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Modelling and Analysis of Heavy Vehical Chassis

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ABSTRACT

Whenever the number of vehicles increase, the usage of the petrol increase respectively. The lack of petrol makes the price increase by time to time. The emission from the vehicle makes the environment faces the air pollution that in critical level. Many steps need to reduce the number of the vehicle in other side to reduce the price of the petrol. Besides that also use to reduce the air pollution. The big number of vehicles in each country makes the prevention to reduce the number of vehicle difficult. So, the other prevention is increase the efficiency of the vehicle's engine. When the engine at the efficient level, the emission is at the low level and the most important is the usage of petrol is low. The prevention is reducing the weight of the body and chassis of each vehicle. This paper focused to reduce the usage of petrol by design and analyzing the chassis to reduce the weight of the chassis of vehicle. At the same time, the global usage of the petrol also reduced.

Keywords:
Air pollution
Efficiency
Emission
Chassis

1. Introduction

Automotive chassis is skeletal frames on which various mechanical parts are mounted Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile [3].

Generally, the basic chassis types consist of backbone, ladder, space frame and monocoque. Different types of chassis design result the different performance. So to improve the performance of vehicle this work concentrates on chassis design and analysis [1].

2. Chassis Design Principle

The fundamental principle of a chassis design states that the chassis is to be designed to achieve the torsional rigidity and light weight in order to achieve good handling performance of a vehicle. By the definition, torsional rigidity is refers to the ability of chassis to resist twisting force or torque. In the other words, torsional rigidity is the amount of torque required to twist the frame by one degree. These parameters also applied to space frame chassis. The chassis designed must have high torsional rigidity in order against the twisting force or torque [2].

3. Properties of Material used for Manufacturing of Chassis

Stainless Steel (Table 1)

Table 1. Properties of Stainless Steel

Density	7.75e-006 kg mm^-3
Coefficient of Thermal Expansion	1.7e-005 C^-1
Specific Heat	4.8e+005 mJ kg^-1 C^-1
Thermal Conductivity	1.51e-002 W mm^-1 C^-1
Resistivity	7.7e-004 ohm mm
Compressive Ultimate Strength MPa	0
Compressive Yield Strength MPa	207
Tensile Yield Strength MPa	207
Tensile Ultimate Strength MPa	586
Young's Modulus MPa	1.93e+005
Poisson's Ratio	0.31
Bulk Modulus MPa	1.693e+005
Shear Modulus MPa	73664
Relative Permeability	1

Aluminium Alloy (Table 2)

Table 2. Properties of Aluminium Alloy

Density	2.77e-006 kg mm^-3
Coefficient of Thermal Expansion	2.3e-005 C^-1
Specific Heat	8.75e+005 mJ kg^-1 C^-1
Compressive Ultimate Strength MPa	0
Compressive Yield Strength MPa	280
Tensile Yield Strength MPa	280
Tensile Ultimate Strength MPa	310
Young's Modulus MPa	71000
Poisson's Ratio	0.33
Bulk Modulus MPa	69608
Shear Modulus MPa	26692
Relative Permeability	1

Structural Steel (Table 3)

Table 3. Properties of Structural Steel

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm
Compressive Ultimate Strength MPa	0
Compressive Yield Strength MPa	250
Tensile Yield Strength MPa	250
Tensile Ultimate Strength MPa	460
Young's Modulus MPa	2.e+005
Poisson's Ratio	0.3
Bulk Modulus MPa	1.6667e+005
Shear Modulus MPa	76923
Relative Permeability	10000

4. Part Modelling of Chassis in CATIA

4.1 Chassis Frame

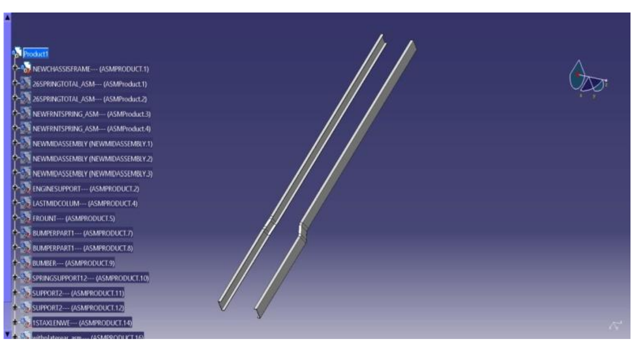

Fig 1. Chassis Frame

4.2 Leaf Spring

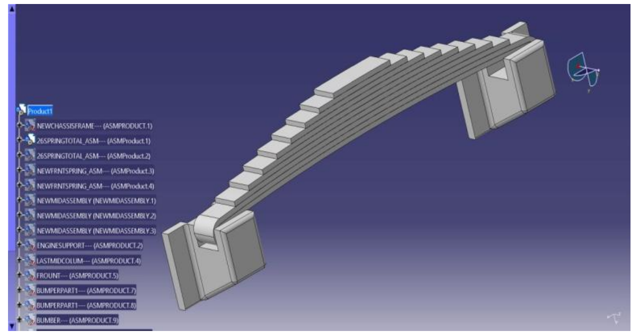

Fig 2. Leaf Spring

4.3 Chassis Frame Support

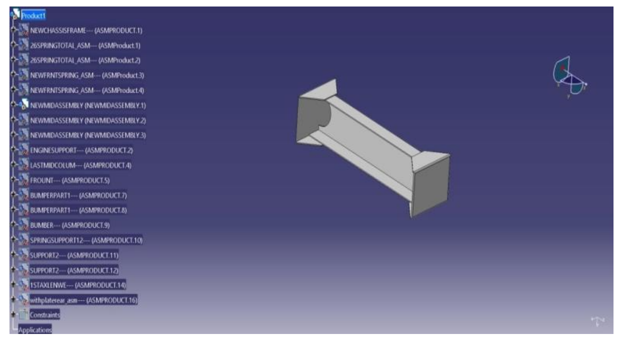

Fig 3. Chassis Frame Support

4.4 Front Axle

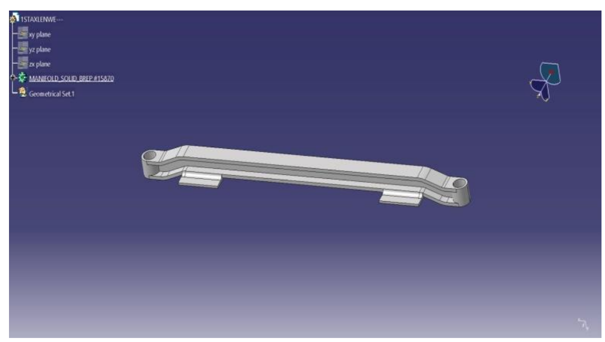

Fig 4. Front Axle

4.5 Rear Axle

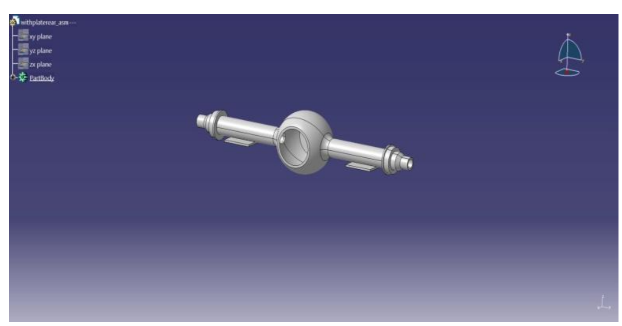

Fig 5. Rear Axle

5. Assembly of Chassis

5.1 Chassis Frame with Leaf Springs

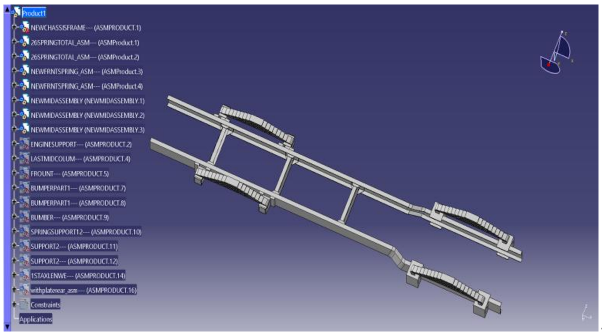

Fig 6. Chassis Frame with Leaf Springs

5.2 Chassis Frame with Engine Support

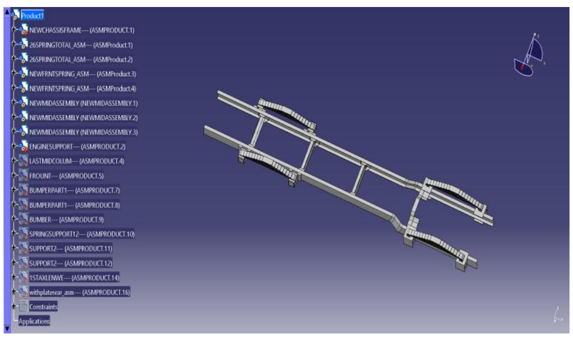

Fig 7. Chassis Frame with Engine Support

5.3 Assembly with Bumper

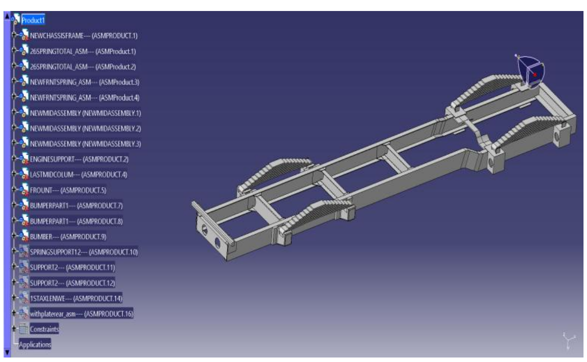

Fig 8. Assembly with Bumper

5.4 Complete Chassis Assembly

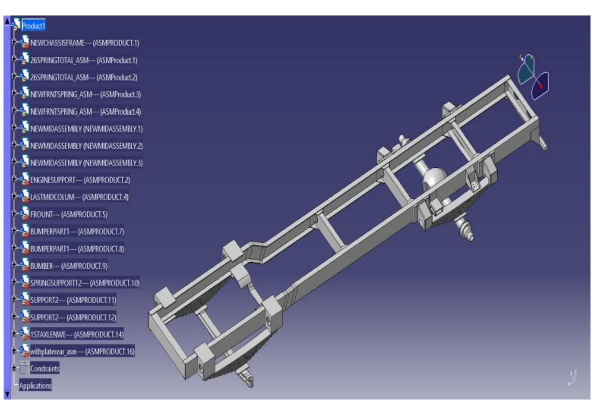

Fig 9. Complete Chassis Assembly

6. Analysis in Ansys

6.1 Chassis Geometry Import

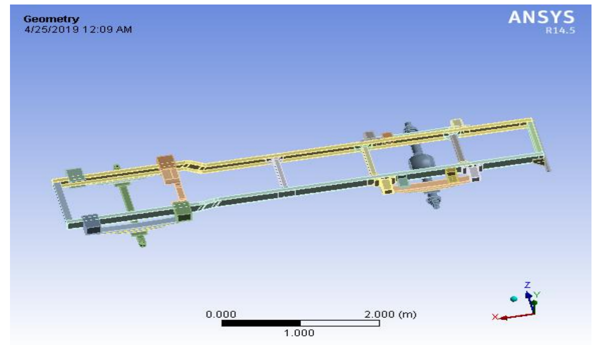

Fig 10. Chassis Geometry Import

6.2 Meshing of Chassis

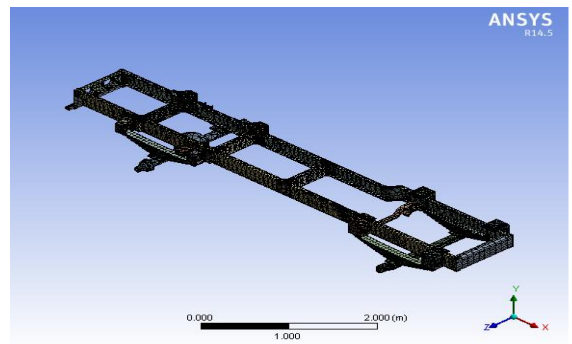

Fig 11. Meshing of Chassis

6.3 Applying Fixed Support

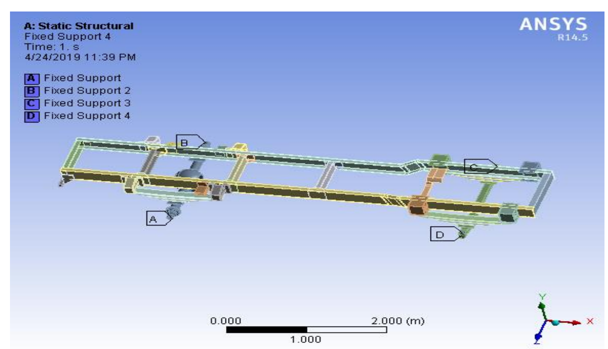

Fig 12. Applying Fixed Support

6.4 Applying Load

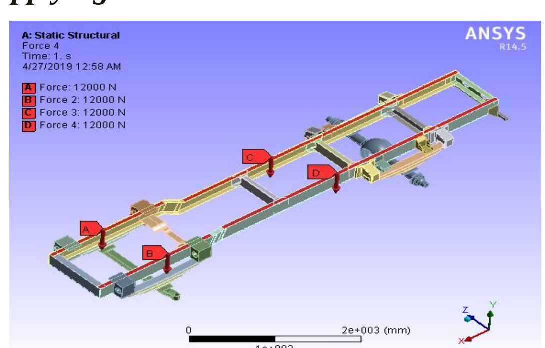

Fig 13. Applying Fixed Support

6.5 Total Deformation of Structural Steel

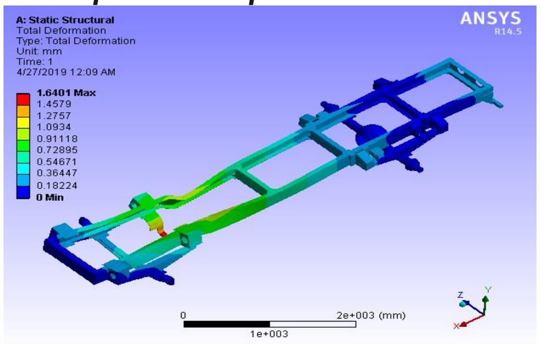

Fig 14. Total Deformation of Structural Steel

6.6 Total deformation of Aluminium Alloy

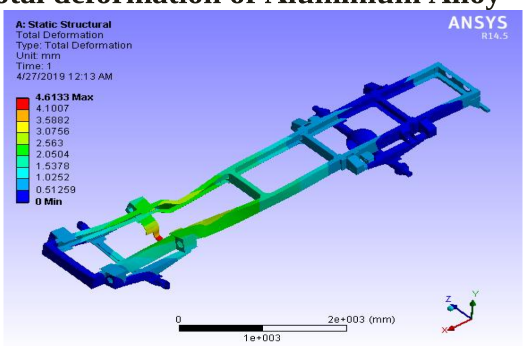

Fig 15. Total deformation of Aluminium Alloy

7. Results

7.1 Aluminium Alloy Results

Table 4. Aluminium Alloy Results

Type	Equivalent (von-Mises) Stress	Maximum Principal Stress	Maximum Shear Stress	Equivalent Elastic Strain	Maximum Principal Elastic Strain
Minimum	2.8485e-004 MPa	-29.914 MPa	1.637e-004 MPa	7.9427e-009 mm/mm	-6.7503e-006 mm/mm
Maximum	194.31 MPa	67.705 MPa	109.2 MPa	2.7738e-003 mm/mm	1.4646e-003 mm/mm

Table 5. Structural Steel Results

Type	Equivalent (von-Mises) Stress	Maximum Principal Stress	Maximum Shear Stress	Equivalent Elastic Strain	Maximum Principal Elastic Strain
Minimum	3.0968e-004 MPa	-26.123 MPa	1.7701e-004 MPa	2.9042e-009 mm/mm	-3.7386e-006 mm/mm
Maximum	194.1 MPa	67.084 MPa	108.84 MPa	9.8304e-004 mm/mm	4.8226e-004 mm/mm

Table 6. Stainless Steel Results

Type	Equivalent (von-Mises) Stress	Maximum Principal Stress	Maximum Shear Stress	Equivalent Elastic Strain	Maximum Principal Elastic Strain
Minimum	3.0133e-004 MPa	-27.155 MPa	1.7254 e-004 MPa	2.9751e-009 mm/mm	-3.4288e-006 mm/mm
Maximum	194.17 MPa	67.296 MPa	108.96 MPa	1.0193e-003 mm/mm	5.1269e-004 mm/mm

Table 7. Comparison of Static Structural Results

Material	Deformation (mm)	Stress (mpa)	Strain (mm/mm)
Aluminum alloy	4.6133	194.3	0.0027
Structural steel	1.6401	194.1	0.0009
Stainless steel	1.6991	194.17	0.0010

7.2 Modal Analysis Results

Table 8. Structural Steel Modal Analysis Results

Total Deformation						
Frequencies (Hz)	36.409	39.969	40.997	50.598	60.022	62.2
Minimum (mm)	0					
Maximum (mm)	0.1485	0.12942	0.1137	0.11001	0.11774	0.21956

Table 9. Aluminium Alloy Modal Analysis Results

Total Deformation						
Frequencies (Hz)	36.508	39.639	41.054	51.278	59.596	60.198
Minimum (mm)	0					
Maximum (mm)	7.8719	6.7822	6.0151	5.9458	10.521	6.3623

Table 10. Stainless Steel Modal Analysis Results

Total Deformation						
Frequencies (Hz)	35.985	39.048	40.446	50.498	58.718	59.33
Minimum (mm)	0					
Maximum (mm)	4.7098	4.0535	3.5987	3.552	6.3174	3.8123

8. Conclusion

8.1 Static Analysis Conclusion

The entire analysis is done with Ansys software in which three different materials are considered. The deformation, stresses and strain values are compared at 12000N load. Stress values are less than yield point of materials. From the above three materials structural steel is the better material suitable for chassis which is having less deformation, stress and strain values compared to aluminium and stainless steel.

8.2 Modal Analysis Conclusion

From the modal analysis of structural steel material we observed frequencies of 36.409, 39.969, 40.997, 50.598, 60.22 and 62.2 Hz. And also we observed the deformations at these frequencies

By using composite materials like aluminium alloy the weight of chassis is reduced four times less than structural steel material. But structural steel material is more economical than aluminium alloy, by taking this factor into consideration structural steel material is used for chassis.

References:

[1] M. Ravi Chandra , S. Sreenivasulu , Syed Altaf Hussain, “Modeling and Structural analysis of heavy vehicle chassis made of polymeric composite material by three different cross sections”, International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.4, July-Aug. 2012 pp-2594-2600, ISSN: 2249-6645.

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