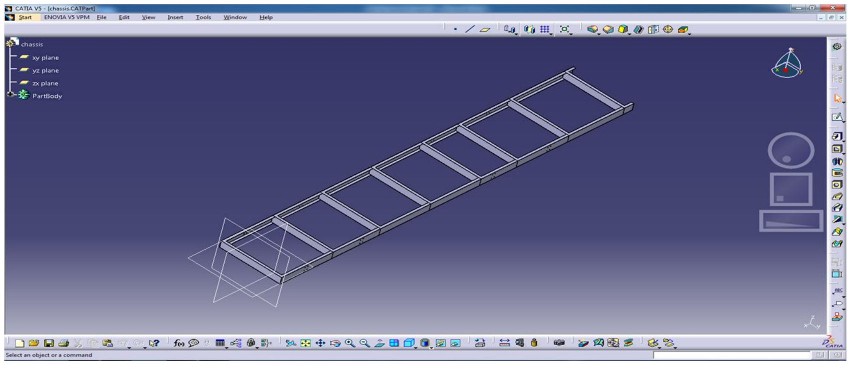

Fig. 1: Heavy Duty Chassis with C Type cross Section.

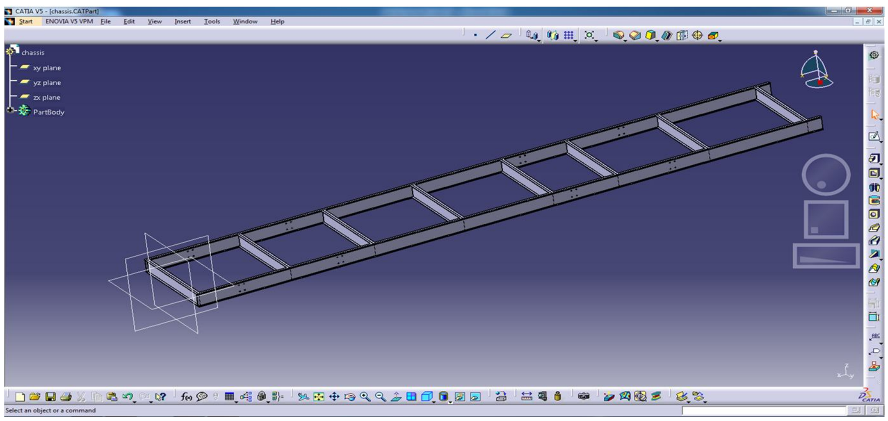

Fig. 2: Heavy Duty Chassis with I Type cross Section.

The Initial Graphics Exchange Specification (IGES) (pronounced eye-jess) is a vendor-neutral file format that allows the digital exchange of information among computer-aided design (CAD) systems.

V. FEA ANALYSIS

A. Meshing

In structural analysis, discretization may involve either of two basic analytical-model types, including. A mesh is a network of line elements and interconnecting nodes used to model a structural system and numerically solve for its simulated behavior under applied loading.

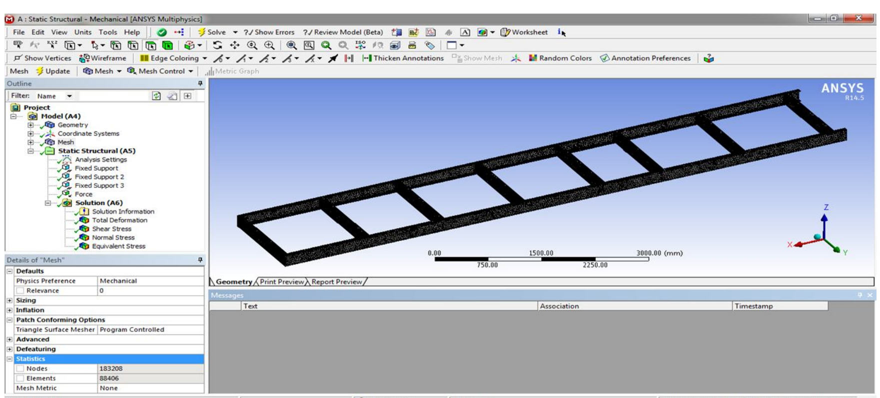

Fig. 3: Meshed View of C type cross sectioned in 3D Tetragonal Element

Type of Element	3D Tetragonal
No. of Elements	88406
No. of Nodes	183208

Table 1: Nodes and Elements

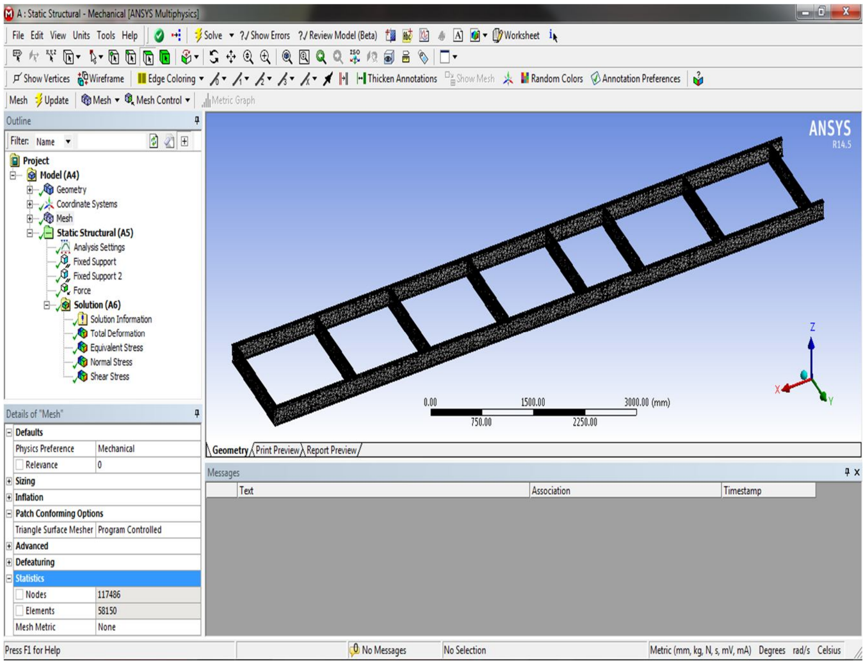

Fig. 4: Meshed View of I type cross sectioned in 3D Tetragonal Element

Type of Element	3D Tetragonal
No. of Elements	117486
No. of Nodes	58150

Table 2: Nodes and Elements

B. Material Properties Applied

1) *Poisson's Ratio:* When applying a load in a certain axis direction and consequently deforming in that direction, the ratio of deformation on the opposite side is called Poisson's Ratio. Easily put, when pulling out the tensile specimen, the proportion of the reduced amount of deformation in the vertical direction from load with respect to the increased deformation amount in the load direction. Basically, it can be used at the elastic region because of the assumption of Hooke's Law, theoretically having a value less than 0.5 greater than zero.
2) *Yield Stress:* As described above, yield stress is the point at which permanent deformation is drastically increased when an external force is increased beyond the elastic limit. As for metallic material, the maximum stress of the elastic limit is the same as yield stress. However, the resin is used to define yield stress in accordance with ISO regulations as these theories cannot be used as-is because of a tendency to show a markedly different SS curve than that of metal.
3) *Density:* Since density is mass per unit volume, the density of a metal can be calculated by submerging it in a known amount of water and measuring how much the water rises. This rise is the volume of the metal. Its mass can be measured using a scale.

Property	Unit	ASTM A302	HSS 550	ASTM A710
Young's Modulus (E)	MPA	2.15e5	6.9e5	2e5
Poisson's Ratio (µ)	-	0.33	0.32	0.29
Density (σ)	Kg/m^3	7790	7800	7850

Table 3: Material Properties of Different Metals used for both type of chassis

C. *Applied Loads on Chassis*

To find the actual loading on chassis, unloaded weight and maximum pay load should be considered. Following figures shows the Specification of 10 Tone, chassis which has required details.

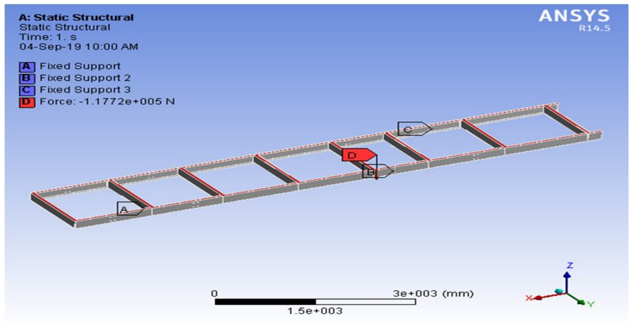

Figure 5: Loading Condition on chassis

The static load conditions are used to for the calculation

Total static load on chassis in N = 10000 X 9.81 N = 117729 N

VI. RESULTS GENERATED

A. *Structural Analysis Results for I Type Chassis*

1) *HSS 550 Material Results:* Figure 6 to Figure 10 shows the analysis results for **HSS 550** in case of **I type chassis**. By observing that results, it is found that maximum stresses will not exceed more than414.14 MPA (Normal Stresses). Deformation is only up to 3.44 mm. Stresses and deformation obtained is acceptable range.

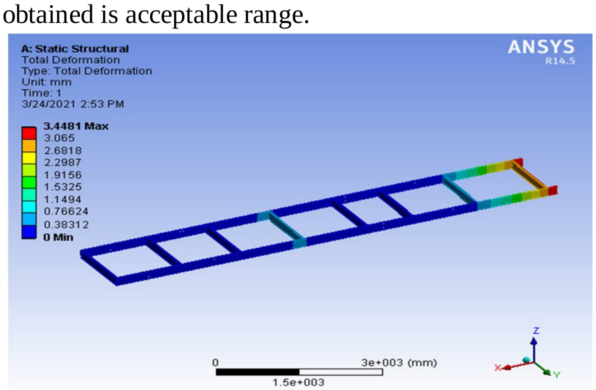

Figure 6: Total Deformation

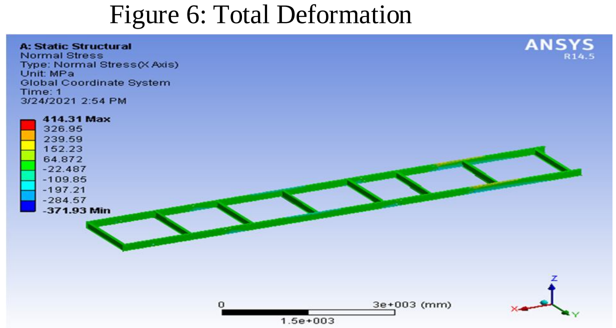

Figure 7: Normal Stresses obtained.

Figure 7 shows the Normal stresses obtained for this case. 414.31 MPA is the maximum stress value obtained for this case. But this stresses are maximum at the holes and remaining body is in green color which has the stress value range up to 64.87 MPA. Hence chances of failure due to normal stresses are rejected. To study these stresses in detail, let us consider Fig. 8 which shows the maximum stress value at the shackle holes. It means that after some time period and running, hole may be enlarged due to wear. But chances of failure are highly rejected.

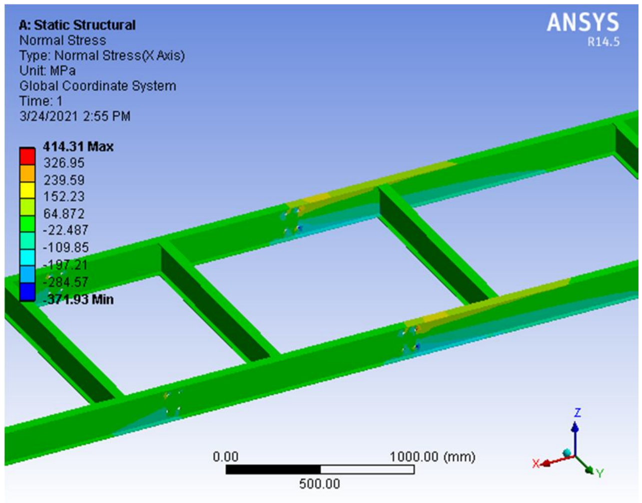

Figure 8: Normal Stresses on holes.

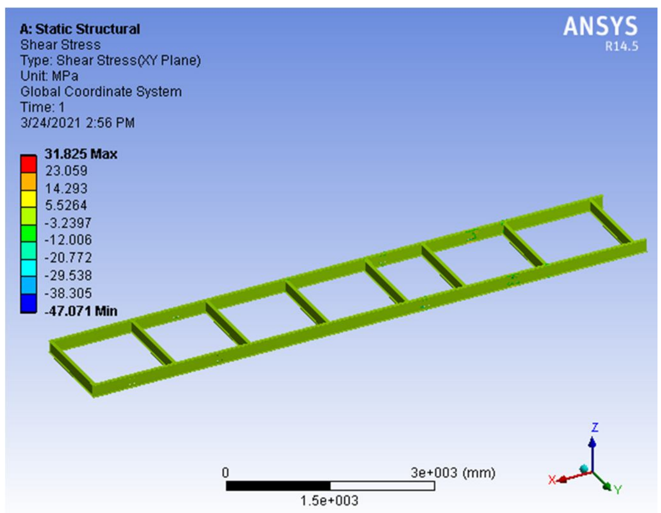

Figure 9: Shear Stresses obtained.

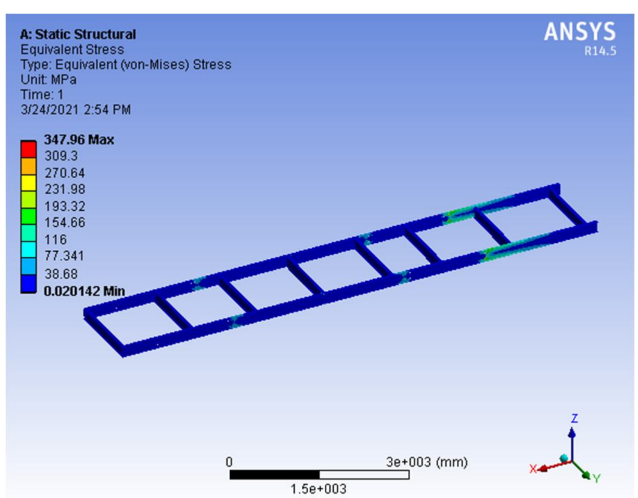

Figure 10: Equivalent Stresses Obtained

VII. TABULATED RESULTS

Table 4: Tabulated Results Generated from the all Analysis Results

Sr. No.	Result	C Type Chassis			I Type Chassis		
		ASTM A302	HSS 550	ASTM A710	ASTM A302	HSS 550	ASTM A710
1	Total Deformation (mm)	11.98	3.64	12.25	11.32	3.44	11.58
2	Equivalent Stresses (MPA)	462.94	467.42	489.86	345.15	347.96	355.35
3	Shear Stress (MPA)	64.85	65.24	66.22	31.82	31.82	31.79
4	Normal Stress (MPA)	497.41	472	553.6	422.32	414.31	393.91
5	1st Mode Deformation (mm)	5.56	5.63	5.53	5.58	5.65	5.56
6	2nd Mode Deformation (mm)	4.54	4.60	4.52	4.63	4.69	4.61
7	3rd Mode Deformation (mm)	6.16	6.24	6.14	6.23	6.31	6.22
8	4th Mode Deformation (mm)	7.75	7.85	7.72	7.9	8	7.87
9	5th Mode Deformation (mm)	6.34	6.42	6.3	6.82	6.9	6.78
10	Frequency (Hz)	55.22	116.3	58.2	56.42	86.61	46.31

VIII. CONCLUSION

By observing above table 4, it is found that the HSS 550 material gives the better results than remaining two materials. It has better strength and ability to absorb vibrations. ASTM A302 and A710 are having maximum normal stress values. Also the shear stress value is greater than HSS 550 material value. But only 31 MPA shear stress value proves the better option as a HSS 550 material. Compared with C and I section, it is found that the I section is better option than the C section due to less deformation and stress values with HSS 550 material.

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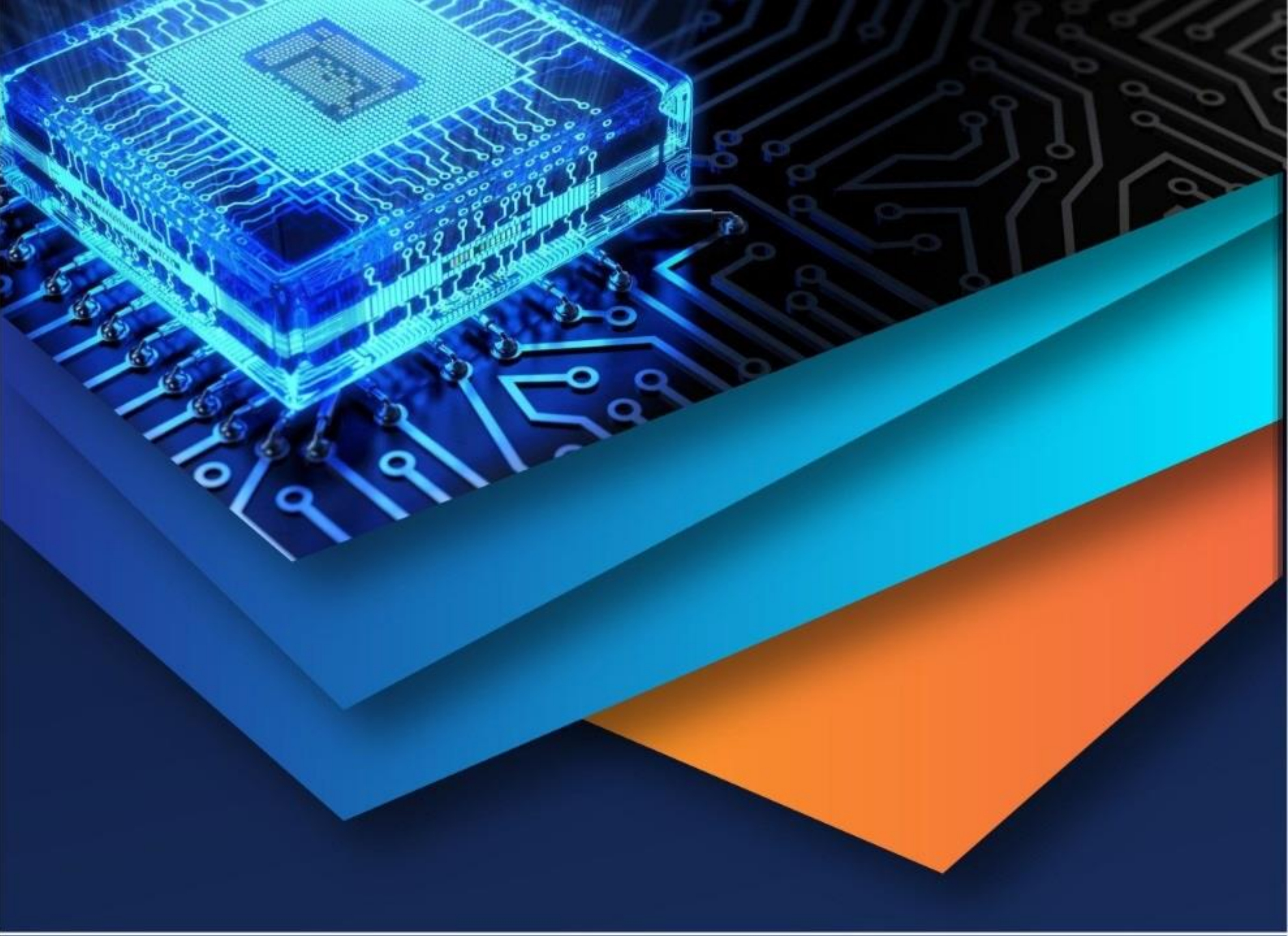

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