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Design of carbon composite structure as an alternative material for an automobile chassis over a steel space frame using Ansys

Priyanka Doddi[1*], S.Sanyasi Naidu [2*]

[1]M. Tech. in Mechanical Engineering
[2]Assistant Professor
[*]MVGR College of Engineering, Vizianagaram, India

Abstract: *The chassis weight and stiffness can influence the riding dynamics of motorsport motors and their performance. The manufacturer's objective is to build a high energy, light-weight and high stress which may be finished by means of correct layout coupled with usage of light-weight, first-rate substances. Although many monocoque composite chassis have been designed, very restrained open literature is to be had on a way to construct one. This paintings focuses layout system of the economic method SAE monocoque race automobile chassis that requires a comprehensive evaluation concerning all components of the chassis, starting from cloth selection, ply placement and layup collection via to structural analysis and evaluating the chassis overall performance towards the design necessities. The most crucial key performance signs have been discovered to be weight, torsional stiffness and the torsional stiffness to weight ratio. Chassis rigidity is found to lower with accelerated torsional stiffness. This caused the belief that having a torsional stiffness of more than ~3 instances the roll stiffness, without problems adds extra weight than handling performance. The desire of a carbon composite structure for the chassis over a metal area frame results in outstanding weight financial savings with out compromising on overall performance. The superior fabric residences of the unidirectional woven carbon fibre which become taken into consideration together with the ability in composite layout and center design utilized to reach at an optimized monocoque composite layout using ANSYS and attain excellent torsional pressure with minimal weight. Despite the dangers of a carbon composite chassis, particularly excessive value and problem in production, the belief is that the benefits outweigh the drawbacks.*

Keywords: **SAE monocoque , torsional stiffness, carbon composite chassis, carbon fiber, Ansys**

INTRODUCTION

Chassis is the helping member for all of the additives within the automobile. It supports the body, engine and different components which make up the car. Chassis lends whole automobile aid and tension. The cause of automotive chassis is to attend to the shape of the automobile and to assist the various loads implemented to that the protection of the chassis can be a major side in the style, and maybe thought of thru all degrees From the past few a long time, the Composite materials play a enormous role within the production industry and expanded its share beginning from packaging to aerospace enterprise.And recently its usage has been elevated inside the automobile enterprise because of the requirement of excessive strength to weight ratio. Especially the synthetic fibres like glass, kevlar and carbon fibres occupied a primary percentage. Although carbon composite structures have outstanding blessings in stiffness to the weight they are now not clean to design and construct [20]. The research by Naoyuki Takahashi [21] succeeded in greatly minimizing the voids by using a prepreg shape coupled with the extraction of air from the passageways within the knitted fabric the layers at low pressure in place of by way of high-pressure squeezing underneath vacuum moulding situations. Jingsi Wu et al[22] initially used the isotropic modelling to set the number one layout objectives and moved in advance with anisotropic composite analysis by using the usage of the carbon-bolstered composites for the layout of monocoque chassis to attain the optimized monocoque composite layout and layup which produced the satisfactory hardpoint, bending stiffness and torsional effects with minimal weight. Tatthep Kanketr et al [23] worked at the layout of CFRP monocoque chassis with the sandwich shape and the optimization accomplished with concerning tacking sequences and the thickness of composite plies the usage of the FEM simulation to obtain the design objective of maximization of torsional stiffness.

MONOCOQUE CHASSIS

To efficaciously address the hassle handy, it's far imperative to gain an anin-intensity know-how of the different chassis sorts and their history, substances used, the special load instances and the relevant load paths. Below, unique chassis design sorts and their characteristics are introduced.

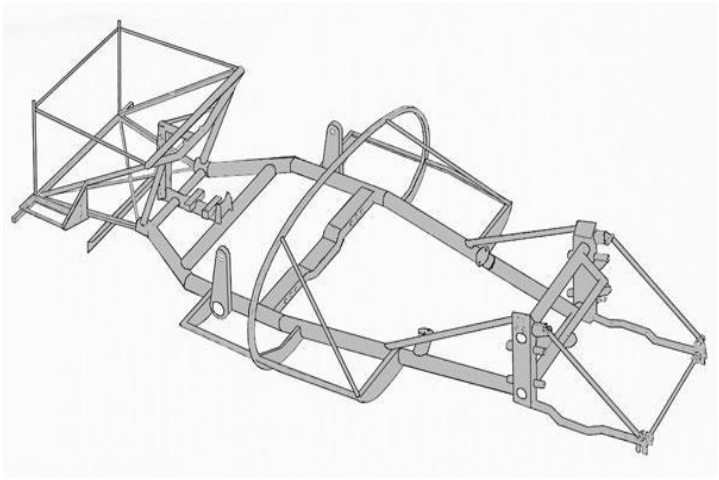
Chassis Design and History

Earlier, race cars were built on big traces, a design trait that contemplated bridge-constructing greater than performance engineering. Before World War II almost all vehicle chassis had been of the girder type, construction of beams, commonly I-fashioned or Z-shaped. Mercedes-Benz delivered tubular beams in 1937. In this type of chassis, the beams were parallel, from axle to axle and the construction turned into known as a twin-tube. It remained in trend for racing automobiles till the early Nineteen Fifties while chassis with space body ideas began appearing with the Lotus Mark Six and Mercedes-Benz 300SL. Space frames persisted to end up broadly used throughout the race automobile enterprise and were additionally implemented in some expert road motors.

Types of Chassis

Twin-tube or Ladder Frame Chassis

The dual-tube or ladder frame includes bearing tubes that span within the driving route of the auto. Historically, those frames had been made of metal tubes, for instance the Lister-Jaguar (determine 3.1) from 1958. In 2006 but, students from the Western Washington University built a dual-tube chassis out of carbon tubes, see determine three.2. The mechanisms holding the two tubes collectively were milled aluminium bulkheads. The most important benefits of a metallic twin tube chassis encompass: simplicity, cheapness and popular ease of construction. A twin-tube chassis is however no longer recommended for any severe, competitive motoring as it affords too low torsional stiffness. Building a lightweight twin-tube chassis isn't smooth, 6 due to the fact all the mounting points want extra sub-frames. These sub-frames hardly ever boom the torsional stiffness.

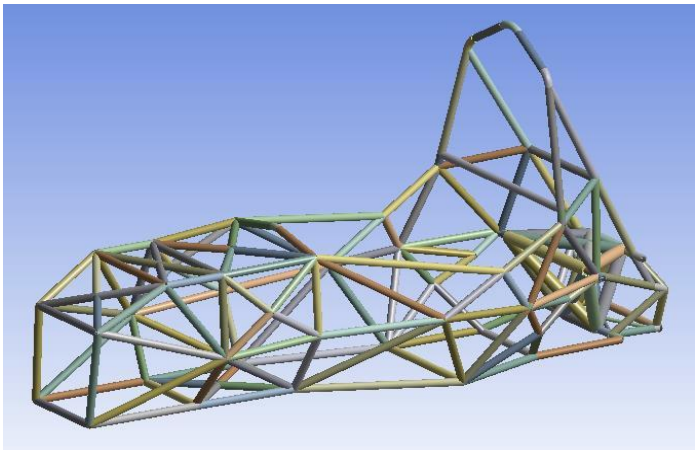


Multi-Tubular Chassis

In idea the time period multi-tubular refers to a chassis this is built up with more than bearing beams which will be used to describe all chassis kinds beside the twintube described above. In exercise, the time period is perhaps great implemented to those chassis, which makes use of 4 major facet rails however cannot be classified in the true area body category. Essentially, this chassis gives terrible overall performance, however has established to be a a success compromise between the dual-tube chassis and the space body in terms of stiffness and manufacturing price. Often, the body member diameter, that's the outer diameter of the frame, must be expanded to acquire a appropriate torsional stiffness. This consequences in a heavier chassis, in evaluation to as an instance, a space frame to be able to be delivered within the next paragraph.

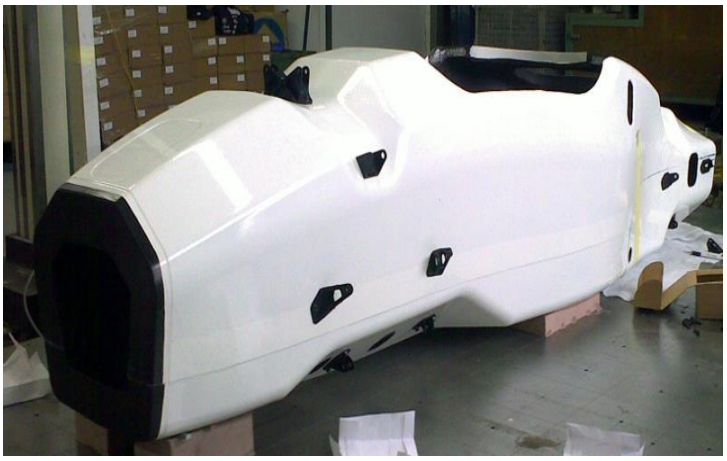
Space Frame

The trendy precept of a space body is to only have beams loaded in tension or compression. This is executed by way of welding the body contributors together at the nodes. Ideally, the nodes take in considerable masses by way of having a supporting beam in all loaded instructions. Because the frame individuals are most effective loaded in anxiety and compression, it's far possible to keep away from the bending of beams, which is what causes the finest losses in torsional stiffness. The CFS team in 2012 used a space frame. supporting beam in all loaded instructions. Because the frame individuals are most effective loaded in anxiety and compression, it's far possible to keep away from the bending of beams, which is what causes the finest losses in torsional stiffness. The CFS team in 2012 used a space frame.



Monocoque chassis

A monocoque chassis, discern 3.Five, is a one-piece shape, which defines the overall shape of the car. Monocoques had been first broadly utilized in aircraft within the Nineteen Thirties. The 1960s race vehicles, which used monocoque chassis, had a cylindrically fashioned creation to enhance the torsional tension.The monocoque chassis offers the principle structural aid, and as a consequence absorbs all of the loads affecting the auto. In race automobiles these days, the maximum not unusual form of monocoque chassis are made of various varieties of composites, as an example Carbon Fibre Reinforced Polymers (CFRP). The advantages of monocoque chassis (especially, composite monocoque chassis) include excessive torsional stiffness and mild weight. There are also some negative aspects, consisting of difficult design and excessive price. Other materials that may be utilized in monocoque constructions are as an example glass fibre and aluminium.



The 2013 CFS hybrid chassis. [CFS 2013]

The hybrid monocoque area body answer, as proven in figure 3.6, is a mixture of a composite monocoque chassis and a rear area body. The monocoque contributes with its low weight and high torsional stiffness, whilst the space body gives an easy to assemble rear, in maximum cases giving better get admission to to the engine. However, a few complications that might appear while the use of a hybrid chassis are to reap a terrific sufficient integration among the 2 sections and the capacity to expect the burden paths between them.

The gift work targeted on the design of a composite monocoque chassis for a method SAE type car. The techniques are offered primarily based on the layout of a components SAE monocoque. While the specific layout isn't consultant of all composite chassis, the techniques and results must be of interest in most composite chassis conditions. Although carbon composite systems have remarkable advantages in stiffness to weight ratio they're now not easy to design and construct. The predominant functions of the monocoque are, first, to provide rigid, safe, and sufficiently robust helps and safety to the driver, engine, and all additives on a automobile at minimal weight. Second, the monocoque should enable the suspension to showcase first rate handling. There are two techniques to designing a chassis to assist coping with, one is to make the monocoque sufficiently sturdy but permit it to be really gentle, and design the whole chassis based on the predicted chassis deflections under various using loads. This method commonly most effective works for vehicles with minimum or even no suspension systems, together with Go-Karts. However, the softer the chassis is, the bigger the deviations of the structural deflections get, and hence, the suspension design turns to be very hard because of various combinations of tire camber, loading, and steer attitude modifications precipitated by varying local and usual chassis deflections. It is likewise very difficult to damp motions of a bendy chassis. The different method is to layout the chassis as inflexible as needed in order to layout the suspension based on an essentially infinitely stiff monocoque. This could be very effective for cars that rely upon their suspension machine for coping with, and feature a extensive range of suspension setups. Since the suspension gadget has a essential impact on the auto's managing, it's far standard to try to make the monocoque accurately stiff sufficient to be considered correctly infinitely stiff.

MATERIALS AND METHODS

The purpose of the work is comply with this layout system from fabric preference, ply placement and layup sequence through to structural evaluation to confirm the chassis meets the design necessities. Below are the steps observed to obtain the objectives.

Establish the important thing overall performance signs or Define the design requirements/

- Selection of the composite materials
- Geometric modelling of monocoque chassis.

- Name the selected enhance shape using Named Selections.
- Meshing of Monoquoq chassi
- Create the composite layup in ANSYS ACP(Pre)
- Extract the chassis properties the use of sensor
- Transfer parts to ANSYS Mechanical.
- Apply boundary conditions and masses to copy stress and electricity check.
- Extract chassis power from ANSYS ACP(Post)
- Evaluate chassis performance in opposition to design requirements

Chassis Stiffness: A key indicator to the overall performance of a race car chassis is longitudinal torsional stiffness. The tension of the chassis between the the front and rear suspension factors is paramount in load transfer and lateral grip in turning. The measure of chassis rigidity used for this workshop is specific rotational stiffness which debts for chassis weight additionally, using the layout to be mild weight and high stiffness.

From the ancient records under are the 3 divisions of precise torsional stress have been diagnosed.

Low overall performance - 2 KN-m/rad/kg

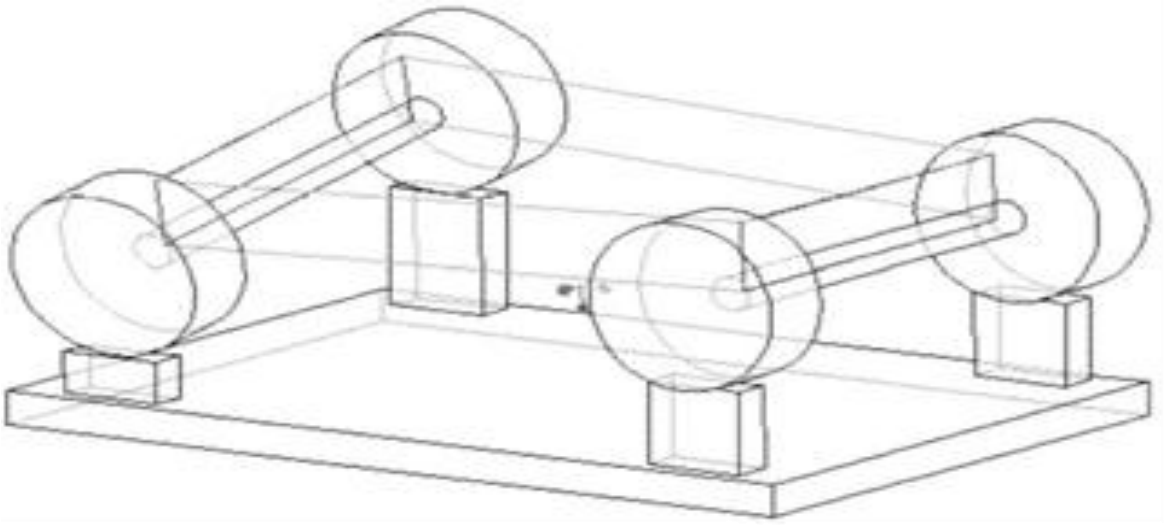
Average Performance - five KN-m/rad/kg

High Performance - 15 KN-m/rad/kg

The chassis for the prevailing have a look at must have a selected stiffness of as a minimum eight kN-m/rad/kg to region it in an above common stiffness category.

Chassis Strength

To ensure a secure design, the chassis ought to have a generous reserve aspect underneath operational situations to account for any damage, manufacturing imperfections or surprising hundreds the auto may additionally encounter.



Maximum torsional loading during worst-case-scenario braking plus track bump

The chassis for the take a look at should have a minimal reserve aspect of 0.Five beneath a most torsional load stumble upon beneath full braking and an impact with a track bump. This load is calculated to be 2500N-m.

Chassis Weight

A mild weight chassis will improve the cars performance in acceleration, braking and cornering, three divisions of chassis weight had been recognized as given underneath

Low performance - 30 kg

Average Performance - 25 kg

High Performance - 20 kg

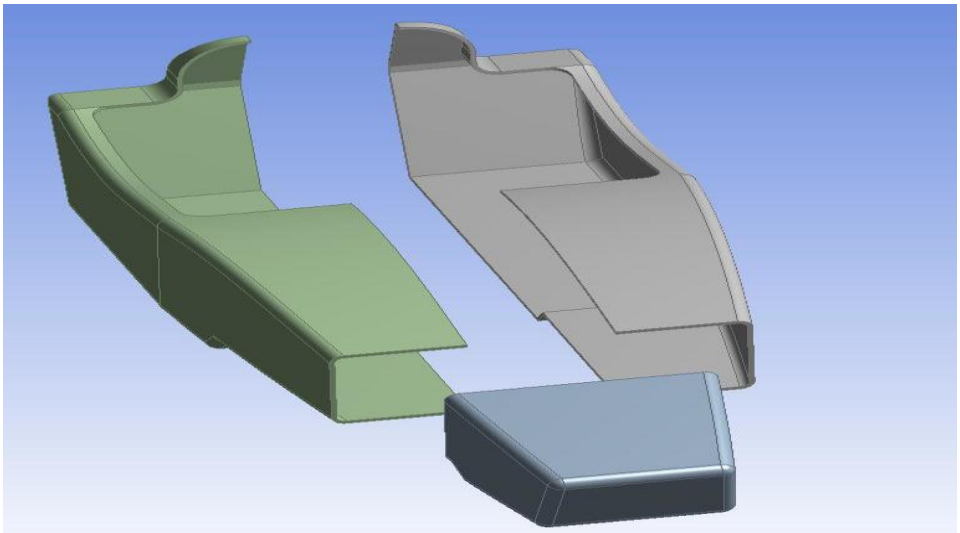
The chassis for this workshop should have a weight of no greater than 25kg to qualify it in a excessive-overall performance weight class

4.2 Materials:

To attain positive chassis overall performance limits, the designer can pick out to optimize the geometry of the chassis or the cloth it is made of. The ideal answer is manifestly to optimize both and therefore the material preference is of great significance.When designing a chassis for most fulfilling performance, a high stiffness to weight ratio is regularly sought. To permit clean layup of the chassis over the mould, a woven carbon fiber fabric could be selected for the general public of the shape.For selected reinforcements, a uni-directional prepreg fabric may even need to be used allowing weight efficient reinforcement and precise fiber orientation.

4.3 Modelling of Chassis:

The chassis for this workshop must have a weight of no greater than 25kg to qualify it in a high-performance weight category.



Exploded view of chassis showing key structural components

RESULTS AND DISCUSSION

S.NO	KPI	Result obtained	Design Target
1	Weight	25.0 Kg	25 Kg
2	Torsional Stiffness	9.44 KN-m/rad/kg	8 KN-m/rad/kg
3	IRF(Strength)	0.340	0.5

Key Performance indicators obtained from simulation

The results acquired from the simulation are provided within the desk five.1.And as compared towards their corresponding layout objectives. The chassis weight received as 25 kg that is and it is equal to common overall performance layout target. The torsional stiffness is found to be nine.Forty four KN-m/rad/kg which is in appropriate agreement of the minimum limit of of 8 KN-m/rad/kg. Similarly, the IRF representing the torsional stiffness is referred to as 0.340 that's under the applicable restriction. Overall, the design proved to be safe to apply as a raw cloth for manufacture of monocoque chassis as a way to reduce the burden of the monocoque chassis considered as secure and the composite material made of carbon fiber prepeg in epoxy produced nice results and performed the layout goals.

CONCLUSIONS

It is important to have a chassis that gives sufficient torsional stiffness to the suspension. Here the unidirectional prepeg carbon fibre strengthened epoxy composite correctly proved to be a feasible material for the monocoque chassis. The values of weight and the torsional stiffness are obtained as 25.08 kg as nine.44 KNm/rad/kg respectively that are suited as per the design targets. In addition, the IRF representing the strength is located to be zero.340 that's in secure zone. The fee of the key performance signs indicates that the cloth selected and the design produced the first-rate effects and carried out the layout targets.A similarly extension of this paintings feasible may be possible to attain the improved overall performance by way of converting the layup for different composite configurations like hybrid composites and honeycomb shape etc..

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