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Design and Analysis of Pressure Vessel used in Gasoline Industries

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Abstract: Pressure vessels are closed containers used for handling and storing of fluids. It passes the sequence of hydrostatic test. The process industry designers have recognized the limitations for confining large volumes of high internal pressures in single wall vessel. The increment in thickness beyond certain value will posses only fabrication difficulties. Multilayer pressure vessels are reliable equipment useful in wide range of operating conditions. So for this purpose we are adding the material called carbon fibre to steel. We are using hydrogen as a fluid in both single wall pressure vessel and multilayer pressure vessel at the pressure of 21 N/mm². Single wall pressure vessel and multilayer pressure vessels are designed in "Solidworks". The stresses, strains, displacements, frequencies developed in solid wall pressure vessel and multilayer pressure vessel are analyzed by using "COSMOS".

Keywords: Design, Analysis, Solid and multilayer pressure vessel, Solidworks, COSMOS.

I. INTRODUCTION

The pressure vessels are used to store fluids under pressure. The fluid being stored may undergo a change of state inside the pressure vessels as in case of steam boilers or it may combine with other reagents as in chemical plants. Pressure vessels find wide applications in thermal and nuclear power plants process, and chemical industries, in space and ocean depths, and in water, steam, gas and air supply systems in industries. The material of a pressure vessel may be brittle such as cast iron or ductile such as mild steel. High pressure vessels are used as reactors, separators and heat exchangers. They are vessel with an integral bottom and a removable top head and are generally provided with an inlet, heating and cooling systems and also an agitator system. High pressure vessels are used for a pressure range of 15 N/mm² to a maximum of 300 N/mm². These are essentially thick walled cylindrical vessels ranging in size from small tubes to several meters diameter. Both the size of the vessel and the pressure involved with dictate the type of construction used.

II. DIMENSIONS AND PROPERTIES

A. For Solid Wall Pressure Vessel

1) Analysis type = Static and Modal
2) Material = Steel (Iron-85%, Chromium-13%, Carbon-2%)
3) Design pressure = 21 N/mm²
4) Inside radius of vessel =1143 mm
5) Thickness = 219 mm
6) Length = 3352 mm

Description	Material	Young's Modulus (G Pa)	Density (kg/m³)	Poisson's ratio	Yield strength (M Pa)
Vessel	Steel S235	190	8050	0.26	215
Dished ends	Steel S235	190	8050	0.26	215

B. For Multilayer Pressure Vessel

1) Analysis type = Static and Modal
2) Material type = 1. Steel (Iron-85%, Chromium-13%, Carbon-2%)
2. Carbon fibre (Polyacrylonitrile-90%, Resin-10%)
3) Design pressure = 21 N/mm²
4) Inside radius of vessel = 1143 mm

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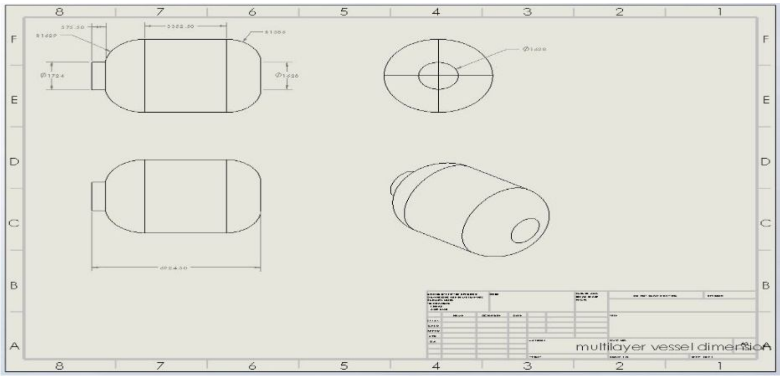
5) Thickness = 219 mm
6) Length = 3352 mm
7) Number of layers = 5
8) Thickness of each layer = 12 mm

Description	Material	Young's Modulus (G Pa)	Density (kg/m^3)	Poisson's ratio	Yield strength (M Pa)
Vessel	Steel S235	190	8050	0.26	215
Dished ends	Steel S235	190	8050	0.26	215
Vessel	Carbon fibre	70	1600	0.10	600
Dished ends	Carbon fibre	70	1600	0.10	600

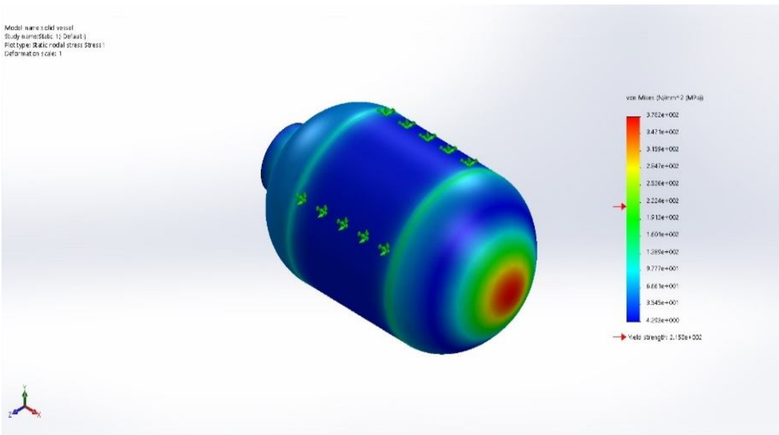
III. MODEL-PRESSURE VESSEL



IV. ANALYSIS

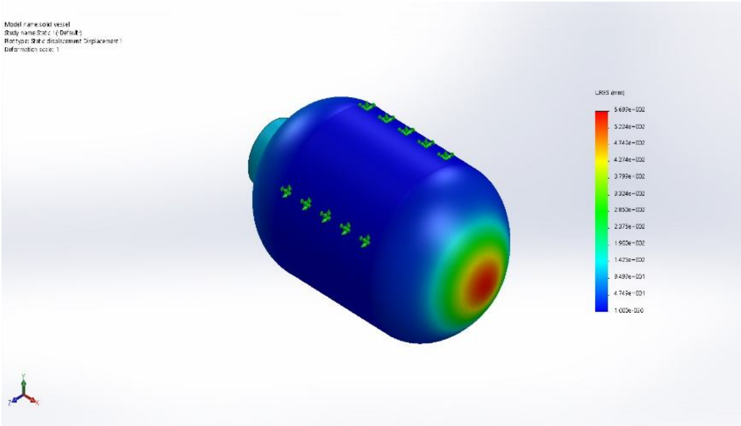
A. For Solid Wall Pressure Vessel
1) Static Analysis:
a) Stress:

Name	Type	Minimum	Maximum
Stress	VON: von Mises stress	4.293e+000N/mm^2 (MPa) Node: 39720	3.782e+002N/mm^2 (MPa) Node: 21613



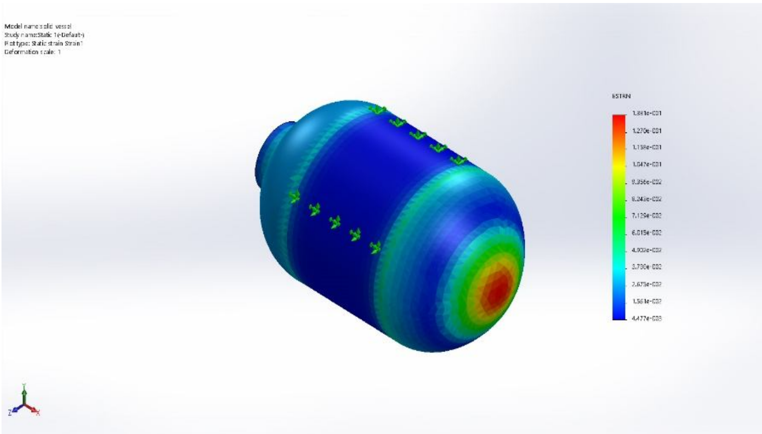
b) Displacement:

Name	Type	Minimum	Maximum
Displacement	URES: Resultant Displacement	0.000e+000mm Node: 1743	0.000e+000mm Node: 1743



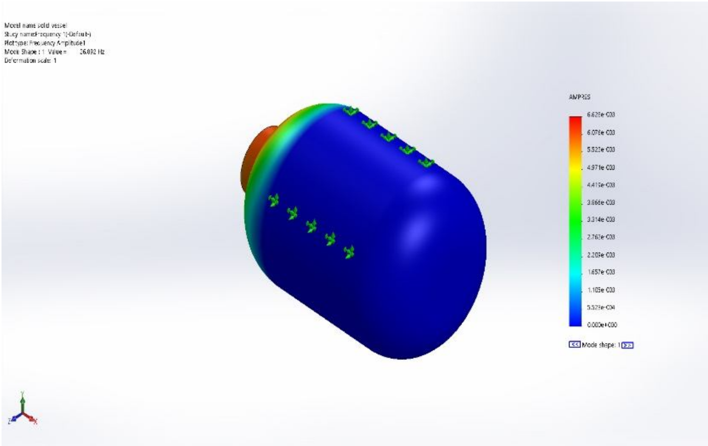
c) Strain:

Name	Type	Minimum	Maximum
Strain	ESTRN: Equivalent Strain	4.477e-003 Element: 701	1.381e-001 Element: 24188

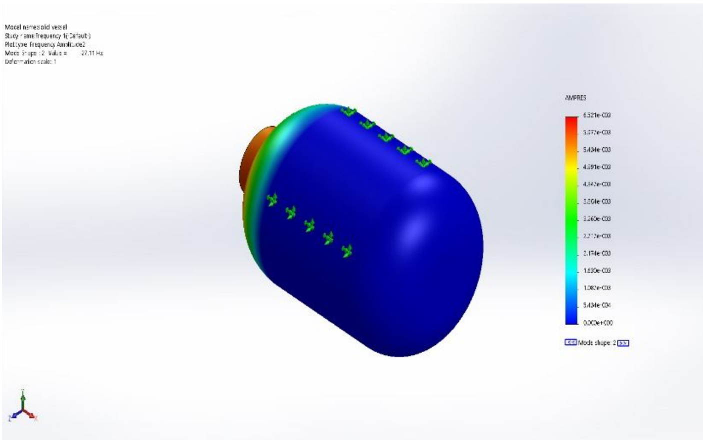


2) Modal Analysis:

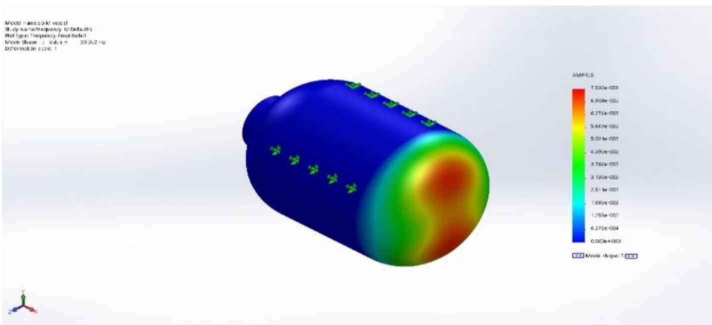
Name	Type	Minimum	Maximum
Amplitude 1	AMPRES: Resultant Amplitude Plot for Mode Shape: 1(Value = 26.8921 Hz)	0.000e+000 Node: 1743	6.628e-003 Node: 244



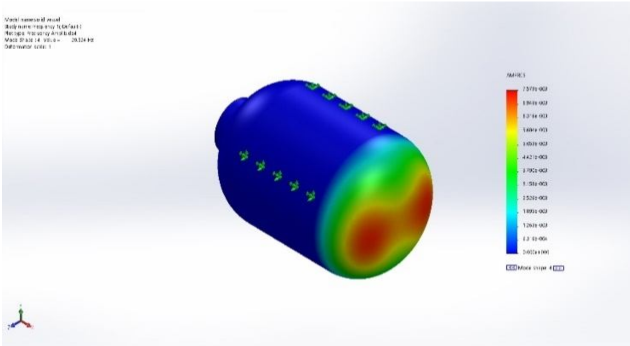
Name	Type	Minimum	Maximum
Amplitude 2	AMPRES: Resultant Amplitude Plot for Mode Shape: 2(Value = 27.11 Hz)	0.000e+000 Node: 1743	6.521e-003 Node: 337



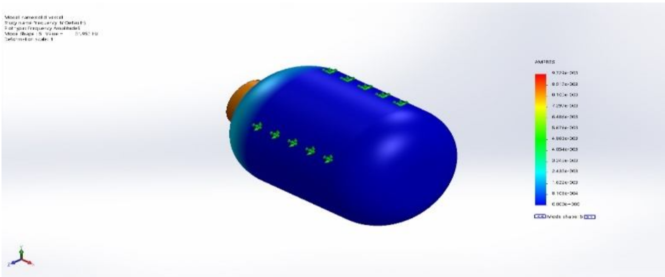
Name	Type	Minimum	Maximum
Amplitude 3	AMPRES: Resultant Amplitude Plot for Mode Shape: 3(Value = 29.3825 Hz)	0.000e+000 Node: 1743	7.532e-003 Node: 20851



Name	Type	Minimum	Maximum
Amplitude 4	AMPRES: Resultant Amplitude Plot for Mode Shape: 4(Value = 29.5239 Hz)	0.000e+000 Node: 1743	7.579e-003 Node: 4949



Name	Type	Minimum	Maximum
Amplitude 5	AMPRES: Resultant Amplitude Plot for Mode Shape: 5(Value = 31.9516 Hz)	0.000e+000 Node: 1743	9.729e-003 Node: 6

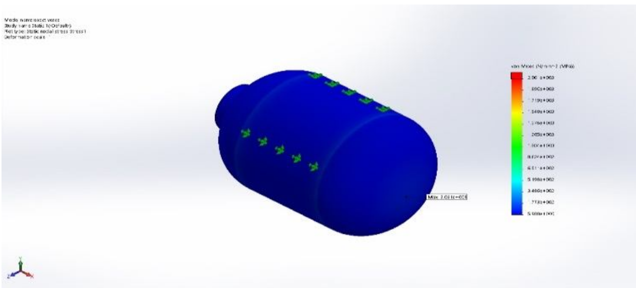


B. For Multilayer Pressure Vessel

1) Static Analysis:

a) Stress:

Name	Type	Minimum	Maximum
Stress	VON: von Mises Stress	5.988e+000N/mm^2 (MPa) Node: 212755	2.061e+003N/mm^2 (MPa) Node: 152260



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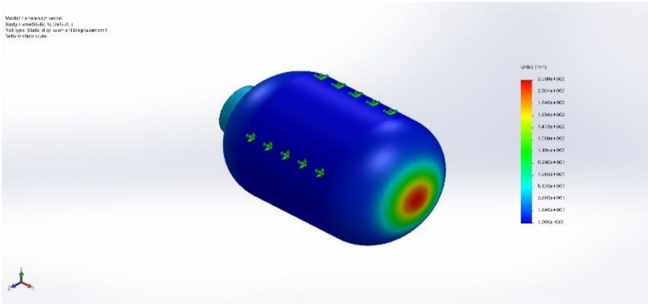
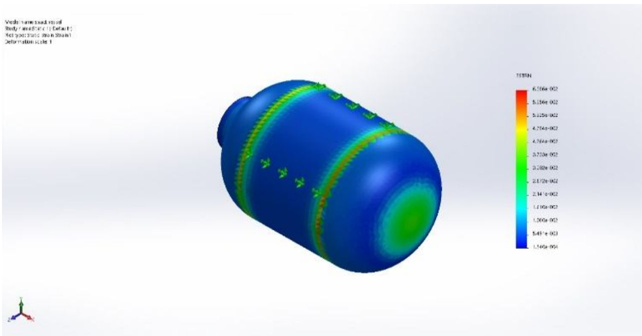
b) Displacement:

Name	Type	Minimum	Maximum
Displacement	URES: Resultant Displacement	0.000e+000mm Node: 183056	2.208e+002mm Node: 66458



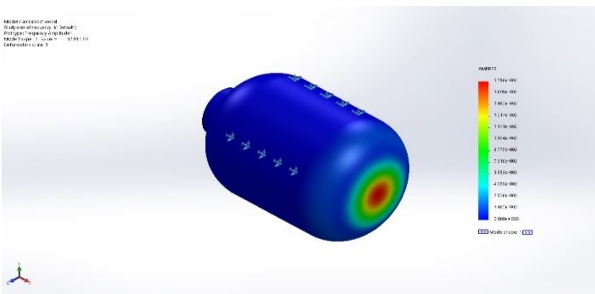
c) Strain:

Name	Type	Minimum	Maximum
Strain	ESTRN: Equivalent Strain	1.840e-004 Element: 111603	6.386e-002 Element: 136275



2) Modal Analysis:

Name	Type	Minimum	Maximum
Amplitude 1	AMPRES: Resultant Amplitude Plot for Mode Shape: 1(Value = 37.9109 Hz)	0.000e+000 Node: 135677	1.756e-002 Node: 16848



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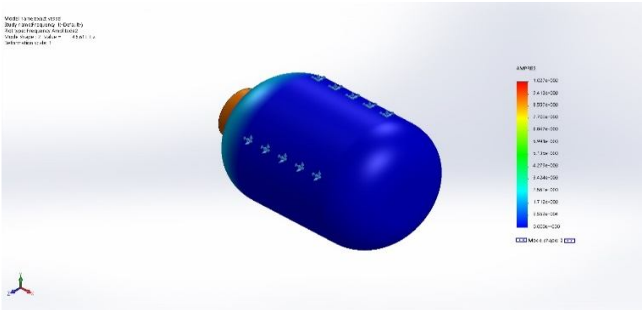
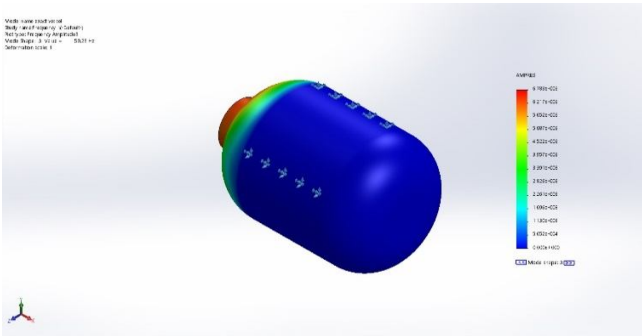
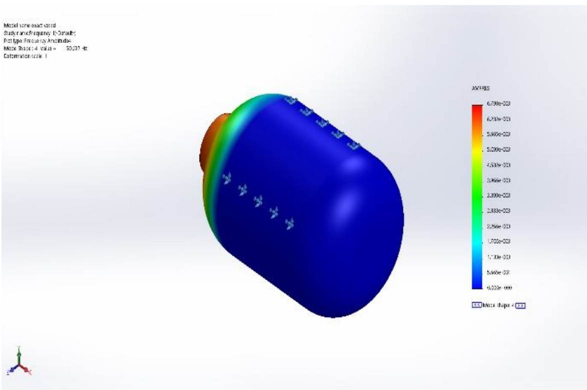
Name	Type	Minimum	Maximum
Amplitude 2	AMPRES: Resultant Amplitude Plot for Mode Shape: 2(Value = 46.6183 Hz)	0.000e+000 Node: 135677	1.027e-002 Node: 2



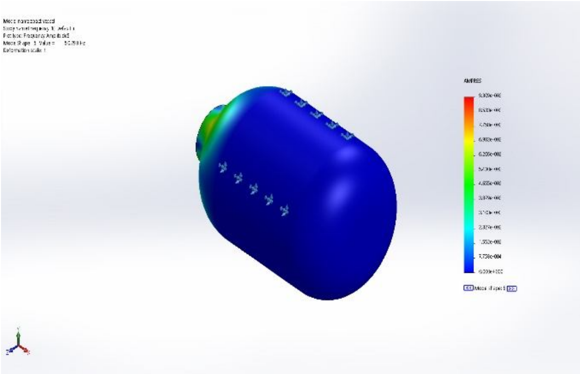
Name	Type	Minimum	Maximum
Amplitude 3	AMPRES: Resultant Amplitude Plot for Mode Shape: 3(Value = 50.2801 Hz	0.000e+000 Node: 135677	6.783e-003 Node: 5578



Name	Type	Minimum	Maximum
Amplitude 4	AMPRES: Resultant Amplitude Plot for Mode Shape: 4(Value = 50.297 Hz)	0.000e+000 Node: 135677	6.798e-003 Node: 358



Name	Type	Minimum	Maximum
Amplitude 5	AMPRES: Resultant Amplitude Plot for Mode Shape: 5(Value = 50.7976 Hz)	0.000e+000 Node: 135677	9.309e-003 Node: 451



V. RESULTS

A. *Static Analysis*

Single wall pressure vessel			Multilayer pressure vessel		
Material	Displacement (mm)	Stress (N/mm^2)	Material	Displacement (mm)	Stress (N/mm^2)
Steel	5.699e2	3.78e2	Steel and Carbon fibre	2.208e2	2.061e3

B. *Modal Analysis*

Material	Amplitude 1 (Hz)	Amplitude 2 (Hz)	Amplitude 3 (Hz)	Amplitude 4 (Hz)	Amplitude 5 (Hz)
Steel	26.892	27.11	29.382	29.524	31.952
Steel and Carbon fibre	37.911	46.618	50.28	50.297	50.798

C. *Weight Comparison*

Single wall pressure vessel		Multilayer pressure vessel	
Steel	197703 kg	Steel and Carbon fibre	181159.29 kg

VI. CONCLUSION

A. At present solid wall pressure vessels are used extensively. But buy using multilayered vessels, there is a huge difference in weight. The weight is almost decreased by 16543.71kg when multilayered vessels are used in place of solid vessels.

B. This decreases not only the overall weight of the component but also the cost of the material required to manufactured the pressure vessels. This is one of the main aspects of designer to keep the weight and cost as low as possible.

C. Owing to the advantages of the multi layered pressure vessels over the conventional single walls pressure vessels, it is concluded that multi layered pressure vessels are superior for high pressures and high temperature operating conditions.

D. By analysis it is proved that using carbon fibre is also safe since the analyzed stress value is less than yield stress value 600 M Pa and also less than that by using carbon fibre. The factor of safety obtained is also more than 2.

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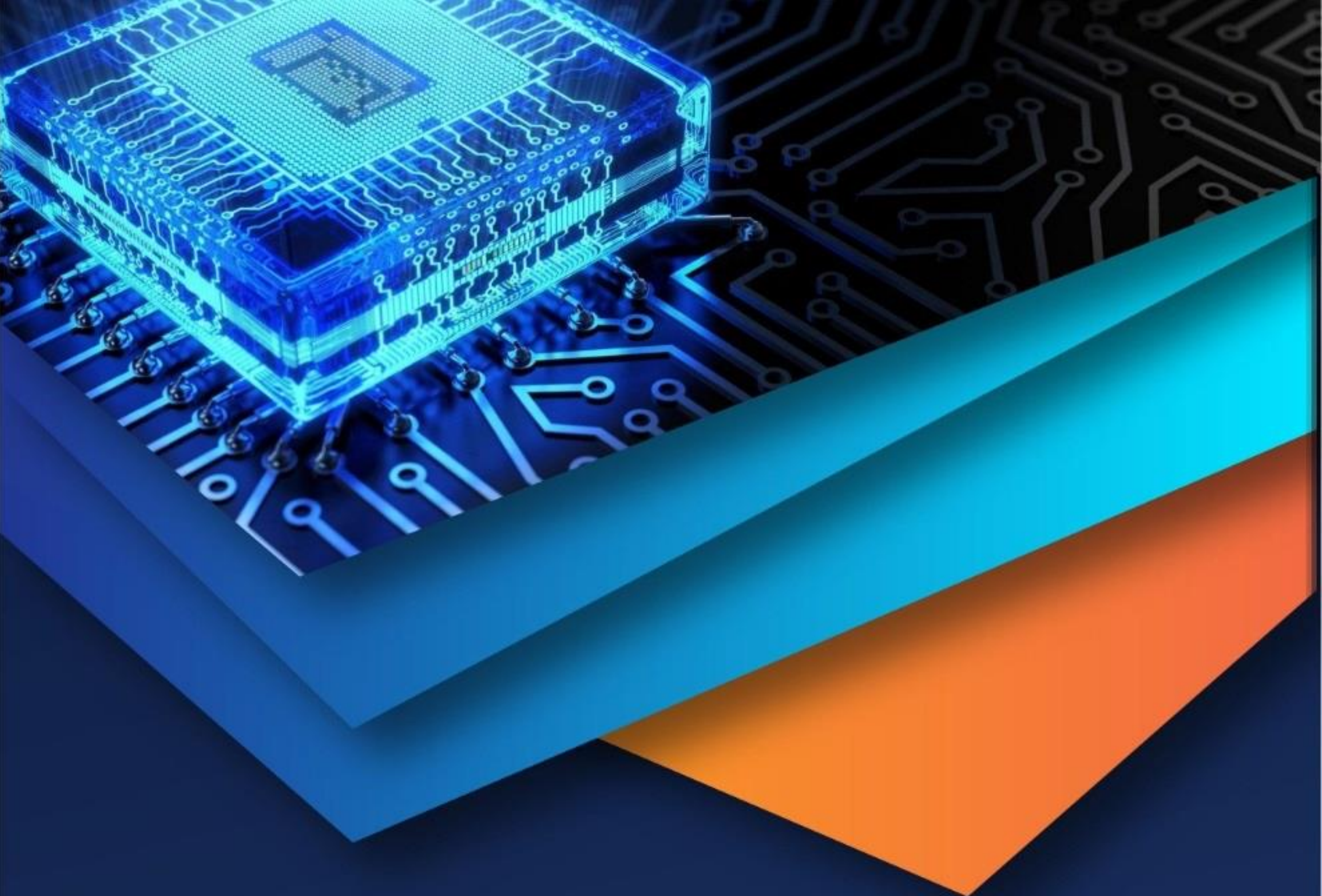

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