Design and Impact Crash Analysis of Go-Kart Chassis

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Abstract- *Vehicles are the most significant aspect of transportation; nevertheless, it is also critical to ensure that everything during a ride is comfortable and safe in the event of an accident. A crash analysis is used to determine how the car will react in the event of a frontal or sideways accident. ANSYS software will be used to simulate and analyses impacts and collisions involving a Go-Kart frame model in this project. It must also resist deflection and distortion under static and dynamic loads.ANSYS software will be used to test the model under impact frontal collision conditions and determine the resulting deformation and stresses with respect to a time of 0.0007 sec for ramp loading. The crash analysis simulation and results can be used to evaluate the current frame's crashworthiness as well as look for methods to improve the design. This form of simulation is an important component of the design process since it can eliminate the need for expensive destructive testing with the help of explicit dynamics and optimization.*

Keywords- Go-Kart, Impact Frontal Collision, Explicit Dynamics & Optimization.

I. INTRODUCTION

Crash and structural analysis are the two most significant engineering techniques in designing a high-quality vehicle in automobile design.

Computer simulation technologies have substantially improved the safety, dependability, and comfort of today's automobiles, as well as their environmental and production efficiency.

There are many new physical safety measures to protect the occupants sitting inside the automobile, such as airbags, ABS control brakes, traction control, and now most of the technology, such as embedded sensors for auto recognition of human and braking safety, are the new sources of preventing crash.

The accident response behavior is a less visible aspect that drivers and passengers cannot immediately perceive. The car body and various components are the protective barrier for the occupants of a well-designed automobile.

II. LITERATURE REVIEW

This The main goal of this project is to study the Explicit dynamics caused due to the vehicle moving on irregular road surface and also due to impact collision on frontal body.

Sr. No	Author	Title
1	By: T. Ananda Babu D. Vijay Praveen Dr.M.Venkateswarao	"Crash Analysis of Car Chassis Frame Using Finite Element Method"
2	Puli Suresh Kumar	"Crash Analysis of Car Chassis Frame Using Finite Element Method".
3	K. Vamsi Krishna, K.V.P.P. Chandu	"Modeling and Crash Analysis of Car Integral Frame Using Fem Method".
4.	Akshay P. Lokhande, Abhijeet G. Darekar, SanketC.NaikNimbal kar, Abhishek P. Patil	"Crash Analysis of Vehicle"
5.	G D Lohith Kumar, H S Manjunath, N Shashikanth, Venkatesh Reddy	"Crash Analysis of four wheel vehicle for different velocity"
6.	L Praveen, N Sandeep Kumar	"Crash Analysis Of A Composite Car Body"

III. PROBLEM STATEMENT

- Driver safety is critical, as the driver is responsible for maintaining vehicle control in the case of an accident.
- The frame of a big vehicle, such as the 2002 Ford Explorer, is made of structural steel. Corrosion occurs when steel constructions, such as bridges, are exposed to air and water.

- It can become fatigued and crack under repetitive stress and higher temperatures.
- These are the primary issues with steel, which are addressed by using Al 6061 and other materials.
- To construct a chassis that meets all of the optimal design requirements, the frame must be:
- Keep the driver alive in a 4g frontal and 3g side crash.
- Keeping the frame as light as possible.
- Provide mounting structures for all subsystems that can resist the loads they generate.
- To resist centrifugal force during cornering.
- To endure the forces resulting from abrupt braking and acceleration**.**

IV. OBJECTIVES

The safety of automobile occupants during contact on the front-end structure of the car in a frontal impact, the lateral structure of the car in a side collision, and the rear end structure of a car in a rear impact is investigated using crash simulations.

Crash simulation can also be used to assess pedestrian injury. The main aims, on the other hand, can be stated as follows:

i. To ensure the driver's safety.
ii. Material selection based on its strength.
iii. Reducing the vehicle's weight while maintaining its safety.
iv. To save money on genuine crash testing.
v. The findings can be utilized to examine frame crashworthiness as well as look into ways to improve the design.
vi. To construct a chassis that meets all of the optimal design requirements, the frame must be:
vii. Keep the driver alive in a 4g frontal and 3g side crash.
viii. Keeping the frame as light as possible.
ix. Provide mounting structures for all subsystems that can resist the loads they generate.
x. To resist centrifugal force during cornering.
xi. To endure the forces resulting from abrupt braking and acceleration.

V. METHODOLOGY

Step 1: At first we started this assignment by gathering the number of research papers. After that optimization, structural analysis and model analysis of the alternator project of our goal.
Step 2: Problem identification after doing the market survey and material selection.
Step 3: - Once the materials have been chosen, the 3D model and drafting will be completed using CATIA software.
Step 4: Dynamic structural analysis will be used to evaluate the FEM solution first.
Step 5: Optimize the topology.
Step 6: Compare the materials.

VI. PRESENT THEORIES AND PRACTICES

Body materials should also have enough strength and controlled deformations under load to absorb crash energy while still allowing enough survivable room for effective occupant protection in the event of a collision.

Furthermore, the structure should be lightweight to save on gasoline.

Over the previous six decades, stamped steel components have made up the majority of mass-produced car bodywork.
Only a few limited productions and specialized car bodywork are made using composite materials or aluminum by manufacturers. There are a variety of materials utilized nowadays for chassis manufacture, including honeycomb structure. Due to their varying applications, different vehicles require different materials.
Material
AL6061/T1

Density = 2.7g/cc
Ultimate tensile strength = 310 MPa
Tensile yield strength = 276 MPa
Young’s modulus = 68.9 GPa
Poisons ratio = 0.33
Major application – Aircraft fitting, camera lens mount, coupling, marine fitting, brake pistons, hydraulic pistons, bike frame etc.

AISI 4043

Density = 7.83g/cc
Ultimate tensile strength = 560 Mpa
Tensile yield strength = 460 Mpa
Young’s modulus = 190-210 GPa
Poisons ratio = 0.27-0.3
Major application – Aircraft engine mounts, welding tubing etc.

VII.DESIGN

Design Procedure
1. CATIA v5 Software is used to generate the CAD model of the wheelchair.

2.In CATIA v5 software, generative shape design with plane-based sketch has been prepared and converted to 3D using sketch-based tools.
3.The dimensions of 3D wheelchair for the designed model has been taken from according to average human height and research papers.
4.Then the final 3D model is converted to IGS or STP for ANSYS importation.
5.Finally drafting of the of the 3D product is extracted from the drafting option using the conversion method.
6.Use of Boolean operation is one of the main important tools in order to achieve the zero geometry errors.

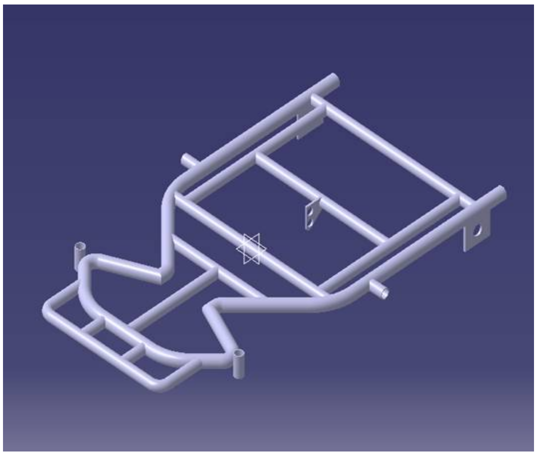


Figure.1 chassis of Go kart Catia v5

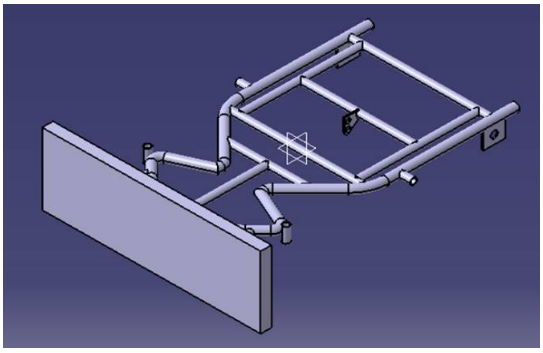


Figure.2 wall with go-kart frame

VIII. ANALYSIS

8.1 Unit system adopted

Table 8.1-unit system

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

8.2 Geometry

Table 8.2 geometry properties

Bounding Box		
Length X	376.21 mm	30. mm
Length Y	1058.1 mm	230.41 mm
Length Z	152.4 mm	13.5 mm
Properties		
Volume	7.3716e+006 mm³	5.625e+007 mm³
Mass	57.719 kg	137.25 kg
Centroid X	-42.532 mm	961.5 mm
Centroid Y	-3.0984e-002 mm	-4.5211e-014 mm
Centroid Z	-4.0952 mm	-3.3908e-014 mm
Moment of Inertia Ip1	7.2525e+006 kg·m m²	2.8594e+007 kg·mm²
Moment of Inertia Ip2	1.9239e+007 kg·m m²	2.9237e+006 kg·mm²
Moment of Inertia Ip3	2.6415e+007 kg·m m²	2.5799e+007 kg·mm²

6.3 Meshing

Table 8.3 Mesh Definition

Object Name	*Patch Conforming Method*	*Body Sizing*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	2 Bodies	
Definition		
Suppressed	No	
Method	Tetrahedrons	
Algorithm	Patch Conforming	
Element Order	Use Global Setting	
Type		Element Size
Element Size		20 mm
Advanced		
Defeature Size		Default
Behavior		Soft

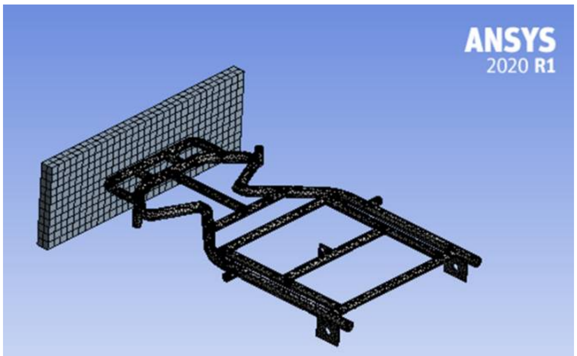


Figure.3 Mesh

- Type or method of Mesh
- Tetrahedron shape + linear
- Mesh size 20 mm
- 3D element type

Table 8.4 elements

Statistics	
Nodes	21988
Elements	44054

8.5 Boundary condition

Step Controls	
Number Of Steps	1
Current Step Number	1
Load Step Type	Explicit Time Integration
End Time	7.e-004
Resume from Cycle	0
Maximum Number of Cycles	1e+07

Definition	
Pre-Stress Environment	None Available
Pressure Initialization	From Deformed State
Input Type	Velocity
Define By	Components
Coordinate System	Global Coordinate System
X Component	27778 mm/s

Figure 8.4 boundary condition fixed type

8.6 Solution

Table 8.5 overall result of Steel 4043 Material

Results			
Minimum	0. mm	0. MPa	3.9548e-006 mm/mm
Maximum	19.824 mm	912.3 MPa	0.11394 mm/mm
Average	9.836 mm	108.57 MPa	6.0383e-003 mm/mm

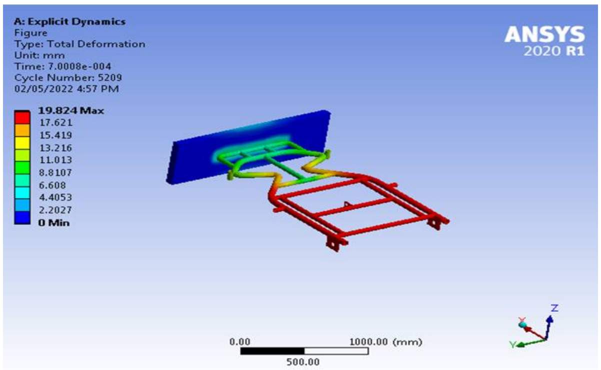
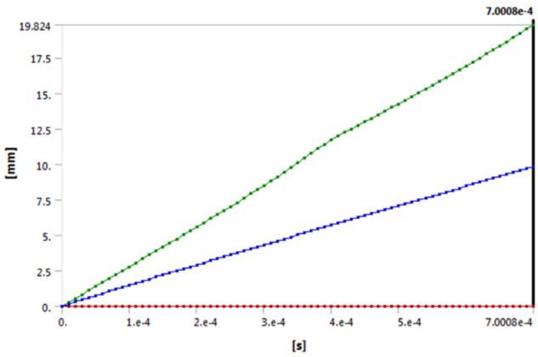


Figure.4 Total deformation of Material 4043 steel



Graph.1 Total deformation of Material 4043 steel

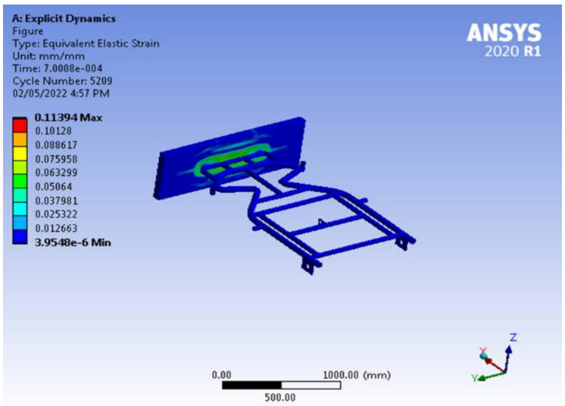
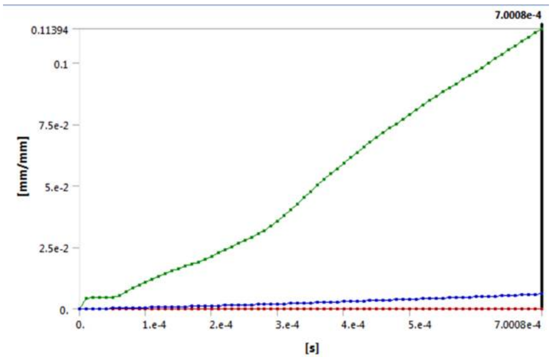


Figure.5 Von-Misses Strain



Graph.2 Von-Misses Strain

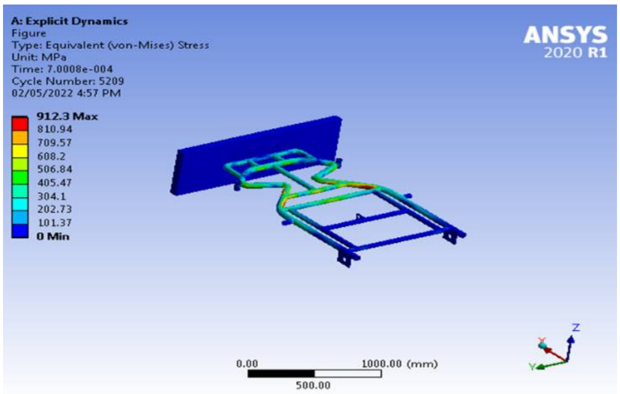
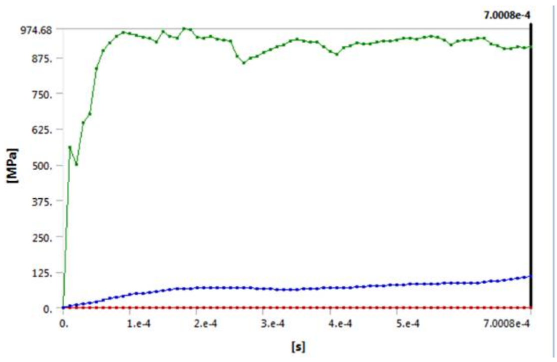


Figure.6 Von-Misses Stress



Graph.3 Von-Misses Stress

Discussion of iteration one

- In first iteration of FEA we have simulated the Impact frontal crash of a proposed Go-Kart chassis.
- For time period of 0.0007 for a time step 101 & at speed of 100 Km/hr or 27778 mm/sec.
- The observed total deformation is 19.795 mm maximum as we all can see in the result section with a stress concentration factor of 912.3 Mpa.
- Which is more compared to yield strength of the standard material.
- In next iteration we are going to change the material and compare the result.

Iteration 2 Material Aluminum 6061/T

In this iteration boundary conditions are maintained constant same as for the steel body but, only material have been changed to consider the material effect on the impact.

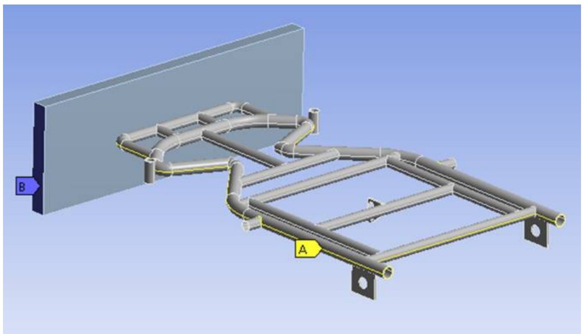
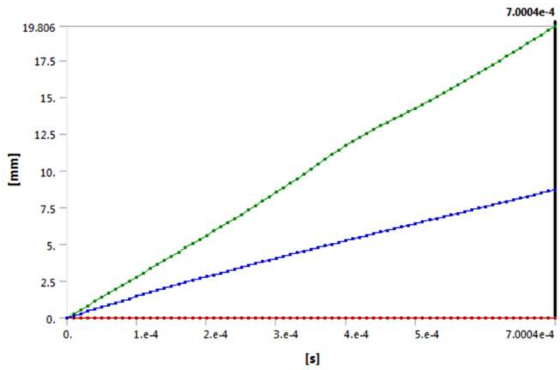


Figure.7 Boundary Conditions

Result Total Deformation

5.8e-004	16.361	7.3285
5.9007e-004	16.643	7.4443
6.0001e-004	16.922	7.5588
6.1008e-004	17.202	7.6748
6.2002e-004	17.478	7.7894
6.3009e-004	17.76	7.9054
6.4003e-004	18.045	8.0199
6.501e-004	18.34	8.1358
6.6004e-004	18.634	8.2503
6.701e-004	18.93	8.3661
6.8004e-004	19.222	8.4806
6.9011e-004	19.518	8.5965
7.0004e-004	19.806	8.711

Figure.8 Result total deformation in 6061 t1



Graph.4 Total Deformation in 6061 t1

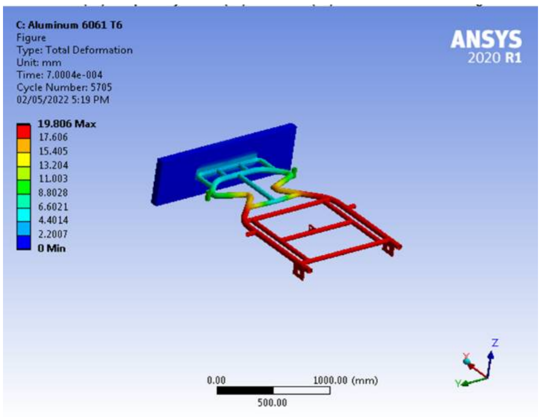
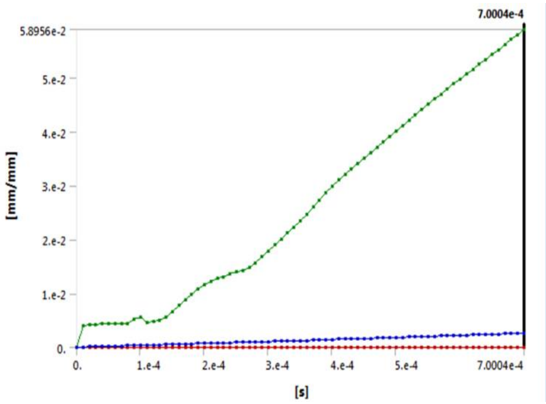


Figure.9 Total Deformation in 6061 t1

Von Misses Strain

6.0001e-004	4.9543e-006	4.9756e-002	2.2303e-003
6.1008e-004	3.4493e-006	5.065e-002	2.2696e-003
6.2002e-004	7.6225e-006	5.1536e-002	2.3087e-003
6.3009e-004	8.3968e-006	5.2448e-002	2.3484e-003
6.4003e-004	1.2757e-005	5.336e-002	2.3873e-003
6.501e-004	1.54e-005	5.4293e-002	2.4262e-003
6.6004e-004	8.2055e-006	5.5223e-002	2.4661e-003
6.701e-004	7.2713e-006	5.617e-002	2.5082e-003
6.8004e-004	1.2931e-005	5.7105e-002	2.5491e-003
6.9011e-004	1.3506e-005	5.8045e-002	2.5908e-003
7.0004e-004	7.5626e-006	5.8956e-002	2.6324e-003

Figure.10 Result Von-Misses strain in 6061 t1



Graph.5 Result Von-Misses strain in 6061 t1

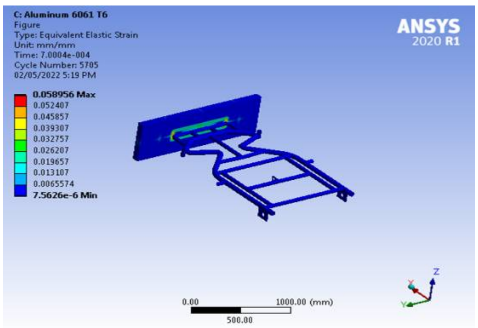
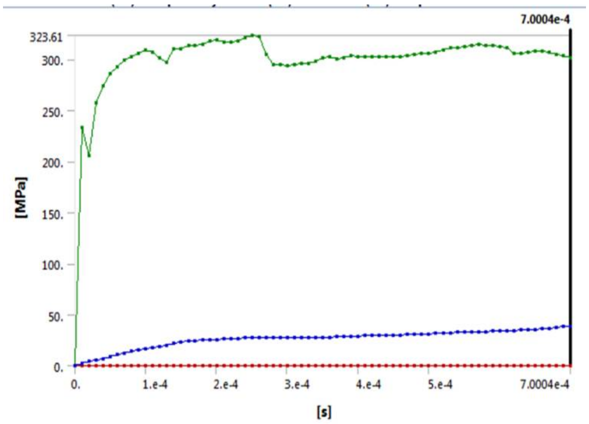


Figure.11 Result Von-Misses strain in 6061 t1

Von Misses Stress

6.0001e-004		313.14	33.87
6.1008e-004		311.13	34.193
6.2002e-004		306.06	34.465
6.3009e-004		305.81	34.783
6.4003e-004		307.31	35.131
6.501e-004		308.69	35.579
6.6004e-004		308.	36.15
6.701e-004		306.81	36.839
6.8004e-004		304.92	37.496
6.9011e-004		303.61	38.235
7.0004e-004		301.25	39.046

Table 8.6Result Von-Misses stress in 6061 t1



Graph.6 Von-Misses stress in 6061 t1

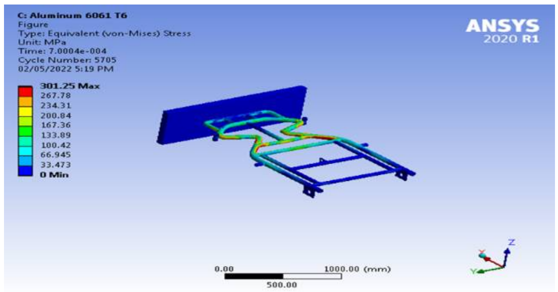


Figure.12 Von-Misses stress in 6061 t1

Discussion of iteration 2

In this iteration the stress concentration factor has been brought back to minimum value as we all can observe in the stress field hence it is failing but successfully the designed stress is lowered.

Innext iteration we will put the module to topology optimization based on strength enhancement redesign of the chassis will be made and FEA will be solved.

Topology Optimization

1. To simulate a part under topology formation, it must be simulated with one of the main modules of system like static, transient, Dynamic, CFD, Model or IC engines etc.

2. After the main module boundary processing a topology optimization module or scope is combined with the static structural analysis, results section from static are targeted into the optimization and upon the requirement we can optimize the part for required constraints mode like percentage of reduction of material from part stress based, strain based, vibrational based and mass based.

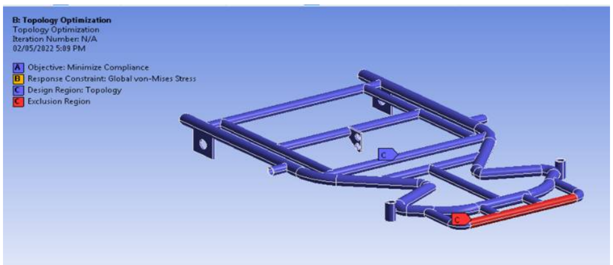


Figure.13 Optimization region

Objective

Right click on the grid to add, modify and delete a row.

Enabled	Response Type	Goal	Criterion	Formulation	Environment Name	Weight	Multiple Sets	Start Step	End Step	Step
☑	Compliance	Minimize	N/A	Program Controlled	Static Structural	N/A	Enabled	1	1	1

Figure.14 Objective

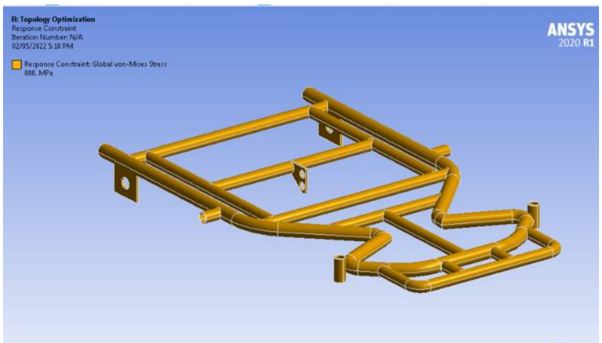
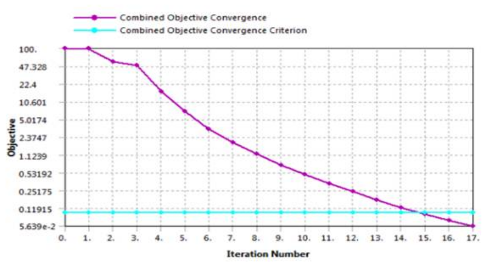


Figure.15 Response Constraint is Global Von-Misses Stress

The maximum stress obtained in Steel 4340 before optimization was 913.85 Mpa, the objective of the optimization is to reduce the Global stress by improving the support structure on the go kart chassis. To reduce the stress factors now we had to Modify the design so that stress can be brought lower than the existed.



Graph.7 Minimize compliance /Vs No of iterations performed

After Redesign

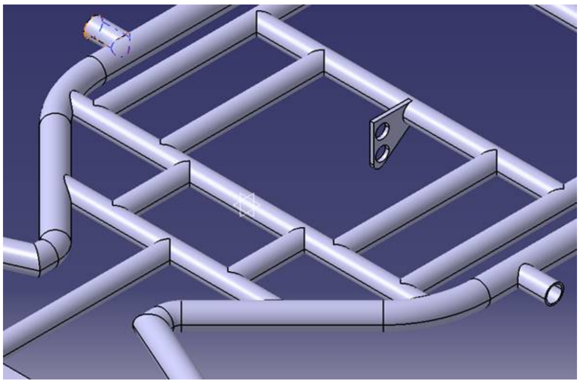


Figure.16 Modification Area

Iteration FEA analysis of redesigned part

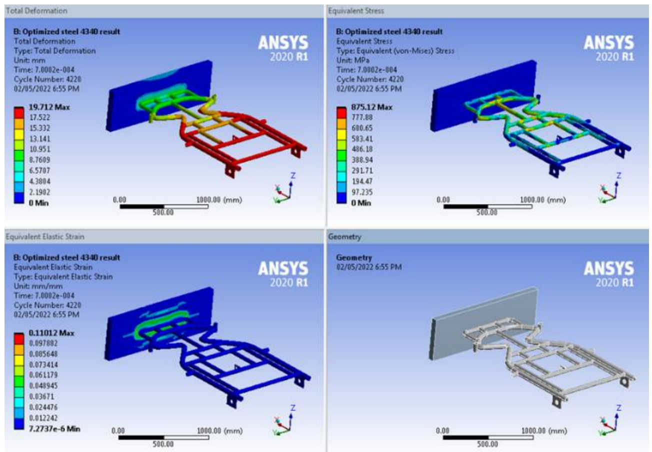


Figure.17Optimized Part With Material Steel 4043

Discussion

After optimization (Modification) in the Part, now the stress factor is brought to little low.

Before optimization – 912.3 Mpa in 4043 steel
After optimization - 875.12 Mpa in 4043 steel

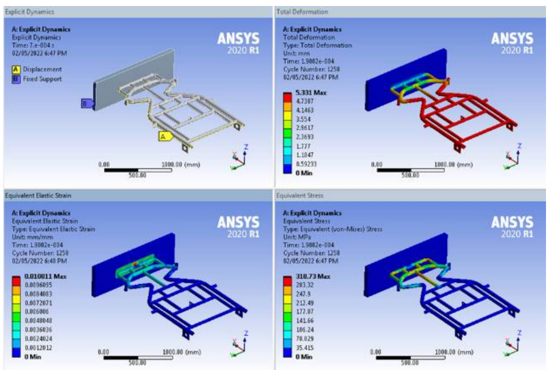


Figure.18Redesigned Part Material Aluminum 6063 T6

Hence, we can see that change in deformation is observed for the proposed material after the modification

Aluminum is a very desirable metal because it is more malleable and elastic than steel. Aluminum can go places and create shapes that steel cannot, often forming deeper or more intricate spinning's. Especially for parts with deep and straight walls, aluminum is the material of choice.

Before optimization - 19.806 mm
After Optimization - 5.331 mm

Table 6.6 Overall results tabular

Sl No	Material	Optimization	Total Deformation in mm	Strain	Stress in Mpa
1.	Steel 4043	Before Optimization	19.824	0.11394	912.3
2.	Aluminum 6063 T6	Before Optimization	19.806	0.058956	301.25
3.	Steel 4043	After Optimization	19.712	0.11012	875.52
4.	**Aluminum 6063 T6**	**After Optimization**	**5.331**	**0.0108**	**318.73**

IX. CONCLUSION

For drivers & passengers' safety one must analyze the chassis of vehicle whether the vehicle body undergoes any sever condition when the front body impacts major load while accidents.

Design part has been developed using CATIA v5 software.

Analysis of two material on a proposed part geometry has been conducted using ANSYS workbench followed by optimization and material comparison.

Following are the results of a go kart chassis frame having, circular cross-section path with a displacement in x & y direction & a vehicle speed of 27778 mm/sec i.e 100 km/hr. velocity towards a wall of concrete 75mm thick.

A key benefit of aluminum is its natural resistance to rust and corrosion. Unlike steel, aluminum is protected by a layer of aluminum oxide, which acts to protect the metal from exposure with air and oxygen two elements that are needed for the oxidative effects of corrosion.

Finally, aluminum is the best material when compared to weight, rust & corrosion resistance, malleable and elastic and can absorb the shocks of it so stress is low the only disadvantage is cost.

Future Scope for the Project

1. Only one iteration of optimization has been considered to show that, how a strength can be increased without changing thickness or any other parameter only by just adding an eternal support as a link at failure area.
2. Composite materials are available to study on.
3. One can change the cross-section of the channel from hollow circular to solid or any other geometry.

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