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Design and Fabrication of All-Terrain Vehicle with CVT

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Abstract- The goal of this report is to provide a brief yet adequate information about the methodology used by our team to build a technically sound and reliable quad bike. Quad bikes , also known as Quads, are a type of All Terrain Vehicle (ATV) widely used in hilly areas and on agricultural farms across the globe. In this report, the procedures followed, the various selections and analysis made by our team is explained. The primary objective is to build a reliable, feature-rich and economical quad bike with goodperformance.

I. INTRODUCTION:

With keeping the competition requirements, design constraints, mentioned in the rulebook, and driver safety in mind, we have designed a quad bike which is not only feature and quality-rich, but also economical both in terms of manufacturing and maintaining. Thorough research and complete analysis were made before finalising the ideas and suggestions on every single part. The selection of components was influenced by

1.Reliability 2.Driver safety 3.Performance in various fields and 4. Market availability and cost.

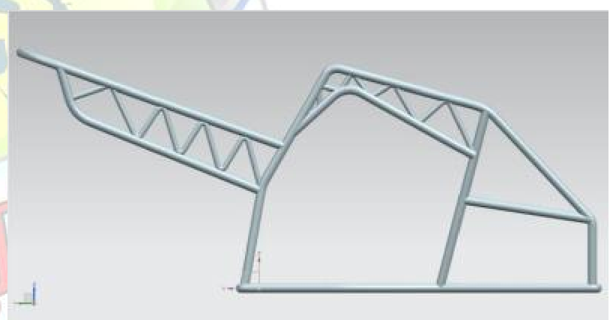
NX 10 and CREO 3.0 were the softwares used for designing the vehicle and ANSYS 16.0 was the software used for Finite Element Analysis.

II. FRAME DESIGN:

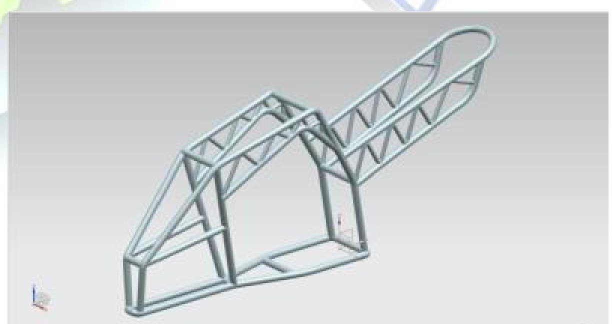
Frame ,is the backbone of every vehicle. Hence it forms the basis of all vehicle design. We began our design with the frame. After extensive research we decided to use the trellis frame technology.

Trellis Frame- A trellis frame is made up of large number of short steel tubes welded together to form a trellis. This frame is proven to provide very good stability and strength. Our frame design reduces flexure and torsion dramatically when compared to normal quad bike frame designs.

The frame was designed in NX 10 software keeping in mind the dimensions of the various parts that are to be fitted to the frame. The frame shape and topology were finalised through trial and error method, after many attempts to improve the overall strength and stability. The final design of the frame is shown below.



Side view of the Frame



Isometric view of the Frame

This frame, although easy to manufacture, increases the weight of the vehicle considerably due to more amount of steel used than average. But we utilised that fact to our advantage to reduce the vehicle's top speed.

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Material Selection- The requirements of a good material are:

1.appreciable strength 2.low cost 3.less weight 4.good and easy weldability

Based on all these factors, we filtered all the materials available and were left with only two; 1.Chromoly SAE 4130 steel tubes and 2.SAE 1020 steel tube

Table 1: Material Comparison

Properties	***Chromoly 4130***	***SAE 1020***
Density	7.80 g/cc	7.87 g/cc
Yield strength	517 MPA	496 MPA
Ultimate strength	655 MPA	600 MPA
Carbon %	0.28-0.33	0.17-0.23
Young's Modulus	205 GPA	200 GPA
Cost	450/metre	100/metre

Table 1. shows us that Chromoly 4130 is superior to SAE1020 in almost all physical properties. But the availability and cost of chromoly 4130 makes it a tough choice. Moreover 4130 tubes needs to be heat treated before and after each welding and the fact that it can be welded only using MIG/TIG welding makes it even more difficult to consider. When chromoly 4130 tubes are welded under normal conditions using common welding techniques, the final product is proven to be not much different than the same product manufactured using 1020 tubes. Table 2 will show us clearly why SAE1020 is chosen by us as the frame material.

Table 2: Material Selection

Factors	***Rating (1-10)***	
	Chromoly 4130	***SAE 1020***
Strength	9	6
Weight	8	6
Cost	4	8
Availability	6	9
Weldability	5	8
Total(max:50)	32	37

Hence, SAE 1020 DOM seamless tubes are chosen as our frame material

III. FRAME ANALYSIS:

Different versions of the frame were analysed using ANSYS software and improvements were made during each iteration. The ansys reports of final design are shown below.

FRONTAL IMPACT:

The front impact analysis will show us how the chassis of the vehicle will survive a frontal crash. Consider that the bike is moving at 55kmph. We know that,

We assume that 4G force will act on the front part under these conditions.

4G force corresponding to our vehicle is:

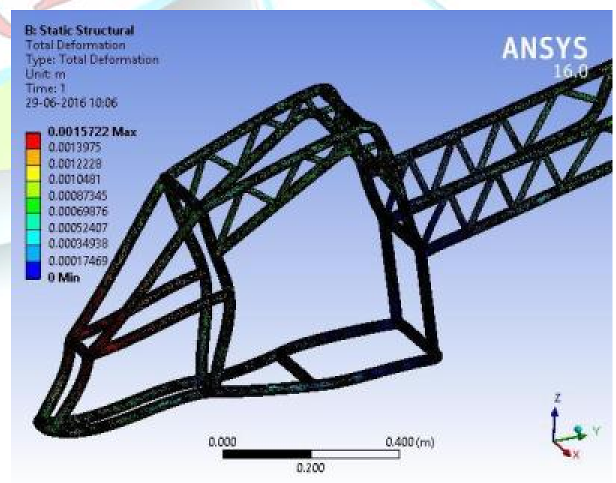
F = 4×g×m

Where, g-acceleration due to gravity(m/s)

m-wet mass of the vehicle (kg)

F = 4×9.81×230= 9025. Let us round it off to 10000N

Hence a force of 10000N is applied during analysis on the front part. The results are shown below.



Total deformation (Front)

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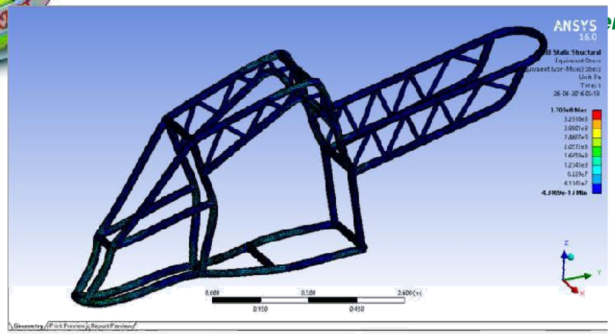


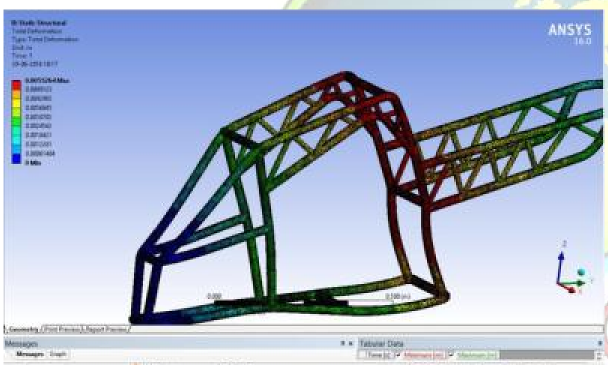
Equivalent Stress (Front)

REAR IMPACT:

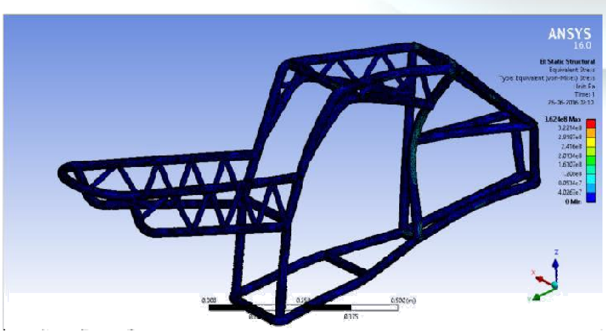
Rear impact analysis shows the deformation on the chassis when load is applied on the rear. Here,

Let us again consider 4G force for this test too.

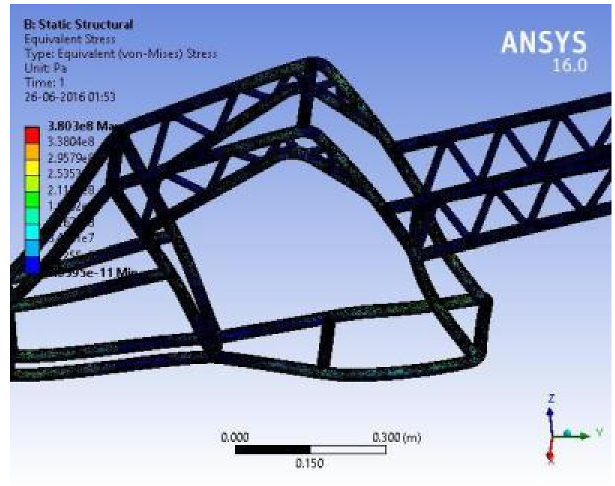
Hence a force of 10000N is applied keeping the front portion fixed. The results are shown below.



Total deformation (Rear)



Equivalent stress (Side)



Equivalent stress (Rear)

SIDE IMPACT:

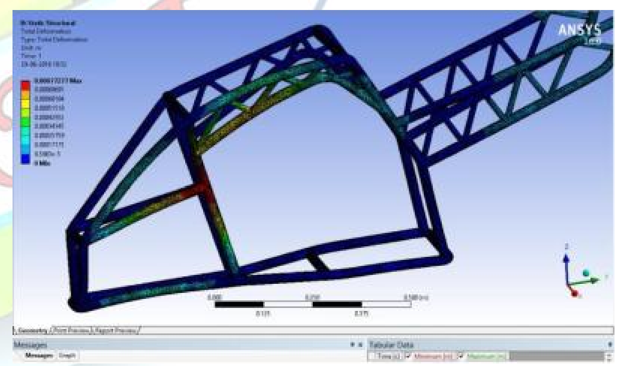
Side impact analysis shows the deformation when load is applied on either side keeping the other side fixed.

3G force is assumed to act on the vehicle.

3G force for our vehicle is:

F = 3×9.81×230 = 6769N

Hence a force of 7000N is applied.



Total deformation (Side)

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IV. SUSPENSION:

DESIGN METHODOLOGY:-

The objectives of suspension system is met with its proper design of front and rear suspension geometry such that body roll is reduced. Proper camber and caster angles are provided. The shock absorbers are set for damping to ensure smooth riding.

Table 3: Basic dimensions

Camber angle	-3deg
Caster angle	+4deg
Ride height	8in
Front track length	46in
Rear track length	44.5in
Wheel base	50in

Front suspension:-

For our front suspension we chose one with a Double arm wishbone type suspension. It provided spacious mounting position, load bearing capacity besides better camber recovery. The two front suspensions are custom made.

Design of the control arms also includes maximum adjustability in order to tune the suspension for a given task at hand.

It also gives negative camber at cornering which gives stability.

The upper arm is shorter to the lower arm and it is set in non parallel position.

Table 4:

LENGTH OF A ARMS	
UPPER	310cm
LOWER	330cm

The motion ratio here is

A / (A+B) = 230/330 = 0.69

Rear suspension :-

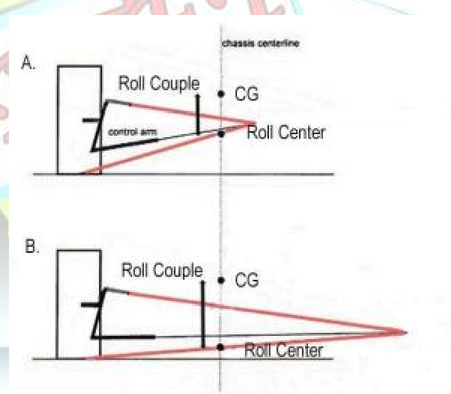
The rear suspension unlike the front one consists of monoshock spring with a damper. We used Honda CB Unicorn rear monoshock for this purpose. The rear suspension is designed by considering the same design principles as in the front suspensions except that it is designed in such a way that the spring rate is 20% more than that of in the front suspension. Since the weight distribution ratio is higher at the rear. This gives better motion control of the front axle and the wheels relative to the frame.

A swing arm is mounted on which the mono shock is placed. This gives better control. Also since force received is soft at rear, Roll is close to infinite. This arrangement saves cost as well as serves the main purpose of suspension.

Chosen length of swing arm is 56cm after calculation. The inclination of front springs are 65deg while that of rear monoshock is 60deg.

Roll centre height:-

The roll centre height is calculated as below



Shock Absorbers:-

Factors assumed from data book for springs for front is

1) Material chosen: Plain Carbon Steel

2) Spring index C = D/d=8.5 [Here D is mean diameter, d is diameter of the wire]

3) Shear Stress (ζ) = 16000N/cm^2

4) Helix angle of the spring α = 6 degrees

THE required parameters for front and rear spring is

Table 5: Spring details

	DIAMETER OF WIRE	MEAN DIAMETER	PITCH	NO. OF COILS
FRONT	0.5cm	7cm	21.8 mm	17
REAR	1cm	8cm	22mm	10

Main Considerations taken into account for designing:-

We have positioned our roll centers above the ground in the front and rear respectively. These values minimize jacking forces.

The ratio of Rear to Front Roll center is 1.4, close to 1.5 which is considered ideal. Nose dive type roll axis is set.

The control arms have been tried to set close to optimum lengths.

The motion ratio is 0.69 which is not exceeding 0.7.

V.CONCLUSION:

We have succeeded to design a quad bike which is distinct yet reliable, economical to manufacture and maintain and technically sound. Also we managed to do that by fully complying with the rulebook. Various parts or components that are going to be used in this quad bike, the reasons why they were chosen, the analysis reports of some, are explained in detail in this report. Therefore, in conclusion, we have designed a quad bike that is few steps ahead of the market that is existing today and will appeal to all types of customers/drivers.

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VII. OVERALL CAD MODEL:

The overall CAD model was assembled using CREO 3.0 software.

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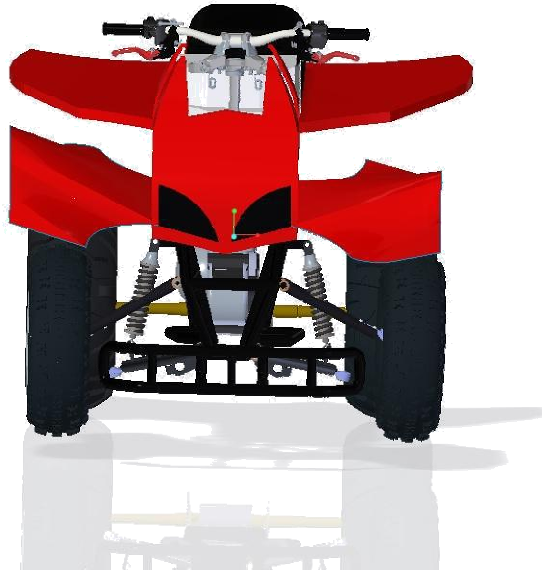

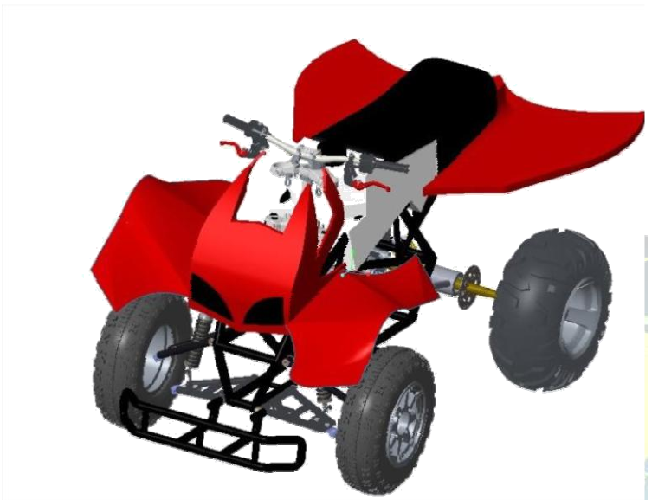

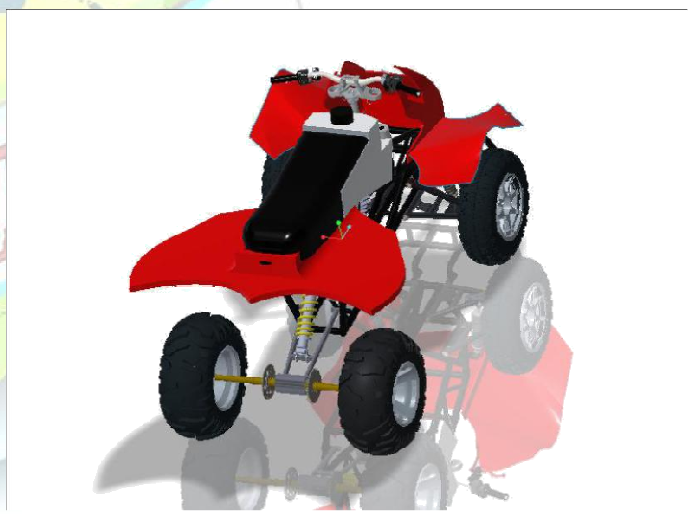

VIII.MANUFACTURED VEHICLE: