Structural Analysis of Ladder Chassis for Optimization

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Abstract:

Automotive chassis is an important part of an automobile. It forms the bones of a vehicle. The chassis serves as a frame work for supporting the body and different parts of the automobile, it should be rigid enough to withstand the shock, twist, vibration and other stresses & its principle function is to carry the maximum load for all designed operating condition safely. An important consideration in chassis design is to have adequate bending stiffness along with strength for better handling characteristics. Therefore, maximum shear stress and deflection are important criteria for the chassis design. This paper describes Structural analysis & optimization of vehicle chassis with constraints of maximum shear stress and deflection of chassis under maximum load. In the present work, we have taken higher strength as the main issue, so the dimensions of an existing vehicle chassis of a TATA LP 912 Diesel BS4 bus is taken for analysis with materials namely Steel alloy (Austenitic) subjected to the same load. The four different vehicle chassis have been modeled by considering four different cross-sections. Namely C, I, Rectangular Box (Hollow) and Rectangular Box (Intermediate) type cross sections. For validation the design is done by applying the vertical loads acting on the horizontal different cross sections.

Keywords- Vehicle chassis, Static analysis, Steel alloy (Austenitic), Rectangular Box (Hollow) and Rectangular Box (Intermediate) type cross sections.

1. Introduction

Chassis is considered to be one of the significant structures of an automobile. It is usually made of a steel frame, which holds the body and motor of an automotive vehicle. To be precise, car chassis or automobile chassis is a skeletal frame which bolts various mechanical parts like engine, tires, brakes, steering and axle assemblies. Chassis usually made of light a metal or composite plastic which provides strength needed for supporting vehicle components and load into it. Here I listed several different types of automotive chassis which include ladder chassis, backbone chassis, monologue chassis and tubular space frame chassis.[1]

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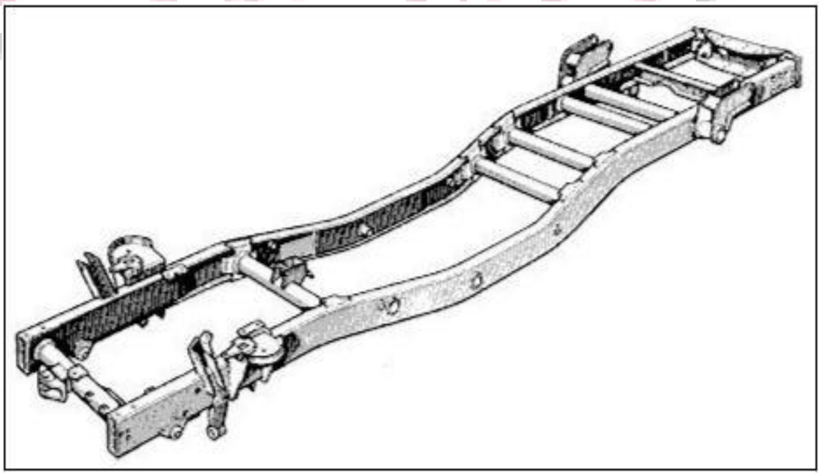

Figure 1: Ladder chassis

The different kind of chassis is backbone chassis which has a square tube like spine and simple in shape. It normally made up of glass fiber this is used for becoming a member of front and rear axle together and liable for maximum of the mechanical strength of the framework. The space within the shape is used for positioning the force shaft in case a rear-wheel pressure. Furthermore, the drive teach, engine and suspensions are all linked to every of the ends of the chassis. This type of chassis is powerful sufficient to provide support smaller sports automobile besides it is easy to make and cost effective.[2]

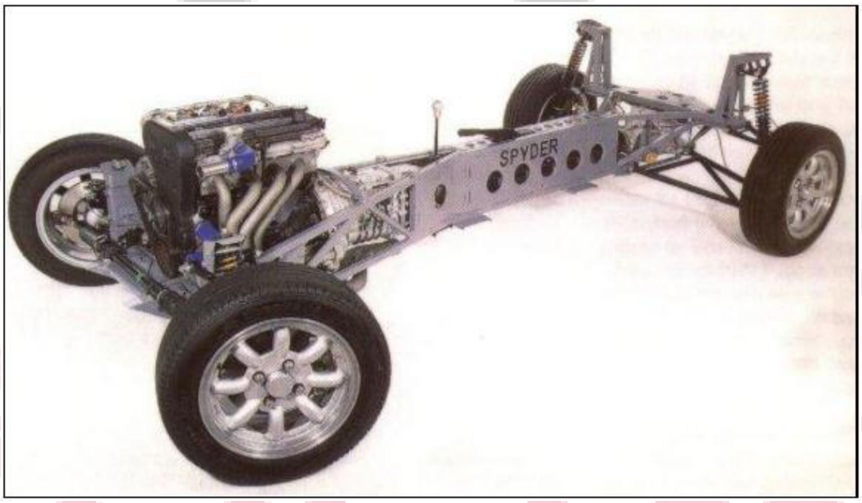

Figure 2: Backbone chassis

As for monologue chassis, most cutting-edge automobiles in recent times use this kind of chassis. A monologue chassis is a single piece of framework that offers shape to the car. A one-piece chassis is constructed by way of welding numerous portions collectively. It is different from the ladder and resolution chassis as not like them integrated with the body in a unmarried piece, while the former best assist the strain contributors. The stressful of a monologue chassis particularly multiplied on the grounds that it's miles value powerful and suitable for robotized manufacturing.[3]

Figure 3: Monologue chassis

In this look at, it is determined that tubular area body chassis is used for the urban car. Since lad der chassis isn't strong sufficient, motor racing engineers have evolved a three-dimensional layout which referred to as tubular space body. Tubular area frame chassis employs dozens of round-phase tubes (so me may use rectangular-segment tubes for less difficult connection to the frame panels though circular segment presents the maxi mum electricity), position in one-of-a-kind directions to provide mechanical power towards forces from everywhere. These tubes are welded collectively and shape a complicated shape. For better electricity required by means of high performance sports cars, tubular area frame chassis typically incorporate a sturdy shape beneath both doors. Tubular area frame chassis also very strong in any course as compared with ladder chassis and monologue chassis of the same weight.[4]

Figure 4: Space frame chassis

2. Chassis Design Principle

The fundamental precept of a chassis layout states that the chassis is to be designed to acquire the torsional rigidity and light weight in order to attain true coping with overall performance of a race car. By the definition, torsional stress is refers to the capability of chassis to withstand twisting force or torque. In the alternative words, torsional. [5]

Rigidity is the quantity of torque required to curve the body by way of one degree. These parameters additionally implemented to area body chassis. Generally, the effect of the torsional tension on area body is different to the monocoque due to their production format; however the structure is used to approximate the equal results as the difficult to curve monocoque chassis. [6]

According to the declaration above, chassis designed ought to have high torsional tension in order against the twisting force or torque. In order to increase torsional rigidity at the chassis, the layout of tube pipes arrangement have to be considered. By strategically positioning a frame member, torsional stress growth drastically.[7]

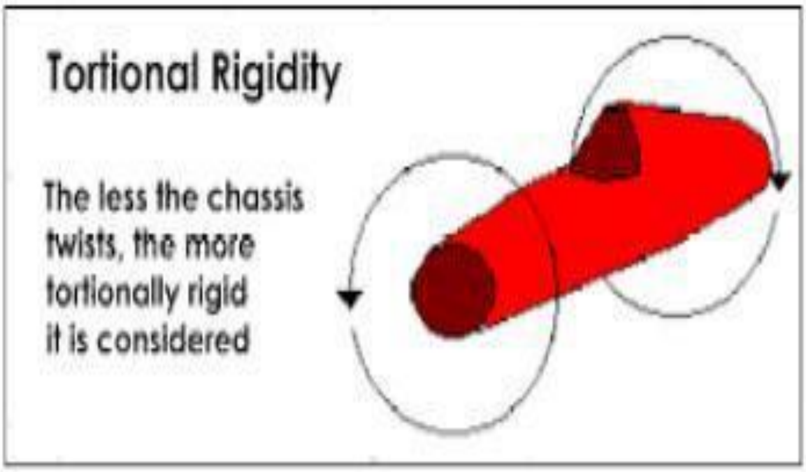

Figure 5: Torsional rigid of car chassis

The triangulated box imparts strength by stressing the diagonal in tension and compression. As shown, the box will not easily deformed by bending force due to the triangulated format of frame. Hence, most race car chassis today designed in triangulated.[8]

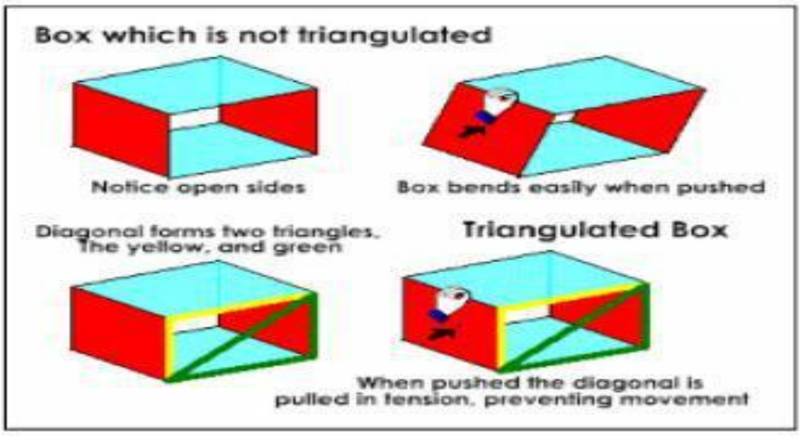

Figure 6: The strategy on positioning space frame number

3. Structure Steel Mechanical properties S460

Table 1 Structure Steel Mechanical properties S460

Material Field Variable	Value	Units
Density	7850	Kg/m^3
Young's modulus	2E+05	Mpa
Poisson Ratio	0.30	

Shear modulus	76923	Mpa
Bulk Modulus	1.6667E+05	Mpa
Tensile Yield Strength	250	Mpa
Compressive Yield Strength	250	Mpa
Tensile Ultimate Strength	460	Mpa
Compressive Ultimate Strength	0	Mpa

4.**Aluminum Alloy Properties Al (6061)**

Table. 2 Aluminum Alloy Properties Al (6061)

Material Field Variable	**Value**	**Units**
Density	2770	Kg/m^3
Young's modulus	2.3E+05	Mpa
Poisson Ratio	0.33	
Shear modulus	26692	Mpa
Bulk Modulus	69608	Mpa
Tensile Yield Strength	280	Mpa
Compressive Yield Strength	280	Mpa
Tensile Ultimate Strength	310	Mpa
Compressive Ultimate Strength	0	Mpa

5. Epoxy E-Glass UD

Table.3 Epoxy E-Glass UD

Material Field Variable	**Value**	**Units**
Density	2000	Kg/m^3
Young's modulus X Direction	45000	Mpa
Young's modulus Y Direction	10000	Mpa
Young's modulus Z Direction	10000	Mpa
Poisson Ratio XY	0.3	

Poisson Ratio YZ	0.4	
Poisson Ratio ZX	0.3	
Shear modulus XY	5000	
Shear modulus YZ	3846.2	
Shear modulusXZ	5000	

6. Epoxy E-Carbon UD

Table. 4 Epoxy E-Carbon UD

Material Field Variable	Value	Units
Density	1490	Kg/m^3
Young's modulus X Direction	125000	Mpa
Young's modulus Y Direction	8600	Mpa
Young's modulus Z Direction	8600	Mpa
Poisson Ratio XY	0.27	
Poisson Ratio YZ	0.4	
Poisson Ratio ZX	0.27	
Shear modulus XY	4700	
Shear modulus YZ	3100	
Shear modulusXZ	4700	

7. Epoxy S-Glass UD

Table. 5 Epoxy S-Glass UD

Material Field Variable	Value	Units
Density	2010	Kg/m^3
Young's modulus X Direction	45000	Mpa
Young's modulus Y Direction	10000	Mpa

Young's modulus Z Direction	10000	Mpa
Poisson Ratio XY	0.3	
Poisson Ratio YZ	0.4	
Poisson Ratio ZX	0.3	
Shear modulus XY	5000	
Shear modulus YZ	3846.2	

8. Finite Element Analysis (FEA) Using ANSYS

Finite Element Analysis (FEA) changed into first advanced via R. Courant in 1943, who utilized the Ritz method of numerical evaluation and minimization of version calculus to reap approximate solutions to vibration structures. FEA includes a computer model of a cloth or layout that is stressed and analyzed for precise outcomes. It is used in new product design, and existing product refinement. A company is able to verify a proposed design can be able to carry out to the client's specs previous to manufacturing or creation. Modifying an existing product or shape is utilized to qualify the product or shape for a new carrier circumstance. In case of structural failure, FEA may be used to assist decide the layout adjustments to fulfill the brand new circumstance

B. Ramana Naik and C. Shashikanth [9] have objective to investigate an car chassis for a ten tonne car. The modeling is completed the usage of Pro-E, and evaluation is performed the usage of ANSYS. The overhangs of the chassis are calculated for the stresses and deflections analytically and are compared with the effects received with the evaluation software. Modal Analysis is also executed to find the natural frequency of the chassis and visible that it's far above than its excitation frequency. The Theoretical calculations and FE evaluation results are compared and it is determined that they're within the cloth houses. This frequency is greater than 4 instances the very best frequency of the excitation (i.E. 33 Hz) consequently the chassis can faithfully transmit the input excitation to the automobile frame with none amplification.

Kamlesh Y. Patil and Eknath R. Deore [10] have research the Ladder Chassis body of TATA 912 Diesel Bus and The version of the chassis changed into created in Pro-E and analyzed with ANSYS for Various Cross Sections for same load conditions. They found that the Rectangular Box (Hollow) section is more power full than the traditional metallic alloy chassis with C and I design specs. The Rectangular Box (Hollow) section is having least` deflection i.e., 2.683 mm and pressure is 127 N/mm2 in all of the three type of chassis of different pass segment.

Sharma et al [11] have research the chassis of a Heavy Vehicle TATA LPS 2515 EX with 3 specific alloys subjected to the equal situations of the metal chassis. The three material used for the chassis are grey cast iron, AISI4130 alloy steel and ASTM A710 STEEL GRADE A. The 3 one-of-a-kind vehicle chassis have been modeled by way of considering 3 unique go-sections. Namely C, I, and Box type cross sections. A 3 dimensional stable Model become built within the CAE software CATIA V5 parametric and the evaluation became finished in ANSYS-14.Five. The outcomes shows that the default cloth for the chassis i.E. A709M Grade 345 W Structure metal shows energy same to the AISI 4130 steel alloy however in case of the deformation AISI 4130 alloy is superior to shape steel. So, for the consideration of alloy for the chassis AISI 4130 alloys is higher than others and for one of a kind go sections of the chassis C-section chassis is appropriate for the heavy vans.

Lenin et al [12] modeled a chassis used in a TATA ACE using CATIA. Structural and modal analyses are carried out on chassis the usage of ANSYS. The analysis is executed the use of three materials Cast Iron, Aluminum and E-GLASS EPOXY. By watching structural evaluation consequences, the strain values for Glass Epoxy and E –Glass Epoxy are much less than their respective allowable strain values. So the usage of composites for chassis is safe. From the obtained ANSYS effects it became observed that the appropriate proposed material for automotive chassis is Glass Fiber Reinforced Plastic Materials. But, when in comparison with GFRP the price of CFRP might be better consequently here considered that, the GFRP cloth is appropriate for automotive chassis. Also while compared distinct phase it is located that the I-segment may be suitable for this software.

Conclusion

\ Stress analysis using finite element method was successfully carried out to determine high stress value, maximum deflection and its location on a low loader chassis structure. The corresponding technical drawing and information of the low loader chassis obtained was utilized to develop the finite element model. The results of analysis revealed that the location maximum deflection and maximum stress agrees well with theoretical maximum location of simple beam under uniform loading distribution. This study found out that there is discrepancy between the theoretical (2-D) and numerical (3-D FEA) results. Therefore further analysis will be performed to improve the current FE model. Apart from that, future study will include experimental investigation to determine actual deflection of a similar beam. Structural analysis to optimize the number of Box-beams that lead to weight and cost reduction will be reported imminently.

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