Design and Development of Roll Cage For an All-Terrain Vehicle

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Abstract- *All-terrain vehicles (ATVs) are motorized vehicles with large, low pressure tyres. ATVs are designed to carry one rider on uneven surfaces. ATVs weigh up to 600 pounds and can reach speeds of 75 mph. The main objective of this research work is to perform a structural analysis on an ATV frame considering mainly the safety features including total safety of driver during any crash or any accident, to have a compact structure with less weight and with good aesthetics as well. The numerical analysis of the frame is accomplished in ANSYS software using structural model prepared in CREO software.*

Keywords- About four key words or phrases in alphabetical order, separated by commas. Keywords are used to retrieve documents in an information system such as an online journal or a search engine. (Mention 4-5 keywords)

I. INTRODUCTION

The objective of the study is to design and develop the roll cage for All - Terrain Vehicle. Material for the roll cage is selected based on strength, cost and availability. The roll cage is designed to incorporate all the automotive sub-systems. A software model is prepared in Solid works software. Later the design is tested against all modes of failure by conducting various simulations and stress analysis with the aid of Ansys Software. Based on the result obtained from these tests the design is modified accordingly. After successfully designing the roll cage, it is ready for fabricated.

The vehicle is required to have a combination frame and roll cage consisting of steel members. As weight is critical in a vehicle powered by a small engine, a balance must be found between the strength and weight of the design. To best optimize this balance the use of solid modeling and finite element analysis (FEA) software is extremely useful in addition to conventional analysis. The following paper outlines the design and analysis of the roll cage design

A frame of a vehicle plays the most important role in safety of the passenger. The frame contains the operator, engine, brake system, fuel system, and steering mechanism, and must be of adequate strength to protect the operator in the event o rollover or impact. The passenger cabin must have the capacity to resist all the forces exerted upon it. This can be achieved either by using high strength material or better cross sections against the applied load. But the most feasible way to balance the dry mass of roll-cage with the optimum number of members is done by triangulation method. The roll cage must be constructed of steel tubing, with minimum dimensional and strength requirements dictated by SAE. The SAE BAJA vehicle development manual also restricts us about the vehicle weight, shape and size, and dimensions. Circular cross-section is employed for the roll cage development as it helps to overcome difficulties like increment in dimension, rise in the overall weight and decrease in fuel efficiency. It's always a perfect one to resist the twisting and the rolling effects, therefore is preferred for torsional rigidity.

Roll Cage can be called as skeleton of a vehicle, besides its purpose being seating the driver, providing safety and incorporating other sub-systems of the vehicle, the main purpose is to form a frame or so called Chassis. We have designed the roll cage keeping in view the safety and aesthetics. These are the two factors which matters us the most, therefore they are given utmost consideration. This paper deals with design of chassis frame for an All Terrain Vehicle and Various loading tests like Front Impact, Rear Impact & Side Impact test have been conducted on the roll cage.

II. LITERATURE REVIEW

Khelan Chaudhari et al 2013 The study aims to design, develop and fabricate a roll cage for an All-Terrain Vehicle (ATV) in accordance with the rulebook of BAJA 2013 given by SAE. A roll cage is a skeleton of an ATV. The roll cage not only forms the structural base but also a 3-D shell surrounding the occupant which protects the occupant in case of impact and roll over incidents. The roll cage also adds to the aesthetics of a vehicle. The design and development comprises of material selection, chassis and frame design, cross section determination, determining strength requirements of roll cage, stress analysis and simulations to test the ATV against failure. Finally the roll cage is fabricated as per the tools and techniques available in the workshop.

Denish S. Mevawala et al 2014 An all-terrain vehicle (ATV), also known as a quad, quad bike, three-wheeler, or four-wheeler, is defined by the American National Standards Institute (ANSI) as a vehicle that travels on low pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. A roll cage is a skeleton of an ATV. The roll cage not only forms the structural base but also a 3-D shell surrounding the occupant which protects the occupant in case of impact and roll over incidents. The roll cage also adds to the aesthetics of a vehicle. So determining strength requirements of roll cage, stress analysis is carried out using FEA software Ansys workbench. This paper deals with design of roll cage for an ATV and Various loading tests like Front Impact, Side Impact and rear impact have been conducted. The modeling and stress analysis is done by ANSYS software. We have focused on every point of roll cage to improve the performance of vehicle without failure of roll cage.

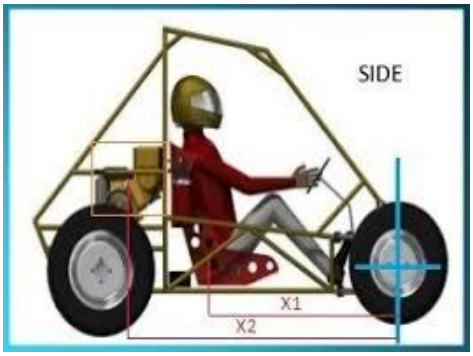

Fig. 1 Load & Supports

III. DISCUSSION

R. Bhandari et al 2014 The SAE-BAJA competition is arranged every year with a purpose to have teams of engineering students design, build and race a prototype of a four-wheel, one passenger, off-road vehicle. The most important aspect of the vehicle design is the frame. The frame contains the operator, engine, brake system, fuel system and steering mechanism, it must be of adequate strength to protect the operator in the event of a rollover or impact. The roll cage must be constructed of steel tubing, with minimum dimensional and strength requirements dictated by Society of Automotive Engineers (SAE). Increased concern about the roll cage has created the importance of simulation and analysis thereby predicting failure modes of the frame. In the present paper, we have used ANSYS to investigate the response of the frame under various impacts. We considered a direct frontal impact and side impact that results in a 4g horizontal loading, a rollover impact of 3g deceleration value, bump impact and front torsional impact analysis with 3g deceleration value. The impact loading is simulated by restricting displacements at certain locations, and applying discrete forces at various points on the frame where the weight is concentrated. Throughout the analysis of roll cage more emphasis was given on obtaining a allowable factor of safety and designed according to it.

Sandeep Garg et al 2013 We have tried to design an all terrain vehicle that meets international standards and is also cost effective at the same time. We have focused on every point of roll cage to improve the performance of vehicle without failure of roll cage. We began the task of designing by conducting extensive research of ATV roll cage through finite element analysis. A roll cage is a skeleton of an ATV. The roll cage not only forms the structural base but also a 3-D shell surrounding the occupant which protects the occupant in case of impact and roll over incidents. The roll cage also adds to the aesthetics of a vehicle. The design and development comprises of material selection, chassis and frame design, cross section determination, determining strength requirements of roll cage, stress analysis and simulations to test the ATV against failure.

Deep Shrivastava et al 2014 Designing purpose of this Quad bike is to manufacture an off road vehicle that could help in transportation in hilly areas, farming field and as a reliable experience for a weekend enthusiast. In order to accomplish this task, different design aspects of a Quad Bike. vehicle were analyzed, and certain elements of the bike were chosen for specific focus. There are many facets to an off-road vehicle, such as the chassis, suspension, steering, drive-train, and braking, all of which require thorough design concentration. The points of the car I decided to specifically focus on were the chassis, drive-train, and suspension. The most time and effort went into designing and implementing these components of the vehicle because it was felt that they most dramatically effect the off-road driving experience. During the entire design process, consumer interest through innovative, inexpensive, and effective methods was always the primary goal.

Amal Tom Kumbiluvelil et al 2013 Automotive chassis is an important part of an automobile. The chassis serves as a frame work for supporting the body and different parts of the automobile. Also, it should be rigid enough to withstand the shock, twist, vibration and other stresses. Along with strength, an important consideration in chassis design is to have adequate bending stiffness for better handling characteristics. So, strength and stiffness are two important criteria for the design of the chassis. This report is the work performed towards the static structural analysis of the All-Terrain Vehicle chassis. Structural systems like the chassis can be easily analyzed using the finite element techniques. So a

proper finite element model of the chassis is to be developed. The chassis is modeled in Solid Works. FEA is done on the modeled chassis using the Solid Works Simulation.

P. Anjani Devi et al 2014 The objective is to design and develop the roll cage for All - Terrain Vehicle accordance with the rulebook of BAJA 2014 given by SAE. The frame of the SAE Baja vehicle needs to be lightweight and structurally sound to be competitive but still protect the driver. The vehicle needs to traverse all types of off-road conditions including large rocks, downed logs, mud holes, steep inclines, jumps and off camber turns. During the competition events there is significant risk of rollovers, falling from steep ledges, collisions with stationary objects, or impacts from other vehicles. Material for the roll cage is selected based on strength and availability. A software model is prepared in Pro-engineer. Later the design is tested against all modes of failure by conducting various simulations and stress analysis with the aid of ANSYS 13. Based on the result obtained from these tests the design is modified accordingly. A target of 2 is set for Yield Factor of Safety.

Saurabh Bhand et al 2016 All-terrain vehicles (ATV's) are nowadays one of the most popular vehicles with its extraordinary capability of travelling through all terrains. ATV was first made in USA and is defined by (ANSI) as the vehicle that travels with low-pressure tires. Only a single person can sit in these vehicles and also used for racing events and many applications. With the increase in use there are major accidents and deaths recorded due to failure of roll cage therefore careful and optimum designing of Roll cage is very important. The safety can be determined by performing various types of analysis on roll-cage which is most dominating part of ATV since it is responsible to take all the force acting on it. In this paper we have performed the static analysis on Roll cage with help of ANSYS-16 by applying the forces on it, we have performed front impact, rear impact, side impact, torsion and bump analysis from these analysis we have calculated the magnitude of stress developed and deformation .

Fig .2 Roll Cage img

IV. CONCLUSION

The minimum factor of safety obtained for the above analysis done with calculated force is. This makes this chassis usable as a roll cage for the AllTerrain vehicle. In this research analysis is carried out on a roll cage frame made of AISI 4130 and AISI 1018 tubular sections. The structural response of this roll cage frame is studied with respect to load in various conditions. A frame is designed that corrects weaknesses of previously designed frames. Upmost attention has kept on compactness of the frame as well as increased strength in critical areas to have the proper safety of driver during any impact. A complete analysis has done by ANSYS simulation software which will elevate the validity of the design.

The objective of designing a single-passenger off-road race vehicle with high safety and low production costs seems to be accomplished. The design process included using Solid Works, CATIA and ANSYS software packages to model, simulate, and assist in the analysis of the completed vehicle. After initial testing it will be seen that our design should improve the design and durability of all the systems on the car and make any necessary changes up until the leaves for the competition. We had successfully analyzed the roll cage structure for its strength against the collision from front, rear, as well as side. Factor of safety is under the safe limit. The roll cage is sustained 4G force from front as well as rear & 2G force from side. Hence, deformation & stresses are under the limit.

The design, development and fabrication of the roll cage is carried out successfully. The roll cage is used to build an ATV by integrating all the other automotive systems like transmission, suspension, steering, brakes and other miscellaneous elements.The usage of finite element analysis was invaluable to the design and analysis of the frame.

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