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A Review on Design and Analysis of Tubular Spaceframe Chassis

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Abstract: ***Formula Student Competitions are held globally. In these competition students design, fabricate and compete with a formula style race car. Chassis is an important component of automobile system. It supports and carries other components of the automobile. Tubular spaceframe chassis is widely used type of chassis for such race cars. Space frame chassis is formed by joining a series of tubes together that forms a structure that supports other components of automobile. The chassis needs to strong enough to sustain the loads acting on it also it should be lightweight. Factor of safety is an important parameter that should be considered while designing the chassis. Once the design is created analysis is performed to check whether the design is safe. In this paper a review has been made on the design and analysis of tubular spaceframe chassis.***
Keywords: ***FSAE, Tubular Spaceframe Chassis, Design, Factor of Safety, Analysis***

I. INTRODUCTION

In an automobile system chassis is one of the most important component. It supports and carries other components of the automobile. It also connects the components of automobile. Chassis is subjected to various loads hence its main function is to sustain those loads that are acting on it without structural failure. There are different types of chassis such as ladder frame, monocoque, spaceframe etc. However, tubular spaceframe chassis is widely used type of chassis for FSAE race cars. Tubular spaceframe chassis is a tubular structure that is formed by joining a series of tubes together so that it can support and accommodate other components, sub-systems of the race car. The tubular members are arranged in triangular pattern as a result the spaceframe chassis consists of multiple trusses which help in load distribution. The working principle of spaceframe is similar to working of truss. Material selection plays an important role in the overall process of design and analysis of chassis. Various types of analysis are performed on the chassis to check whether the design is safe.

II. LITERATURE REVIEW

1) *Abhijeet Das (2015)*[1] *:* Presented their work on design of formula race car chassis. The study provides introduction about the steel tube space frame chassis used for the race car and the design process to be followed based on the experience of team UFO Racers. Tubular spaceframe chassis is popular type of chassis used for FSAE race car owing to the factors such as cost effective manufacturing, requirement of simple tools, easy rectification for the damage to the chassis. Spaceframe chassis is formed by a series of tubes joined together which forms a structure that connects the components together. This work provides basic methodologies and theories that needs to be considered while designing the components hence providing a baseline for new teams to create their first design. The design process consists of series of steps from initial assignment of task to design to the construction of chassis. The steps involved are identification of restrictions, required performance criteria, methodology and design techniques to be followed, use of CAD software for designing the chassis. SOLIDWORKS 2014 software was used for designing the chassis. The steps involved in design process were discussed in depth starting from the initial setup, then modelling of fixed elements and lastly the modelling of variable elements. This work provides an in-depth study of the process taken to arrive at final design.
2) *Apoorva Tyagi (2016)*[2]*:* The study was carried out to design and analyze the chassis used for formula student race car. Tubular spaceframe chassis was selected for this study as it is widely used in automotive application. Chassis is important component of an automobile; it holds all other components of the automobile together. The chassis is required to be lightweight, strong and stiff as it is used for Formula Student vehicle. The design was based on the rules set up by FSAE and are used as reference as reference while designing the chassis. These rules are important as it ensures the safety of the students/driver driving and testing the car. The design of the chassis presented in this study was done using CAD software CATIA V5. In order to minimize the weight and maximize the stiffness of chassis different design iterations were carried out. Analysis of the model was done using ANSYS APDL software. While performing the analysis different load conditions were considered. Chromoly 4130 was the material selected for the analysis of chassis. With proper analysis the final design exhibited good properties. The maximum stress observed on chassis was around 215 MPa which was less than the yield strength of the material used for analysis. The

maximum deflection was noted as 0.87mm. Hence the design was considered safe as the maximum stress was less than the yield strength of the material and the maximum deflection was less than 1mm.

3) *M L Mohamad, M T A Rahman, S F Khan, M H Basha, A H Adom and M S M Hashim (2017)[3]:* The main purpose of the study was to make improvement in chassis used by UniMAP Automotive Racing Team. In this study three chassis designs were created based on the rules stated by FSAE rulebook (2017/2018). Analysis consisting of five tests that included front roll hoop test, main roll hoop test, side impact, static torsional loading, static shear were performed on all three designs. The material selected for analysis was Steel Grade ASTM A36. From the three designs best design was selected based on Von Mises Stress and torsional displacement. Based on the results obtained Design 1 chassis was considered best because it had the lowest value of maximum torsional displacement compared to other two designs and also the existing design. The weight of new chassis design (26.77 kg) was reduced by 16.7% from existing chassis (32.77 kg). The torsional rigidity of the chassis was increased by 37.74%.

4) *Arindam Ghosh, Rishika Saha, Sourav Dhali, Adrija Das, Prasid Biswas, Alok Kumar Dubey (2018)[4]:* The objective of this paper was to present a clear idea about the types of analysis that should be performed on formula student race car chassis alongwith the amount of load to be applied for ensuring the structural stability of the chassis for the safety of driver. For a race car chassis design the safety of the driver is a huge concern. In this study chassis of team CYGNUS RACING was used for performing different type of analysis. The analysis was carried out using SOLIDWORKS software. It was discussed that after the completion of design the next task is selection of material for chassis and it plays a crucial role. Strength, weight to strength ratio and cost of the material are some important factors that should be considered while selecting the material. Comparison of three different materials AISI 4130, AISI 1020, AISI 1018 was done based on their properties and AISI 4130 was the material selected for the chassis as it's weight to strength ratio was high compared to other two types. After selection of material the next step is to perform analysis. Altogether nine different types of analysis were performed on the chassis that are as follows front impact, side impact, rear impact, front torsional analysis, rear torsional analysis, modal or frequency analysis, vertical bending analysis, acceleration test and lateral bending analysis. The amount of forces, G-loads to be applied for analysis were presented with simplified calculations also the steps to be followed while performing analysis were explained and the maximum stress, maximum displacement and minimum factor of safety results were listed for individual analysis performed. The conclusion indicated that the material selection process plays a crucial role in stability of chassis during different loading conditions and the factor of safety should always be considered while designing the chassis. For all the analysis performed except the modal analysis the maximum stress generated was less than the yeild strength of the material AISI 4130. Modal analysis was performed to examine that the frequency of engine and chassis should not match to avoid resonance.

5) *Swati Upadhyay, Ganesh Badiger, (2020)[5]:* Presented their work on design and analysis of the chassis used for Supra race car. The objective of this study was to give information about design and analysis of chassis. Tubular spaceframe chassis is the preferred type of chassis used for such race cars. The tubular spaceframe arrangement consists of number of tubes joined together to form a structure that support the components of automobile mounted on it. Small members are added in triangular pattern which is similar to a truss bridge. The chassis is expected to be lightweight, low cost and easy to manufacture. The chassis model presented in this study was modelled using CATIA software and the analysis was performed using ANSYS WORKBENCH software. Material selected for analysis was AISI 4130. Three type of dynamic analysis were performed that are as follows front impact, side impact and rear impact. For analysis the weight of car was assumed 190 kg. For front impact analysis, impact force of 18468 N was applied similarly, for side impact and rear impact the impact forces of 9949 N and 10554 N were applied and the equivalent stress and deformation were determined for each impact analysis performed. The chassis was considered safe. Thus, this study presented a systematic way for design and analysis of chassis along with simplified calculations for impact forces.

III. CONCLUSION

We can conclude that following a systematic approach for design and analysis is helpful in creating a better design. The triangular arrangement of members in spaceframe chassis is helpful in reducing the stress distribution. Also eliminating unnecessary members helps in reducing the weight of chassis. Factor of safety is an important parameter that should be considered while designing the chassis. Material selection plays a vital role in the design and analysis process. Various factors like strength, weight to strength ratio, cost, availability should be considered while selecting the material. However from the above study it was found that AISI 4130 and AISI 1018 are widely used material for tubular spaceframe chassis.

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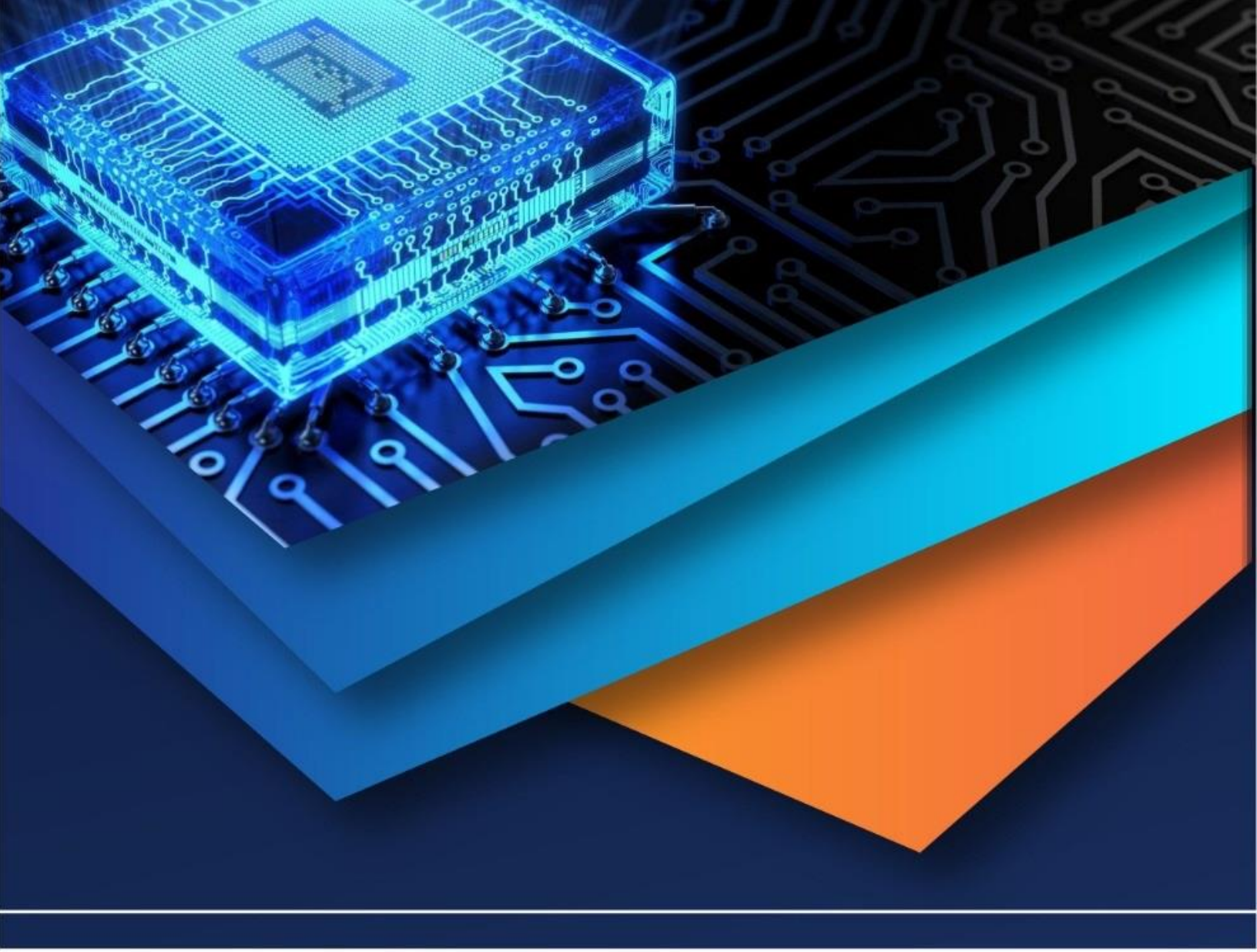

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