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A Research Survey on Truck Chassis Design

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Abstract: *A failure in a heavy duty truck frame generally involves crack growth under mixed mode I/II/III loading since the vehicle loads are highly nonlinear transient and multi-axial with large deformation behavior. The propagation of cracks in truck frame members is important to be well studied since on reaching critical crack lengths it can lead to complete breakdown of the vehicle and this may lead to catastrophic accidents with loss of life. A failure analysis investigation was performed on a fractured heavy duty truck frame rail obtained during endurance track testing. The fracture observed was on the frame web within the torque rod connection to the rear drive axle of the vehicle.*

Keywords: heavy duty truck, frame, deformation, fracture.

Introduction

The chassis is the component of an automobile which acts as a chassis to support the vehicle body. Provides strength and stability to the vehicle when exposed to different conditions. He kept the engine part, the cabin, the transmission, the axles, the suspension system and other chassis components. Through careful macroscopic and microscopic observations, the crack was found to be primarily caused due to aggressively drilled open-hole close to an existing bolt hole. The drilled hole created small crack initiations within a high stress location of the frame.
• FRANC3D crack growth simulation tool combined with NASTRAN finite element solver was used in this work to simulate frame crack growth under full vehicle dynamic loads.

The simulation results obtained showed good correlation to physical crack path and cycles to failure. The lead frame is mounted on the front and rear to absorb the spring effect of the suspension system. The frame is narrowed in the front for better steering lock. The different sections used in the construction of the frame include the channel, the box, the cap, the double channel and the section I. A stress analysis is performed on the frame to determine thecritical point with the maximum stress.

The critical point is the crucial element that leads to the failure of the frame fatigue. The service life of the fire truck chassis depends entirely on the strength of the stress. This modal and static structural analysis works on ladder structures. Static structural analysis includes identification of the maximum load area. The chassis must be rigid and sufficiently resistant to absorb the vibrations caused by the engine, suspension and transmission line. The most commonly used materials for the frame are steel and aluminum. However, it has been discovered that carbon fibers are advantageous over these conventional materials since carbon.

Figure 1: Conventional Frame.

1.1 Basic Concepts of Composite Materials

Composite materials are essentially hybrid materials made up of multiple materials in order to use their individual structural advantages in a single structural material. Various scientific definitions of composite materials can be expressed as follows:

The word compound means composed of two or more parts. A composite material is made up of two other materials. The composite material therefore has the properties of the two materials whichhave been combined.

The word compound in the term compound material means that two or more materials are combined on the macroscopic scale to form a third useful material. The key is the macroscopic examination of a material in which the components can be identified with the naked eye. Different materials can be combined on a microscopic scale, for example when binding metals, but the resulting material is macroscopically homogeneous for all practical purposes, i.e. H. The components cannot be distinguished from the naked eye and basically work together.

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A composite material is a structural material consisting of a combination of two or more components. The components are combined macroscopically and are not soluble in one another.

The key is the macroscopic examination of a material in which the components can be identified with the naked eye. Different materials can be combined on a microscopic scale, for example when binding metals, but the resulting material is macroscopically homogeneous for all practical purposes, i.e. H. The components cannot be distinguished from the naked eye and basically work together. The advantage of composites is that when well-constructed, they generally have the best properties of their components or components and often certain properties that none of the components have. Some of the properties that can be improved by forming a composite are

- Strength
- Fatigue life
- Stiffness
- Temperature
- Dependent behavior
- Corrosion resistance
- Thermal insulation
- Wear resistance

- Thermal conductivity
- Attractiveness
- Acoustical insulation
- Weight

Modern composite materials with fiber-reinforced matrices of different types have sparked a revolution in high-performance structures in recent years. Advanced composites offer significant advantages in terms of strength and rigidity with a low weight compared to conventional metallic materials. With this structural performance comes the freedom to choose the orientation of the fibers for optimal performance. Modern composite materials have been described as revolutionary in the sense that the material and structure can be designed. There are two building blocks that make up the structure of composite materials. A component is called a reinforcement phase and the one in which it is integrated is called a matrix. The material of the reinforcement step can be in the form of fibers, particles, flakes. The materials in the matrix phase are generally continuous. Examples of composite systems include steel reinforced concrete, graphite fiber reinforced epoxy resin, etc.

AL 6061- T-6

T6 temper 6061 has been treated to provide the maximum precipitation hardening (and therefore maximum yield strength) for a 6061 aluminum alloy. It has an ultimate tensile strength of at least 290 MPa (42 ksi) and yield strength of at least 240 MPa (35 ksi). More typical values are 310 MPa (45 ksi) and 270 MPa (39 ksi), respectively.[10] This can exceed the yield strength of certain types of stainless steel.[11] In thicknesses of 6.35 mm (0.250 in) or less, it has elongation of 8% or more; in thicker sections, it has elongation of 10%. T651 temper has similar mechanical properties. The typical value for thermal conductivity for 6061-T6 at 25 °C (77 °F) is around 152 W/m K. A material data sheet [12] defines the fatigue limit under cyclic load as 97 MPa (14 ksi) for 500,000,000 completely reversed cycles using a standard RR Moore test machine and specimen. Note that aluminum does not exhibit a well defined "knee" on its S-n graph, so there is some debate as to how many cycles equates to "infinite life". Also note the actual value of fatigue limit for an application can be dramatically affected by the conventional de-rating factors of loading, gradient, and surface finish. **7050 aluminum** is a heat-treatable alloy which is known as a commercial aerospace alloy.

HEAVY PLATE APPLICATIONS

The alloy offers a combination of high strength, high fatigue strength and high resistance to stress corrosion cracking. Particularly suited to heavy plate applications, the material finds use in fuselage frames, wing skins and other aerospace structures. 7050 alloy is available in two tempers. Cost Composites made from abundant materials available on the domestic market such as carbon, polymers, ceramics and base metals often outweigh these imported strategic materials. When reinforcing fibers that offer the ability to produce composites with high strength and stiffness in combination with low density, it is worth looking more closely at the nature of these fibers and their origin.

TYPICAL APPLICATIONS

Commercial applications for this engineering material include:

- Aerospace structures
- Wing skins
- Commercial & military aircraft applications
- Bulkheads
- Fuselage frames

II. Literaure Review

Sanchit Shrivastava et al. [1] The chassis is a French term and was mainly used to indicate the body parts or the basic structure of the car. It is the backbone of the vehicle. The basic task of the frame is to safely provide the highest load for all expected working situations. A perfectly constructed chassis improves impact resistance, passenger safety and weight. Weight reduction is very important in the automotive industry as it improves fuel consumption, performance and emissions. This article aims to reduce the weight of a truck's chassis by 25 tons through finite element analysis. The material optimization process reinforces the design of heavy commercial frames. The frame design can be reinforced using different materials. The chassis has been designed and simulated with "Altair Hyperworks 17.0" for loads and movements.

L. Kiran et al. [2] The automotive chassis is the backbone of the entire vehicle. A good chassis absorbs all sudden loads, torsional loads and impacts without damaging other parts of the chassis and offers the driver the best driving behavior and handling. Now the Indian auto market is growing and with it the demand for light commercial vehicles. Small but dynamic and reliable utility vehicles with a load capacity of approximately 1 tone are required. A steel staircase structure is generally considered. It turns out that there is a sufficiently high stress value and that a considerable deformation is observed in the frame structure and that the demand for alternative materials increases to resist these loads. This article offers an alternative material and a design concept. For this reason, an analysis of the static structure was performed for equivalent stress and displacement tests for the whole material.

A. Benjamin Asirdason et al.[3] The automotive industry operates various vehicle systems with innovative technologies. It is more important to improve vehicle performance with low production costs. Reducing the weight of various parts of a vehicle can improve the car's performance and efficiency. Composite materials offer a good strength / weight ratio that could be replaced by conventional materials. This thesis deals with the structural analysis of a front crosspiece, which is replaced by a polymeric composite material reinforced with carbon fibers. The front cross member of a TATA407 vehicle chassis is modeled with the CREO 2.0 modeling software and analyzed with Ansys Workbench 14.5. The results of stress distribution and deflection of the convection steel and CFRP cross bars were compared. The strength / weight ratio is improved when using CFRP.

Chintada.Vinnod babu et al. [4] the vehicle chassis is an important part of an automobile. The chassis acts as a chassis to support the bodywork and various parts of the car. The chassis frame must withstand loads that occur in a border area. In addition to strength, it is important to have sufficient bending stiffness for better handling when designing the frame. Strength and rigidity are therefore two important criteria for the design of the frame. This article refers to the work on the static structural analysis of the truck chassis, in which the stress and deformation development of the chassis was carried out by EICHER 11.10 taking into account three different materials such as St52, Ni-Cr steel and CFRP. The chassis is modeled in PRO-E and finite element analysis has been performed in ANSYS.

Avinash V. Gaikwadand Pravin S. Ghawade [5] performed a finite element analysis of a staircase structure with the finite element module ANSYS. They showed that the position of von Misses' maximum stress and maximum shear stress is at the corner of the sidebar. The amplitude of the critical point Von Misses is 190.38 MPa and the maximum extent of the shear stress is 106.08 MPa. The maximum displacement size is 3.0294 mm.

Salvi Gauri Sanjay and Kulkarni Abhijeet [6] performed a finite element analysis of the fire truck chassis for steel and fiber materials. They show the modal and static structural analysis of the frame of the TATA 407 fire truck chassis for steel and carbon fibers. From the analyzed results, the stress, strain and total strain values for the two materials were compared. Since it is easy to analyze the structural systems with the finite element method, the frame is modified with PRO-E and the analysis with finite elements is performed on the ANSYS workbench. From its results with steel and carbon fibers, it can be seen that the equivalent stress for carbon fibers has increased andthe total tension has decreased. Therefore, the tension values of the carbon fibers are below an acceptable limit. Therefore, thanks to its high strength and low weight, it is ideal to use carbon fiber as the chassis material for vehicles. With the same load-bearing capacity, carbon fibers are preferable to steel in the production of lead frames, since (steel frame mass 170.45 kg and carbon fibers = 54.28 kg) reduce the weight of From 60 to 68% and increase the rigidity of the frame of the frame.

Vishal Francis, Rajnish Kumar Rai, [7] Structural analysis of the jeep ladder frame performed with ANSYS. In his work, the chassis of the jeep ladder chassis was analyzed with the ANSYS 14 software, based on the analysis, the following conclusions can be drawn. 1) The generated shear stresses are lower than the allowable value, therefore the construction is safe for the three materials.
2) The cutting stress was found to be the minimum in aluminum alloys and the maximum in mild steel under certain conditions. 3) Under certain boundary conditions, von Mises stress was found as the minimum in the aluminum alloy and the maximum in the titanium alloy.

Sandeep M.B et al. [8] discovered how the orientation of the fibers influences the flexural strength of a pure glass / epoxy composite material. The experimental results showed the difference in the flexural strength of the bidirectional glass fibers with an orientation from 0 to 90 ° and -45 +45 ".

Bhat Ka, Untawale Sp and Katore Hv [9] carried out a fault analysis and optimization of the chassis of the towing vehicle with the ANSYS finite element package. He designed a modified chassis for the tractor truck. The excellent carriage frame designed by the industry uses a C section of 200mm x 75mm x 7mm size and the material used is mild steel. By maintaining the material and dimensions and using the T-cross section instead of "C", safer tensions than "C" and a weight reduction of 31.79 kg were obtained. Since the raw material requirements are lower, the costs forthe frame are ultimately reduced.

Dr. Alice Mathai [10] and others are studying the orientation of airplane wings reinforced with carbon fiber - a parametric study. His study focuses on the effect of orientation on the strength of the panels. The wing of a subsonic aircraft was modeled in the ANSYS software. The performance of the wing under load was examined by varying the orientation of the fiber layers. The study observed that the change in stress occurs with the change in the orientation of the fiber layers of CFRP composites. He concluded that with the same thickness of the skin, a change in the orientation of the fibers leads to a change in displacement. The aim of future work is to perform parametric investigations and optimize components using thickness as a variable. The analysis can also be performed by varying the spacing of the ribs or increasing the number of ribs. The analysis can be deepened by providing stiffeners.

Hemant B. Patil, Sharad D. Kachave and Eknath R. Deore [11] Analysis of vehicle chassis constraints made with different thicknesses. They presented a stress analysis of a lowered truck chassis structure consisting of a C beam for the application of 7.5 tons using FEM. The commercial finite element package CATIA version 5 was used to solve the problem. To reduce the costs of the truck chassis, you need to change the design of the chassis structure or reduce the thickness. Thanks to the improved design, it is also important to determine the tensions of a truck chassis before production. In order to reduce the amount of stress at the critical point of the frame frame, the thickness of the side part, the thickness of the cross member and the position of the cross member have been changed from the rear end. Numerical results have shown that changing the position of the beam can be a good alternative if the thickness cannot be changed. The calculated results are then compared with the analytical calculation, it is noted that the maximum deflection corresponds well to the theoretical approximation, but varies as regards the dimensional aspect.

Vinod B et al. [12] examined the influence of fiber orientation on the flexural properties of bisphenolic compounds reinforced with PALF. The results showed that the orientation of the fibers has a strong impact on the flexural properties of composites with a fiber-reinforced polymer matrix.

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S. Channabasavaraju et al. [14] studied the tensile and flexural properties of composites with a polymer matrix reinforced with glass fibers, graphite and kevlar. The results showed that the variation of the fiber types has a significant influence on the tensile and flexural properties of thecomposite materials.

Prashanth Banakar et al. [15] studied the influence of orientation and thickness of fibers on the tensile properties of laminated polymeric composites. The purpose of his research was to better understand the tensile properties of glass fiber reinforced epoxy composites. The effect of the orientation of the fibers and the thickness of the laminate was examined and experiments were conducted to determine the property data for the material specifications. The laminates were obtained by placing them by hand. The laminates have been cut to ASTM standards. Test-ready samples were subjected to tensile loads on a UTM machine. His research shows that tensile strength mainly depends on the orientation of the fibers and the thickness of the laminated polymeric composites. He concluded

1. Layered samples with a lower thickness lead to greater tensile strength regardless of the orientation of the fibers.
2. The sample is loaded more heavily into samples with a QO orientation than other orientations.
3. The elastic modulus of the samples increases with decreasing thickness.
4. The expansion is minimum for 90 ° orientations and maximum for 30 ° orientations.

Keshavamurthy Y C et al. [16] studied the tensile properties of composites with fiber-reinforced angular layer. The glass / epoxy resin with 0 fiber orientation gave a high resistance compared to 30 * and 45 ° with the same load, size and shape.

Vijaykumar.V.Patel and R.I.Patel [17] carried out a structural analysis of the connection grid using the ANSYS workbench. They showed that the position of von Misses' maximum stress and maximum shear stress is at the corner of the sidebar. The critical point the size of the Von Mises stress is 190.38 MPa and the maximum size of the shear stress is 106.08 MPa. The maximum displacement size is 3.0294 mm.

N. K. Ingole et al [18] made some changes to the existing model of the chassis of the semi-trailer:
1) variation of the transverse areas of the sleepers, 2) variation of the transverse areas of the sleepers and sides, 3) variation of the transverse areas of the sleepers and side members and 4) modification of the position cross members of the main frame of the chassis, taking into account the variable cross sections of the cross members and side members. The maximum load in the existing chassis was found to be 75 MPa and the chassis weight was 751.82 kg. Case 4 involves a reduction in the maximum weight of about 112 kg compared to cases 1, 2 and 3. Therefore, modifications are recommended according to case 4. In case 3, the weight reduction is 88 kg witha maximum stress level of about 25 MPato66 MPa.

Kutay Yilmaz9oban, Ya§ar Kahraman and Sakarya [19], Turkey, carried out chassis optimization work using finished analyzes. His main goal was to reduce the weight of the chassis. For this, they used three thicknesses of 4mm, 5mm and 6mm and after analysis, he came to the conclusion that the thickness of 4mm is better because the stress and displacement are better therethan the other two thicknesses.

Sanya Maria Gomez [20] analyzed wing components such as ribs, spars and plates of hypersonic aircraft using FEM, taking into account the isotropic and composite materials. The optimal orientation was obtained by performing a parametric examination using the ANSYS FEM package by varying the orientation sequence in composite materials.
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III. Problem

Failure analysis of frame rail crack was carried out. Through careful macroscopic and microscopic observations, the crack was found to be primarily caused due to aggressively drilled open-hole close to an existing bolt hole. The drilled hole created small crack initiations within a high stress location of the frame.

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