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(Review Article)

Optimization and analysis of chassis for heavy electric truck under different condition

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Abstract

The design of heavy electric truck chassis is a critical aspect of developing sustainable and efficient transportation solutions. Heavy electric trucks, which are powered by electric motors and rely on large battery packs for energy storage. the structural integrity and strength of the chassis are of utmost importance. the integration of the battery pack into the chassis is a critical consideration. The chassis needs to accommodate the size, weight, and distribution of the battery pack while ensuring proper thermal management and protection. the unique challenges posed by these vehicles. By considering factors such as structural integrity, battery integration, lightweight materials, and other relevant design considerations, it is possible to develop efficient and sustainable heavy electric trucks that meet the demands of modern transportation.

Keywords: Chassis; Heavy EV vehicle; FEM; Stress; Deformation.

1. Introduction

In recent years, road vehicles have undergone significant changes based on their design and other functional elements. Countries currently in the development stage require faster and heavier transport. To meet these needs, manufacturer is developing heavy-duty electric trucks. These vehicles can transport heavy loads faster and more efficiently, but the vehicles must remain safe. Automotive parts including batteries, inverters, motor transmissions, tires, axles, assemblies, brakes, steering systems, etc. It is bolted to the vehicle chassis, which acts as a frame. Provides strength and stability to the vehicle in a variety of conditions. Ladder frames are often used in large commercial vehicles due to their increased load bearing capacity. Car frames provide flexibility and strength to cars. Every vehicle has a body that must support both its own weight and its payload. The weight of electrical components is greater than that of a conventional diesel engine. Main spars, end rails and cross members are just some of the components of the chassis design. Cross members keep the main rails parallel, creating a sturdy box-like structure. Typically connecting plates are used to connect cross members to side members. Trucks are connected by rivets or bolts, while trailers are connected by welding. Designing vehicles with higher payload capacity is a critical issue for the industry. Automotive designers must have a clear understanding of the different stresses encountered in different areas of chassis work. Therefore, we review the literature on chassis analysis in the current work and discuss. The ability of a chassis to withstand bending, have torsional rigidity, and have strength for good handling qualities are essential factors in effective chassis design.[1][2] It is also vital to analyse the chassis under fatigue loading conditions because the fatigue loads operating on it (produced by the weight of the engine and the road conditions) also affect its life and durability.[3]

The weight of the chassis has gradually increased over the past 20 years due to the development of safety features [4]. Significant improvements in chassis design could be made in the early stages of the design process by utilizing sophisticated optimization techniques [5,6]. Numerous scholars, including Duddeck [7], Pedersen [8], and Chiandussi et al. [9], have worked in optimizing the suspension and other body part designs of the car, which helped the car weigh less. The zones of high stresses caused by the imposed large loads during vehicle operation have been identified by FEA

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analysis done on heavy vehicle chassis. The strains are further increased by the self-weight of the chassis frames [10]. Consequently, self-weight considerations should be incorporated into the vehicle chassis design [11].

Using the NASTRAN FEA simulation program, Yang and Chahande [12] carried out a space frame analysis. The heavy vehicle chassis design has been optimized by Kang et al. [13] by the application of the analytical target cascading (ATC) method. The results have demonstrated that the The ATC approach is a useful tool for enhancing the current chassis' design. To minimize the weight and expense of the chassis, E.R. Deore et al. [14] carried out numerical investigations on low-loader chassis by optimizing the side member thickness and positional variation of cross members. According to their research, the thickness of the cross members in the chassis has a major impact on the deformation and pressures that are placed on it.

The goal of the current study is to use experimental and numerical approaches to examine the chassis of an electric truck, a big vehicle. Next, by examining several chassis characteristics, we want to optimize this chassis. The approach we used is detailed in the following section. accomplishing the aforementioned.

2. Methodology

CAD modelling, meshing, applying loads, and boundary conditions to the model are all part of the FEA pre-processing step [15]. the assembly of global stiffness elements, inversions, and multiplications are all part of the solution step. The post-processing, the last phase, entails interpreting the analysis's findings. The specifications for the chassis were acquired from [16]. The general research process is visually depicted in Figure 1.

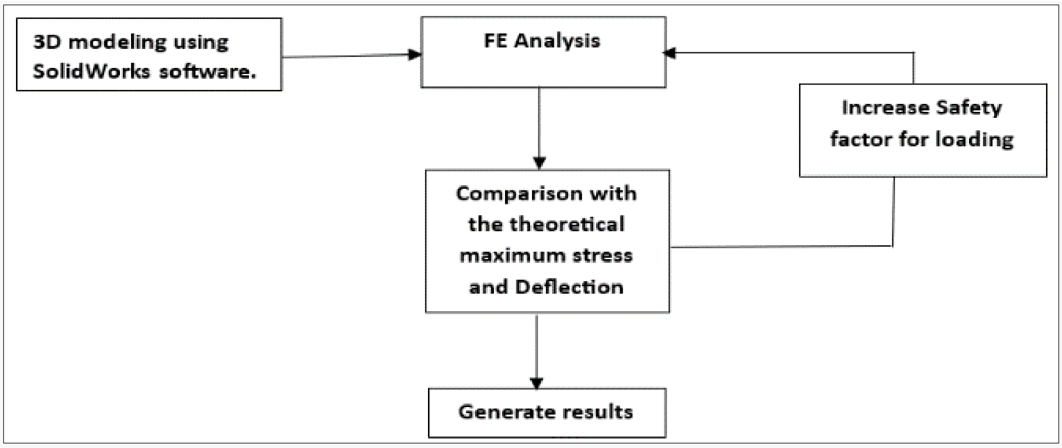

Figure 1 Process flow and analysing [17]

2.1. Desing calculation for chassis frame

- Material and geometry of tata 1612
- Side rail of chassis is made of 'C' channel with 116mm*36mm*5mm.
- Material = structural steel.
- Front overhang = 740mm
- Rear overhang = 1400mm
- Wheelbase = 6670
- Stress produces on beam = 831 N/mm^2

2.2. Material properties

Table 1 Structural steel properties

Parameter	**Specification**
Density	7850 kg/m3
Yong's Modulus	2.e+005
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+001 Pa
Shear Modulus	76923e+006 Pa
Yield Strength	250+006 Pa
Ultimate Strength	460e+006 Pa

2.3. Solidworks model

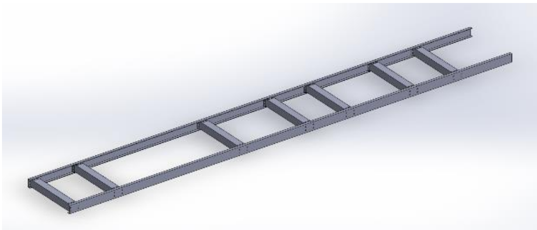

Figure 2 CAD model

The frontal section of the vehicle is shown in Figure 2 on the left side of the chassis.

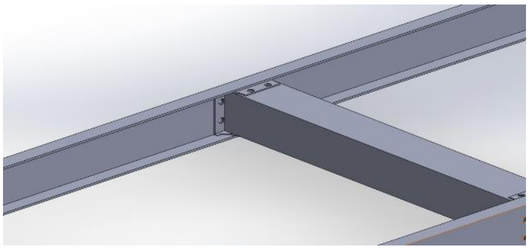

Figure 3 Joints of side rail and cross member with support

Meshing, also known as meshing, is the process of separating regions of complex geometry by dividing it into two- or three-dimensional meshes called elements. This process is critical to performing accurate simulations using FEA. In this meshing value taken as 3mm. After meshing the 57727 nodes and 25720 elements in statistics.

Statistics	
Nodes	57727
Elements	25720

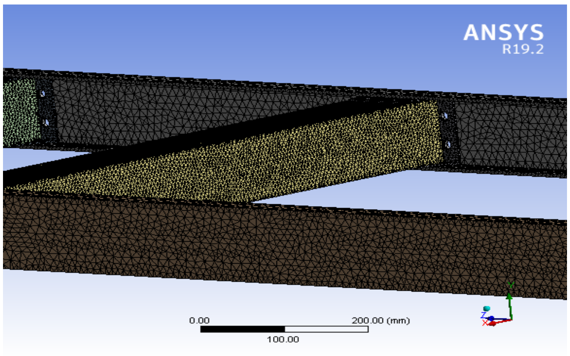

Figure 4 An enlarged image of the mesh model

2.4. Load and boundary condition

Figures 5 and 6 below depict the loads and boundary conditions that are applied to the chassis structure. The front and rear transverse members are the first to get the supports. These transverse components support the wheels, axles, and suspensions. The battery's downward force is 38128.2552 N, whereas the force of the motor plus further electric components is 2745.862 N.

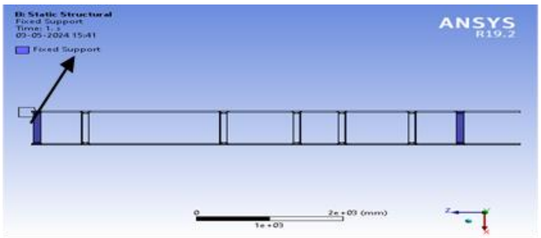

Figure 5 Fixed support

There are two forces applied on chassis cross members. First battery modules downward force is 38128.2552 N at front three cross member after wheelbase and the force of the motor is 2745.862 N at last second or third crossmember and some other EV components.

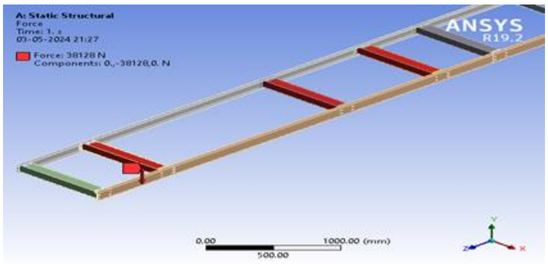

Figure 6 Forces in downward direction (battery modules)

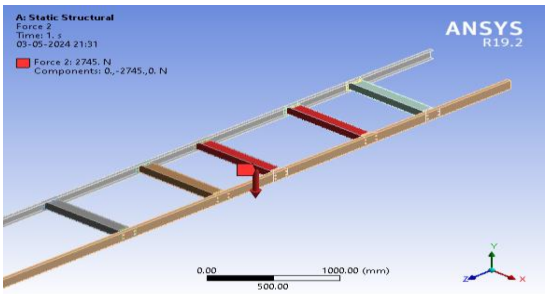

Figure 7 Forces of downward direction (motor)

A sparse matrix solver is used to perform the simulation after the loads and boundary conditions have been established. This is carried out in order to eliminate the sequential step that organizes equations at each iteration and to reuse the same matrix structure throughout the simulation [18]. The There are matrices created for every element. The full element edge length is interpolated from the computed deformation and stresses at nodes. The outcomes of the finite element simulations on the typical chassis are shown in the following section.

2.5. Ev component

2.5.1. Number of battery and weight

Heavy duty trucks will have 9 battery packs. The total energy of each battery pack is 72 kWh, which means a total of 650 of energy. The weight of each battery is 432 kg. for 9 batteries pack the total weight is 3888 kg. [19] [20] In the Tata1612 truck chassis has four wheels at the rear axle and two wheels are front at the front axle. The location of the electric motor is very important in large electric vehicles due to their weight. Basically, motor weighs about 280 kg.

72 kwh x 9 modules = 648 kwh

Approximate 650 kwh

3. Result and discussion

To find the corresponding stresses and deformation, a FE simulation is run on the chassis. Figure 8 illustrates that the longitudinal member areas closest to the supported end have higher equivalent stress. Additionally, the midsection of the chassis has high tension. This indicates that under extreme loading circumstances, the chassis' centre and corner ends may fail. The failure of the chassis may manifest as the beginning of a crack that spreads with repeated stress.

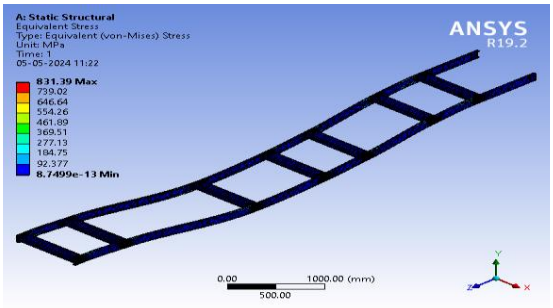

Figure 8 Equivalent stress

Figure 9 displays the chassis deformation plot. Around 12.047 mm of maximal deformation happens at the mid-section/mid-length of the chassis. The transverse elements at the ends experience the least amount of distortion as it declines. arranged It must enhance the chassis to increase its reaction to such loads.

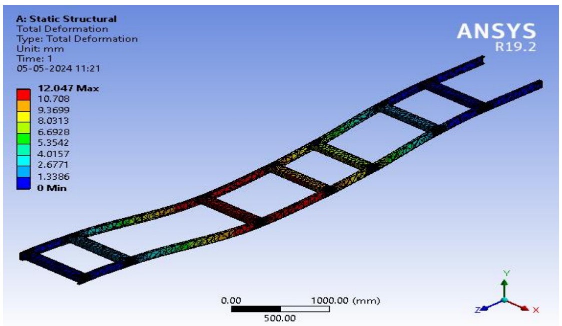

Figure 9 Plot of deformation

4. Conclusion

The dynamics and load-bearing qualities of the chassis are significantly influenced by its dimensions. These qualities can be enhanced, and weight reduced with an efficient design. For instance, a chassis with less bulk will require less material to manufacture.

FE findings for a typical chassis the chassis' FE result includes an electric component. FE findings for a typical chassis to find the equivalent voltage and deformation, FE simulations are run on the chassis. Near the supported ends are the side member portions, which are: Figure 5 illustrates the greater equivalent voltage. Additionally, the central portion of the chassis stress has significant voltage. This indicates that under extreme loading circumstances, damage to the chassis' edges and centre may occur. Chassis failure is a possibility.

The chassis deformation diagram shown in Figure 6. Maximum deformation 12.047 mm occurs at middle/medium length of the chassis. Deformations are reduced and the smallest of the cross elements are located at the end. We need to improve the chassis to improve its response to such things. When it comes to making decisions in the industrial sector, cost is a major consideration. A lighter chassis is an indication of lower production, manufacturing, and material costs. Thus, it is desirable to use the optimization strategy that results in a bigger weight reduction.

Future work

Enhancing the design of vehicle chassis necessitates considering multiple factors. Changes could likely improve the vehicle's chassis design. by rearranging the cross sections' orientation and/or cross member positions. components of the chassis. Furthermore, how the choice of material influences stiffness and strength while bearing large loads. Research is necessary for automotive chassis design. This might significantly affect ratio of chassis strength to weight.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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