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Modal Analysis On Go-Kart Chassis

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Abstract: ***Tubular Frame chassis is the best selection for designing of chassis as it has the properties like light in weight structure, High strength, and other feasible characteristics which are appropriate for a designing a single seated go kart vehicle and all this features play a key role in construction of a chassis. The chassis is divided in to Main-hoop, Front-hoop and other protection sub frames. In which these sections plays a crucial role during Impact so as to save the driver from the extremity. This research mainly focus on the modal analysis where it deals with the natural frequencies developed in various modes which are responsible for the deformation of the chassis. Here this analysis introduces various strategies of Dynamic Analysis. This analysis is performed by using Ansys Workbench of Version 16.0. Ansys is a software which is purely based up on the finite element method. This study figures out six mode shapes at various frequencies. The characteristics of the mode shapes were explained further during the study. This analysis figures out a graph along with various mode shapes of the chassis.***

Keywords: Natural Frequency, Tubular Chassis, Modal Analysis, Ansys Workbench.

I.INTRODUCTION

Go-kart is the vehicle which is entirely designed and fabricated by the students, in which they will apply the concepts of the subjects in real time and increase their skill in various aspects. ISIE is the platform where it organises the events which are related to the formula racing across the various colleges and universities and determines the young talent from the students and encourage them. The students apply various innovative styles so as to overcome the Problem statement. ISIE imposes various rules and regulations for designing the vehicle in which it gives a challenge for the students to design and fabricate the vehicle in constrained limits of design. By means of all these students will utilize all his skills and knowledge to define a problem in multiple aspects. ISIE conducts the several tests in which it identifies best design and conducts Brake test, Speed Test and engine capability in which they find the best car based on all these performances and rewards for it. Chassis is one of the mandatory design in which the students must the material which possess the high strength, low weight, economy, feasibility and availability.

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In which all these characteristics are required for the construction of a chassis. Here the different manufacturing methods shows their impact over the characteristics of chassis material. So, the concern material must possess enough ability to withstand all these external factors. Mainly the chassis structure splits in to various sections namely Main Hoop, Front Hoop, sub frames and other side impact protections along with Crush zone. Crush zone is the main section which are located at the frontal section of the chassis. Its main function is to absorb the maximum energy during impact. Front hoop will shield the rider from the motive force. These sections are responsible for the safety of a rider during a collision or an Impact with an obstacle.

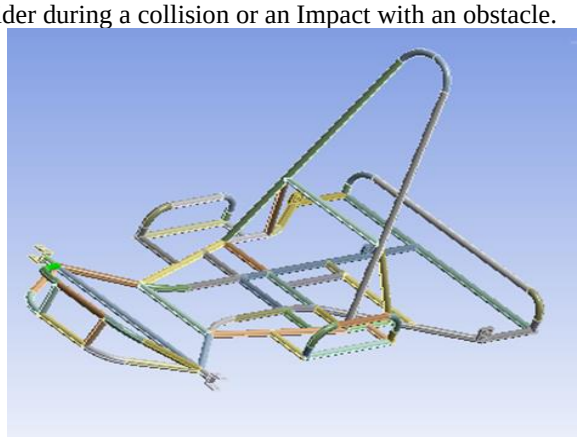

Figure (a)

Various chassis produce diverse dynamic characteristics in which it tends to produce some natural frequency only due to its self-weight. So it's inevitable to inspect the dynamic characteristic of the chassis so that it can be known that the chassis is free from vibration failures or not for its operative life time. This failures may cause due to natural frequency developed within the chassis. There are diverse modes of operations to perform the dynamic characteristics of a chassis, Modal analysis is familiar method to extricate the dynamic behaviour of a chassis. From the modal analysis it can be seen that emergence of six mode shapes of a chassis structure which were occurred at different frequencies are ascertained along with the resonance frequency. Generally, the chassis delighted dynamically due to bumps and crooked road profile along with the mountings on the chassis like, engine, transmission and other accessories which are responsible for vibration. If the vibration caused by the superficial excitation is nearly equal to that of natural frequency then it will build-out a Resonance. In which it is responsible for the superfluous deformation which may leads to failure.

Commencing natural frequency or a resonance are the factors that are responsible for Vibration that occur within the chassis structure. By means of analysis and simulation we can find-out the dynamic characteristics of a chassis. There are assorted number of packages which perform the dynamic analysis for a chassis structure. Ansys is the software that is used for the modal analysis where it is purely based on the finite element methodology. Modal analysis generates a dynamic structural behaviour which are mode shapes that are vibrated at different frequency. This experimentation figures the six mode shapes which are deformed in various modes of direction. Computation is an advanced technique to attain the mode shapes of a chassis structure whenever the rigidity of a structure have been analysed in which the resonance vibration have prohibited. However, the analysis can be done manually by means of finite element method as well as experimentally i.e. based on software based modal analysis. Thus this study stood up for initial experimentation so as to perform the modal analysis in which it figures out dynamic characteristics experimentally.

Theory on Vibrational Analysis:

Fast Fourier Transform (FFT) is one of the measurement technique that have been utilized by the Frequency Response Function (FRP), in which Fast Fourier transform have been using widely for analysing of structural dynamics predominantly in automobiles, so as to trace out the dynamic characteristics that immerses the vibrational characteristics which includes the mode shapes along with natural frequencies of a chassis model. Below formulae states the equation of motion for an undamped system:

$$[m]\left\{\ddot{q}\right\} + [k]\{q\} = \{0\} \text{ -----Equation (1)}$$

Here, the alphabets m, k, q are the constants that means the mass, stiffness and displacement of a system and the equation (1) equals to value zero when there is no applied force for a system. Whereq" is the displacement for linear system. Here Qiis the i^{th} amplitude of mode shape for natural frequency ω_i, Hence:

$$-\omega^2[m] + [k] = \{0\}\text{--------Equation (2)}$$

The results of equation (2) provides Eigen values, in which that the roots of natural frequencies and the Eigen vector were the Amplitude of proportionate natural frequencies. The natural frequencies that are provided by modal analysis doesn't offer details on crucial points of mountings of components that produce vibration.

Finite Element for Model Geometry:

Conventionally the go-kart and other formula vehicles are designed as per the rules and regulations that are insisted by ISIE. The chassis is divided in to several sections in which these sections play a key role while protecting the driver during impact or with impact with an obstacle. Here a 1"inch i.e. 25.4 mm circular diameter tubes with wall thickness of 2 mm were used for constructing the main hoop and front hoop. Whereas, the other tube of same diameter with wall thickness of 1 mm were used to construct the side beam as well as front beam. The tube consists of high wall thickness is used for the sections that are used to withstand the rolling impacts when there is a roll-over of a vehicle. The modelling of chassis is done by means of using set of guidelines provided by the ISIE by means of using Modelling software Solidworks. In the figure (b) it is clear that the chassis which is mounted by means of engine, transmission, fuel tank, driver compartment, steering as well as braking systems and other auxiliaries that are mounted over a chassis. Here all the components as well as mountings are not included for analysis as this study only based on modal analysis. So only chassis is considered for analysis so as to get the accurate results.

Go-kart Configuration:

ISIE contrived the Rulebook in which it explain the in-detail outline of the go-kart vehicle. In which it describes the main aspects of the vehicle. For the contention of the go-kart vehicle competition. Here just by using the basic rules and regulations the designing of the go-kart vehicle must be done with in the constrained limits and then need to fabricate as accordingly. The major aspects of the go-kart vehicle are mentioned in below table (a). Here all the aspects are mandatory as those play the vital role for the production of the chassis. It has hardened ample to conceive the changes that were delivered during the motion of chassis. The chassis must be constructed with the hallow tube as it should have imperative piece with the help of welded parts that shouldn't get off.

Figure (b)

S.no	Aspects	Specification
1.	Height	36" inches to be appraise.
2.	Overall Length	50" inches to be appraise.
3.	Overall Width	40" inches to be appraise.
4.	Track Width	Atleast: 75% of Wheel Base
5.	Wheel Base	Atleast: 42" inches.

Table (a)

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The structure of the chassis is done by means of welding the tubes together so as to form the accurate edges and proper design of the chassis structure. Generally, the chassis is constructed by means of using the steel and other combinations to as to attain the various properties for the structure. The main casing of the vehicle is designed in such a way that it can be tuned so as to adjust with the Track width by means of modifying some aspects like longitudinal parts, raise and the centre so as to attain practicable solidness. Additional sub-frames on either side of the driver's seat will increase torsional impermeability of the vehicle casing. The frame would be existed only for 1 to 2 years as, it subjected to different wear and tears due to racings and experience the ailing effects of weariness. So, that the chassis can be used only for the maximum of 2 years. The go-kart riders would employ another extremity each of 2 to 3 racings so as to assure for execution at consummate conditions.

II.Material Properties:

We can see that there are numerous variety of materials used for the Fabrication. In which each material has various characteristics. Here, different materials were used by various vehicles so as to meet the requirements and demands of the particular application of a go-kart. Here the material chosen for the construction of a chassis must have high strength, less weight, Corrosive resistant, Economic effectiveness of material, Availability, Flexibility. All these factors will make the vehicle to be standard in various aspects. At present there are wide variety of materials accessible in the present days out of all these alloy steels shows a greater characteristic performance as compared to all other materials and also it possess the unremarkable qualities.

AISI followed by four digit numeric name suggests the type of alloy steels. These materials have progressive characteristics and shows great response for Mechanical treatment as well as Heat treatment as compared to Carbon steels. This materials consists of various compositions and various characteristics which are shown below in Table (b) and Table (c). AISI 4130 is the steel alloy that were selected for the construction of the chassis as it possess molybdenum, chromium and other elements which strengthens the material and also it contains low carbon percent, in which the material is feasible for the simple welding.

S.no	Element	Composition (%)
1.	Iron (Fe)	97.03 – 98.22
2.	Chromium (Cr)	0.80 – 1.10
3.	Manganese (Mn)	0.40 – 0.60
4.	Carbon (C)	0.28 – 0.330
5.	Silicon (Si)	0.15 – 0.30
6.	Molybdenum (Mo)	0.15 – 0.25
7.	Phosphorous (P)	0.035

Table (b)

S.no	Characteristic	Value
1.	Ultimate tensile strength	655 Mpa
2.	Tensile strength	560 Mpa
3.	Ultimate yield strength	415 Mpa
4.	Elastic Modulus	210 Gpa
5.	Bulk modulus	140 Gpa
6.	Shear modulus	80 Gpa
7.	Density	7.85 (g/cc)
8.	Poisson's ratio	0.33

Table (c)

III.Boundary Constraints:

There are no weights acted on the chassis except it's self-weight, due to this there were no loads acted on the chassis for Vibrational analysis in all DOF. In which we can clearly observe that the natural response of the chassis in all mode shapes. For this type of analysis, the damping coefficient was neglected. Hence the modal analysis is carried out by fixing the any one support of the chassis and then continued for meshing and later the chassis structure is sent for analysis to attain the inbuilt natural frequencies in various mode shapes.

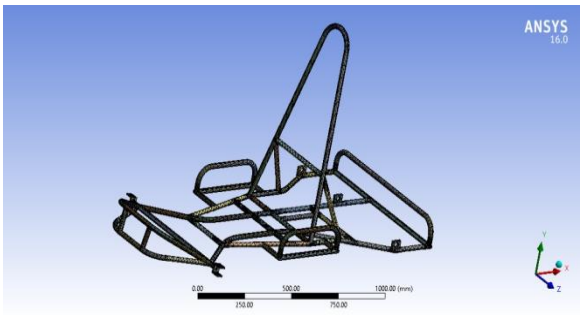

Figure (c)

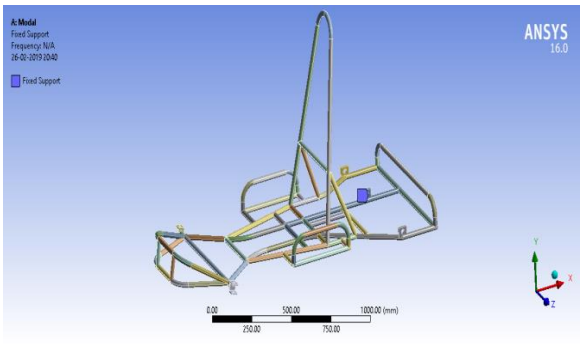

Figure (d)

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IV.Results:

Modal Analysis:

This study utilizes the Modal analysis to determine various mode shapes of chassis that are vibrated at different frequencies. The modal analysis results states that it is very incorporative to determine the response for structural parameters. The various mode shapes that are found by modal analysis is used to investigate the deformation that occurred in chassis as of natural frequencies produced. This study utilizes Ansys Workbench software to perform the modal analysis operation in which it is pre-defined software where constraints must be provided initially and later meshing is performed so as to get the accurate results.In the below table (d) it can be seen that different mode shapes of a chassis that are occurred at various natural frequencies. This mode shapes of chassis acts like back-bone as resonance occurs at this frequency levels. Apart from the frequency it can be noticeable that deformations are also occurred due to the frequency in all mode shapes of a chassis.

S.no	Mode Shapes	Frequency (Hz)
1.	Mode Shape 1	32.28
2.	Mode Shape 2	47.835
3.	Mode Shape 3	54.747
4.	Mode Shape 4	99.076
5.	Mode Shape 5	99.305
6.	Mode Shape 6	105.05

Table (d)

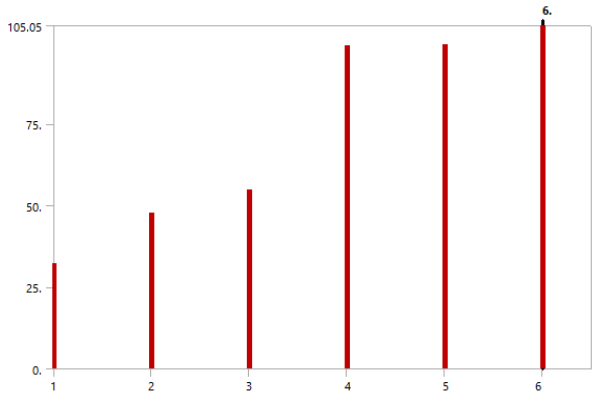

Figure (e)

In the above graph X-axis represents Mode and Y-axis represents Frequency Based on Table (d)

Various mode shapes of the chassis are:

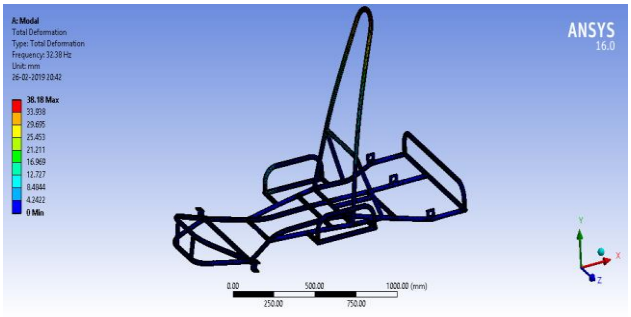

Figure (f)

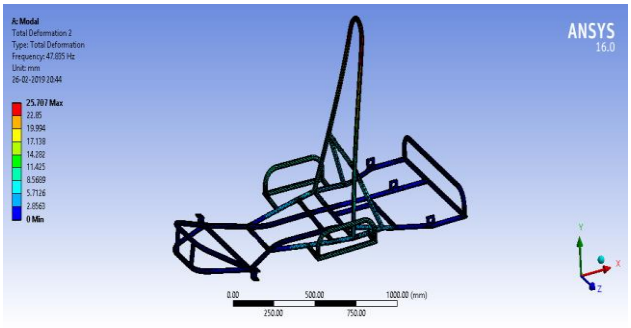

Figure (g)

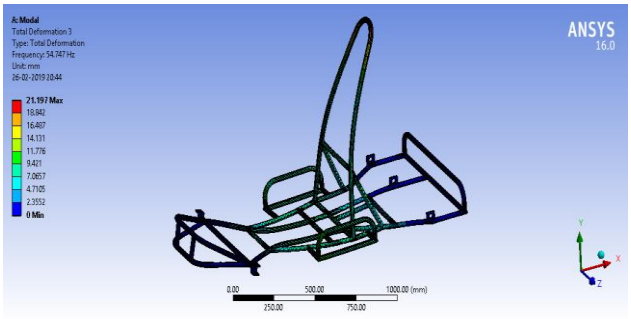

Figure (h)

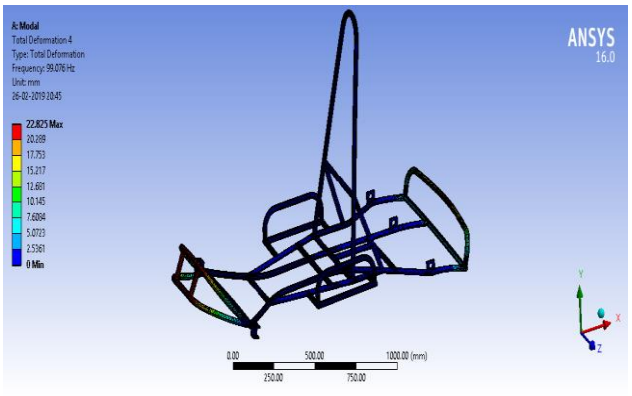

Figure (i)

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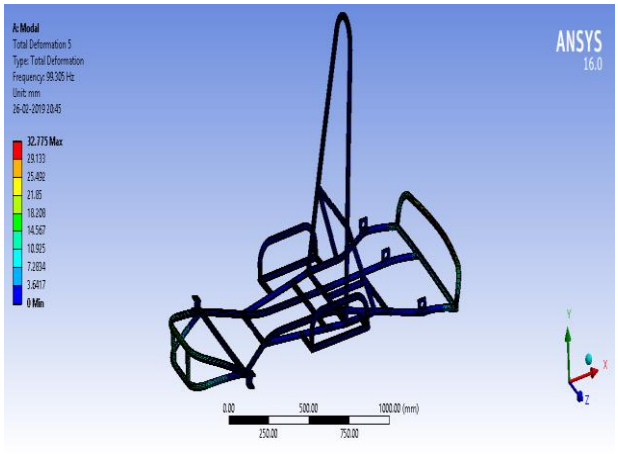

Figure (j)

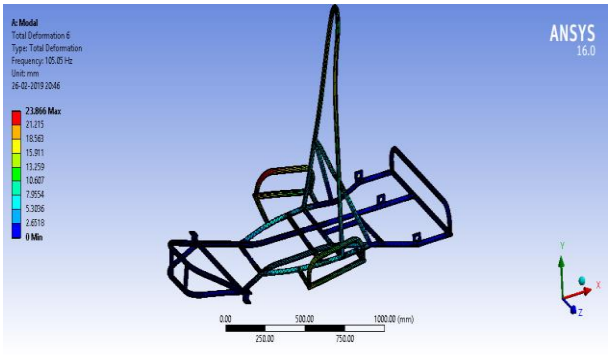

Figure (k)

V.CONCLUSION:

The modal analysis produced different mode shapes of chassis that are vibrated at various natural frequencies within the range of 0 to 150 Hz range of frequency. The natural frequencies that are produced are within the limited range and it is safe and comfortable for usage. Here the generated frequencies do not coincide with any other source of external excitation in which the natural frequency won't be a part of any external deformation. The modes shapes of a chassis that produced from the modal analysis at various frequencies leads to abnormal characteristics which includes Bending, Torsional and the combination of bending and torsional. The deformations that are formed is mainly due to these characteristics. The maximum deformation that have caused with vibration of the chassis is 38.18 mm which is done at the main hoop where it can be rectified by reducing the length of the hoop. Here the deformation occurred is very low and thus, the overall stiffness of the chassis structure is adequate for using in race tracks.

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