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Literature Review on Chassis Design of On-Road Heavy Vehicles

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ABSTRACT

Chassis is the most important structural member in the On-Road vehicles. All the loads generated by other components of the vehicle are transferred to chassis only. So the chassis structure has to be strong enough to with stand the loads in static and dynamic conditions. In most of the On-Road vehicles the cross section of the chassis structure is uniform in spite of the variable loads. In order to overcome more failure in the chassis structure and ensure the safety, the variable section chassis structure has to be designed based on the variable loads along the length of the vehicle. The present study reviewed the literature on chassis design and presented the findings in the subsequent sections.

INTRODUCTION

In modern world ON-Road vehicles have changed drastically based on the design and other functional aspects. Market demands the faster and higher transportation in a short span. In order to meet this market demand, vehicle manufacturers are designing heavy load carrying vehicles. These heavy load carrying vehicles gives an advantage of faster, heavy transportation in a short span. On the other side the safety of the heavy load carrying vehicle has to be ensured. Based on the historical data Chassis/body is responsible for only 7% of the failure types. However, failures of chassis are catastrophic with serious consequences. In some cases, a consequence of these in-service failures results in the recall of all affected vehicles with heavy costs and bad publicity.

Every vehicle has a body, which has to carry both the loads and its own weight. Vehicle body consists of two parts; chassis and bodywork or superstructure. The conventional chassis frame, which is made of pressed steel members, can be considered structurally as grillages. The chassis frame includes cross-members located at critical stress points along the side members. To provide a rigid, box-like structure, the cross-members secure the two main rails in a parallel position. The cross-members are usually attached to the side members by connection plates. The joint is riveted or bolted in trucks and is welded in trailers. Chassis is the backbone of any vehicle. If any failure occurs in chassis it will leads to the collapse of a whole vehicle system. Also chassis is not a component that can be replaced easily. If any failure occurs at chassis, either have to replace the chassis totally or require the cost and effort similar to the new vehicle assembly.

Chassis design should be cost effective, lesser weight, maximum payload, ensures vehicle safety by withstanding the worst loading conditions. A primary criterion in chassis design is to meet safety requirements first and later to reduce weight in order to satisfy fuel economy requirements. It is important to fully understand the primary loads that the vehicle structure must be capable to withstand. These loads must be efficiently transferred through the structure so that the chassis will not be prone to mechanical failure. Hence the present research work has analyzed the literature on chassis design and discussed the findings.

LITERATURE SURVEY

Kenji KARITA, Yoichiro KOHIYAMA, Toshihiko KOBIKI, Kiyoshi OOSHIMA, Mamoru HASHIMOTO (2003) had developed a chassis made by Aluminium. The material selected for the frame is 6061-T6. They used the Variable section extrusion method for making the chassis. It's developed with the help of computer Aided Engineering. Aluminium material gives an advantage of weight reduction. From this study authors found that the Aluminium chassis meets the target of weight reduction, strength and rigidity. Also they concluded that the remaining technical issues will be addressed to enable commercial adoption of the aluminum frame.

Alireza Arab Solghar, Zeinab Arsalanloo (2013) studied and analyzed the chassis of Hyundai Cruz Minibus. ABAQUS Software was used for modeling and simulation. Self weight of the chassis is considered for static analysis and Acceleration, Braking and Road Roughness were considered for dynamic analysis. It's observed that the stresses on chassis caused by braking were more compared with acceleration.

M. Ravichandra, S. Srinivasalu, Syed altaf Hussain (2012) studied the alternate material for chassis. They studied and analyzed Carbon/Epoxy, E-glass/Epoxy and S-glass/Epoxy as chassis material in various cross sections like C, I and Box Section. TATA 2515 EX chassis was taken for study. Pro-E and Ansys software were used for this work. Study reveals that the Carbon/Epoxy I section chassis has superior strength, stiffness and lesser weight compared to other materials and cross section.

Roslan Abd Rahman, Mohd Nasir Tamin, Ojo Kurdi (2008) used FEM stress analysis as a preliminary data for fatigue life prediction. They used ABAQUS software for simulation and analysis and also taken ASTM Low Alloy steel A710 (C) for study. Primary objective was to find the high stressed area where the Fatigue Failure will start. It's found that the chassis opening area having contact with bolt experiences high stress.

N.V.Dhandapani, G Mohan kumar, K.K.Debnath (2012) have used Finite element methods to study the effect of various stress distribution using Ansys software. To investigate the field failure of 100Ton dumper they introduced gussets in failure area. After modification the chassis structure was validated by linear static analysis and found that the modified chassis was safe.

Teo Han Fui, Roslan Abd. Rahman (2007) have studied the 4.5 Ton truck chassis against road roughness and excitations. Vibration induced by Road Roughness and excitation by the vibrating components mounted on chassis were studied. Chassis responses were examined by stress distribution and displacements. Mode shape results determine the suitable mounting locations of components like engine and suspension systems.

Analysis results reveal that the road excitation was a main disturbance to the chassis.

S.S Sane, Ghanashyam Jadhav, H. Ananadaraj (2008) analyzed the light Commercial Vehicle chassis using FEM and simulated the failure during testing. Hyper mesh and Opti-struct software were used for analysis and simulation. During the study they introduced local stiffeners to reduce the magnitude of the stress. The modified chassis stress values were reduced by 44%.

Vijaykumar V. Patel, R. I. Patel (2012) have studied the Ladder chassis frame of Eicher E2 by static structural analysis. For this study chassis was assumed as simply supported beam with overhang. Pro-E and Ansys software were used for this work. The study also involved the analytical calculation of chassis. Both software analysis and analytical calculation results were compared and found that the stress value obtained from software analysis is 10% more and also displacement was 5.92% more.

Kutay Yilmazcoban, Yasar Kahraman (2011) have studied and optimized the thickness of a middle tonnage truck chassis by using Finite Element technique. The main objective of this work was to reduce the material usage through that gaining reduction in material cost. They had analyzed three types of thickness material to chassis and compared the results by stress and displacement. Study reveals that the 4mm thickness is safe enough to carry 15ton load.

N.K.Ingole, D.V. Bhope (2011) analyzed the Tractor Trailer made by Awachat Industries, Wardha to reduce the manufacturing cost. Four different modified designs of trailer were made in Pro-E software and analyzed using Ansys software. Comparing the results of four different designed trailer chassis, 4th design was an optimum design based on weight. It's suggested that the 4th design trailer chassis was suitable for mass production and also cost effective.

V. Veloso, H.S. Magalhaes, G.I. Bicalho, E.S. Palma (2009) studied the Failure of longitudinal stringer of vehicle. Failure observed at near bumpers fixation points of the vehicle suspension during durability test. Initial Crack was created and has grown causing fracture of the component. To overcome this problem they investigated six different types of reinforcement. All six types of reinforcement methods were analyzed using hyper mesh software and results were confirmed that the sixth type of reinforcement gave better results. Based on software results laboratory test had conducted and the failure had not observed. Using the software analysis they eliminated no of laboratory tests and achieved better results in shorter time span. Thus eliminates the major percentage of testing costs.

Yongjie Lu, Shaopu Yang, Shaohua Li, Liqun Chen (2009) have developed virtual prototype model of heavy duty vehicle (DFL1250A9) using multi body dynamics. The geometric structural parameters and nonlinear characteristics of shock absorber and leaf springs were precisely defined. The dynamic model was validated by comparing the testing data. The study reveals that the virtual prototype vehicle model and the testing data's were very close and also Increase of running speed may cause damage.

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Ojo Kurdi, Roslan Abdul Rahman (2010) studied the road roughness effects on stress distribution of heavy vehicle chassis. They had analyzed Static and Dynamic conditions using Finite Element Analysis software to reduce the cost and get optimum design. The load was assumed as a uniform pressure obtained from the maximum loaded weight divided by the total contact area between cargo and upper surface of chassis. In order to get a better result, locally finer meshing was applied in the region which was suspected to have highest stress. From study it's understood that the dominant loading on the truck chassis comes from cargo and its contents as static loading. The road roughness has not given a significant effect to the stress of component.

Alireza Arab Solghar, Zeinab Arsalanloo (2013) studied and Analyzed the chassis of Hyundai Cruz Minibus. ABAQUS Software was used to modeling and simulation. Self weight of the chassis was considered for static analysis and Acceleration, Braking and Road Roughness were considered for dynamic analysis. It's observed that the stresses on chassis caused by braking were more compared with acceleration.

Cicek Karao, glu, N. Sefa Kuralay (2001), have analyzed truck chassis with riveted joints using FEM. The commercial finite element package ANSYS version 11.0 was used for the solution of the problem. In order to achieve a reduction in the magnitude of stress near the riveted joint of the chassis frame, side member thickness, connection plate thickness and connection plate length were varied. Numerical results showed that stresses on the side member can be reduced by increasing the side member thickness.

Zhongzhe D, Ping Z. (2006) has performed Fatigue life analysis and improvement of the auto body in a sports utility vehicle (SUV). The stress distribution under unit displacement excitation was obtained by the finite element (FE) method. A bilateral track model was adopted to obtain load spectra in accordance with the vehicle reliability test. The total life of the auto body was evaluated by the nominal stress method with the assumption of a uni-axial stress state, and thus the critical regions were determined. The life of components with critical regions was further investigated on the basis of multi axial fatigue theory. The results showed that components near suspension were damaged due to impact loads from the road. Topological optimization of the spot weld location in the critical region was carried out by the homogenization method to improve its fatigue life.

K. Chinnaraj, M. Sathya Prasad, Lakshmana Rao (2008) have chosen to optimize the weight of chassis frame assembly of a heavy truck used for long distance goods hauling application. Dynamic stress-strain response of the component due to braking and cornering maneuvers were experimentally measured and reported. A quasi-static approach that approximates the dynamic maneuvers into number of small processes having static equilibriums was followed to carry out the numerical simulation, approximating the dynamic behavior of frame rail assembly during cornering and braking. Using the commercial finite element package ANSYS, the quasi-static numerical simulations were carried out and compared with experimental results. The study helped in understanding prevailing stresses in truck frame rails especially during cornering and braking maneuvers and brought out all geometric locations that may be potential failure locations.

From the various research studies conducted so far it has been understood that the chassis design for heavy vehicle applications starts based on the loads primarily acting on it. In heavy transportation vehicles the vertical load due to pay load is a primary. In order to overcome this vertical load the chassis has to resist the bending moment acting on it. As per the basic equations of pure bending,

Bending moment = bending stress* section modulus

Section modulus = I/y

From the above equations the bending moment is directly proportional to the section modulus. If we need to increase the pay load we have to keep the section modulus proportionately to withstand the bending moment created by the pay load.

In most of the On-Road vehicles the cross section of the chassis structure is uniform in spite of the variable loads. Hence in order to fill the gap, Variable section chassis concept has been developed. The variable section chassis concept is based on the basic principle of more section modulus at more load acting places and less section modulus at less load acting places.

CONCLUSION

The present study has analyzed the various literatures. After a careful analysis of various research studies conducted so for it has been found that sufficient studies have not been conducted on variable section chassis concept. Hence in order to fill the gap future research studies may be conducted on variable section chassis concept in automobiles.

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