Design and Optimization of Suspension System of All Terrain Vehicle

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Abstract - *A major hindrance in the growth of off road industry in country is the cost and the correct utilization of the all-terrain vehicle. To improve the graph of this industry we will work on the current design of suspension to improve the maneuverability and reduce the weight to improve the overall performance of the vehicle. New design will further give opportunities and will open the gateway for other applications too in the country. The suspension system of an ATV (ALL TERRAIN VEHICLE) needs to be adaptive, durable, efficient and relatively cheap. The objective of this paper is to study and design the static and dynamic parameters of suspension system.For this the geometry of front and rear suspension system will be drawn on CAD software SolidWorks and further the suspension components will be analyzed on CAE software ANSYS.*

***Key Words*: Suspension, ALL Terrain Vehicle, CAD, SolidWorks, CAE, ANSYS**

1. INTRODUCTION

An off-road vehicle (ATV) is characterized by the American National Standards Institute (ANSI) as a vehicle that move on low pressure tires, with a seat that is straddled by the administrator, alongside handlebars for controlling controls. In a few vehicles guiding wheel like steering wheel is likewise utilized. As the name recommend, it is intended to arrange a more extensive assortment of landscape than most conventional vehicles is not able to do. Despite the fact that it is road legitimate vehicle in a few nations, it isn't lawful inside most conditions of Australia, the United States and Canada and unquestionably not in India. By the ebb and flow ANSI definition, it is planned for use by a solitary administrator; however a change to incorporate 2 seats is under thought.

Fig -1: Typical ATV

1.1 Suspension

The suspension of a vehicle is basically for both security and execution. As a matter of first importance obligation of the suspension is to hose and retain the vertical forces that a vehicle may experience on an off road track. This can incorporate a little move in weight when the vehicle is stacked with individuals or things to a huge move if the vehicle's tires keep running into a huge impediment on the ground. By hosing the vertical powers in these circumstances, the suspension shields both the vehicle and travelers from undesirable and possibly unsafe vertical vibrations. Suspensions likewise perform two other fundamental capacities. The first is known as ride quality and the second is dealing with the handling of vehicle. The ride stature of a vehicle alludes to the amount of vertical powers that a suspension framework will adequately have the capacity to refute and how agreeable the ride will be for the driver. The taking care of alludes to how well the vehicle can be controlled amid turning, braking, and accelerating by keeping every one of the four wheels in contact with the ground.

1.2 Types of Suspension System

1) Independent suspension system

This framework implies that the suspension is set-up such that permits the wheel on the left and right half of the vehicle to move vertically free here and there while driving on uneven surface. A power following up on the single wheel does not influence alternate as there is no mechanical linkage display between the two center points of a similar vehicle. In a large portion of the vehicle it is utilized in front wheels.

These sorts of suspension typically offer better ride quality and dealing with because of less unsprung weight. The principle favorable position of autonomous suspension is that they require less space, they give easier maneuverability, low weight and so on.

Cases of independent suspension framework are:

Double Wishbones

McPherson Struts

2) Dependent suspension System

In dependent suspension framework there is an inflexible linkage between the two wheels of a similar hub. Power following up on one wheel will influence the contrary wheel.

For each movement of the wheel caused by street anomalies influences the coupled wheel also. It is for the most part utilized in substantial vehicles. It can hold up under stuns with an awesome limit than autonomous suspension. Case of this framework is Strong Axle

3) Semi-Independent System

This kind of framework has both the qualities of reliant and additionally autonomous suspension. In semi-autonomous suspension, the wheel move with respect to each other as in free suspension however the situation of one wheel has some impact on the other wheel. This is finished with the assistance of bending suspension parts. Case of semi-autonomous is Twist Beam.

2. SUSPENSION SELECTION

Depending on various parameters such as driver comfort, required ground clearance and rolling tendency of vehicle we selected double wishbone suspension system at front and semi -trailing arms at the rear.

FRONT SUSPENSION: The twofold A arm comprises of two A-shape structures. The twofold A Arm takes into account simple, free flexibility of camber and toe by means of the toe connections and tie pole joints. Twofold wishbone gives the greatest travel among all suspension frameworks.

Fig -2: Double Wishbone

REAR SUSPENSION: It is a trailing link based suspension with two camber links. The three links allows for camber adjustability in a curved line. The three links is a simple design and swing arm motion naturally absorbs any impact loads.

Fig -3: Semi-trailing arms with two control links

3. DESIGN

3.1 Tire selection for ATV

For keeping the weight of unsprung parts less and to provide adequate heat dissipation we have to select tubeless which also has advantage of providing less rolling resistance. For proper handling and grip in rough terrain we have to choose cross groove tires. Width of tire is also an important parameter in selecting tire so the tire with maximum width available in the market is selected and also as it is an off road vehicle ground clearance should be more than the conventional vehicles so the diameter of tire should also be more.

After keeping in mind all the above points we decide to go for

CARLISLE 23*7R10 with DWT rims 10" made from 6061 heat treated aircraft grade aluminum weighing only 1.4 kg.

Fig -4: Carlisle tire and DWT rim

Table -1: Tire and Rim Dimension

	Front	Rear
Width	7"	7"
Outer Diameter of Tire	23"	23"
Outer Diameter of Rim	10"	10"

3.2 Design of front Suspension System

We have chosen the ideal length of wishbones remembering the required leg space at the front, the required ground freedom and the points at which the wishbones were situated by deciding the required roll center height.

Table -2: Input parameters for Front suspension geometry

Track width front	52”
Wheelbase	56”
Scrub Radius	2”
Toe in	2 degree
Castor Angle	4 degree
Camber Angle	-4 degree
King Pin Inclination	7 degree

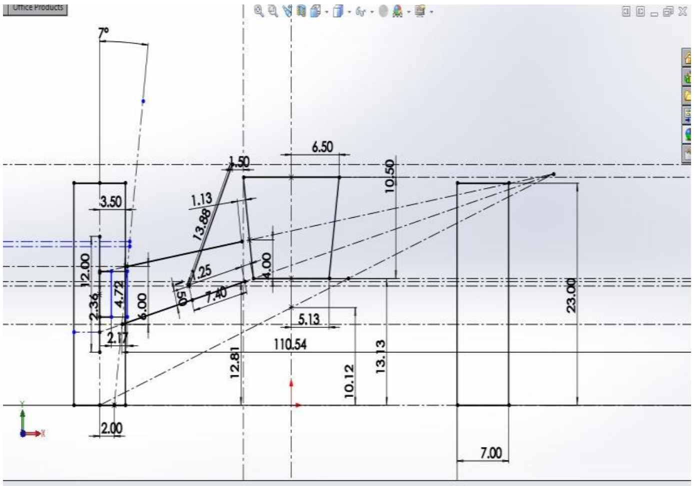

Fig -5: Front view of Front Suspension Geometry

3.3 Design of Rear Suspension System

Semi-trailing arms are a type of independent rear suspension. Compared with non-independent suspensions it offers better ride quality and handling, as a bump under one wheel does not change the geometry of the other, and the unsprung weight is much lower. Compared with the trailing arms suspension it has an advantage that during the suspension movement the camber angle changes, so that the tires remain perpendicular to the ground during body roll. Contrasted and more refined back free back suspension plans, for example, twofold wishbone suspension or multi-connect suspension, its favorable circumstances are bring down cost and many-sided quality and more minimization. The drawbacks are more awful dealing with and ride, due to three elements: in the first place, the unsprung weight is higher in light of the gigantic arms and center points, second, the wheel is emphatically mounted on the arm, so it exchanges more vibration to the body, and third, with the suspension development the back toe edge changes.

Table -3: Input parameters for Rear suspension geometry

Track width Rear	48”
Toe	0 degree

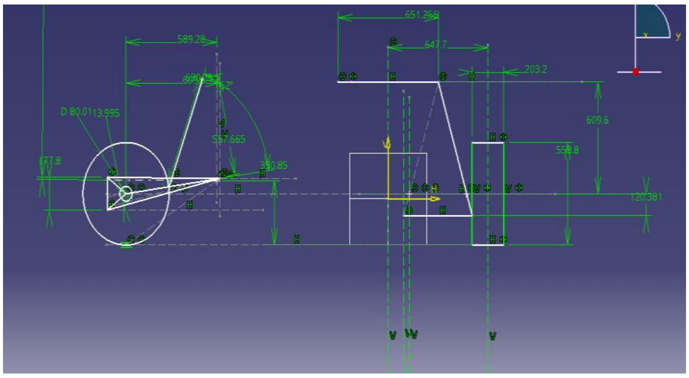

Fig -6: Front view of Rear Suspension Geometry

3.4 Designing of Hubs and Uprights

SolidWorks 2014 was extensively used to arrive at the final rear and front components of suspension and the analysis was done CAE ANSYS Workbench and after the rigorous iterations we got these models.

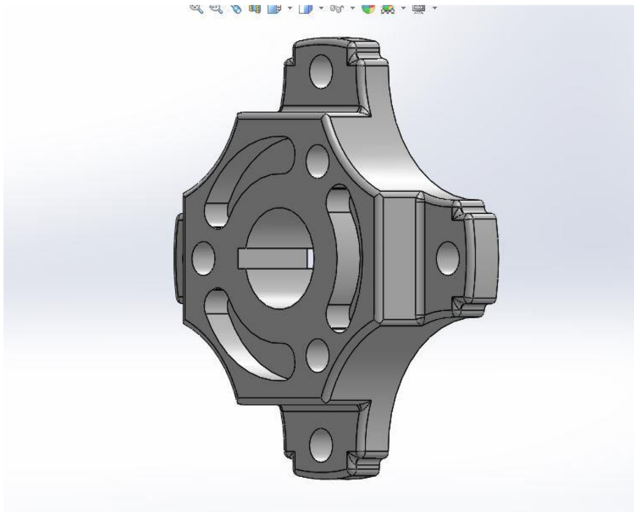

Fig -7: SolidWorks Model of Front Hub

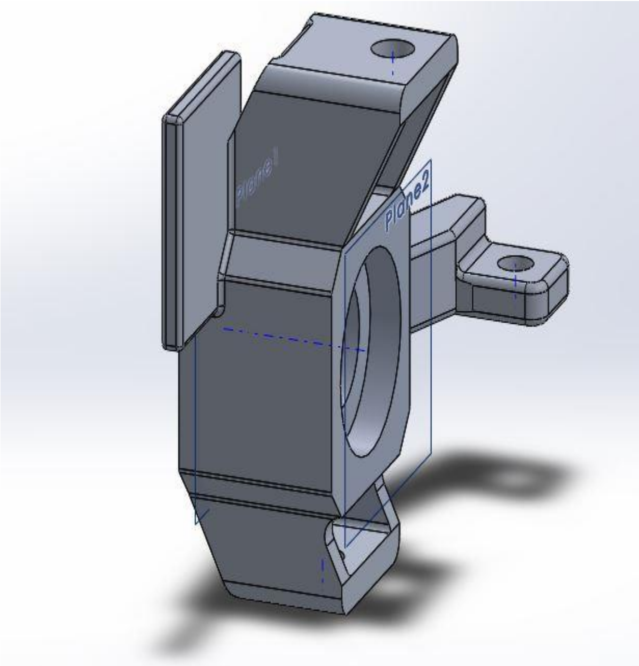

Fig -8: SolidWorks Model of Front left Upright

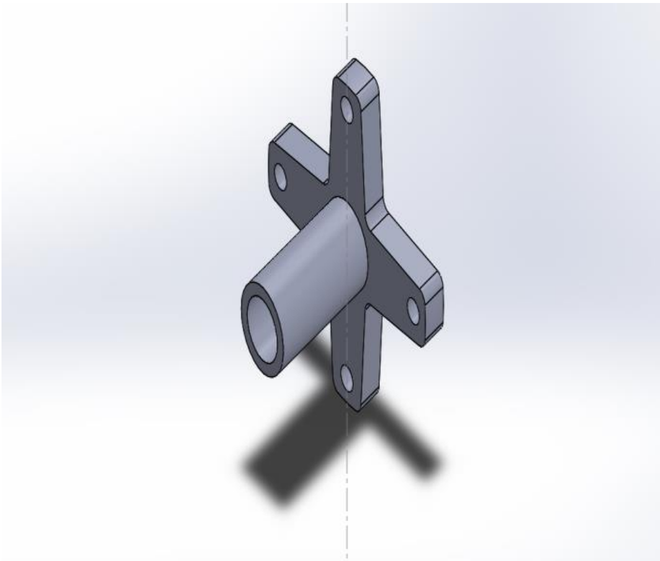

Fig -9: SolidWorks Model of Rear Hub

4. ANALYSIS

The complete components were modeled using SolidWorks and then Assembly was done to check any error caused during the designing phase. For Analysis purpose we used Ansys Workbench. It provided the stress distribution in the component and after the rigorous testing we have arrived at the final models.

4.1 Analysis of Hubs and Uprights

Under the various situations like acceleration, braking, and cornering the hubs and uprights were applied forces with a 2.5g to 3g acceleration with maximum force of 5000N and the factor of safety for critical components were taken to be around 2.5. The material for hubs and upright was chosen to be aluminum 6061 aircraft grade to minimize the weight.

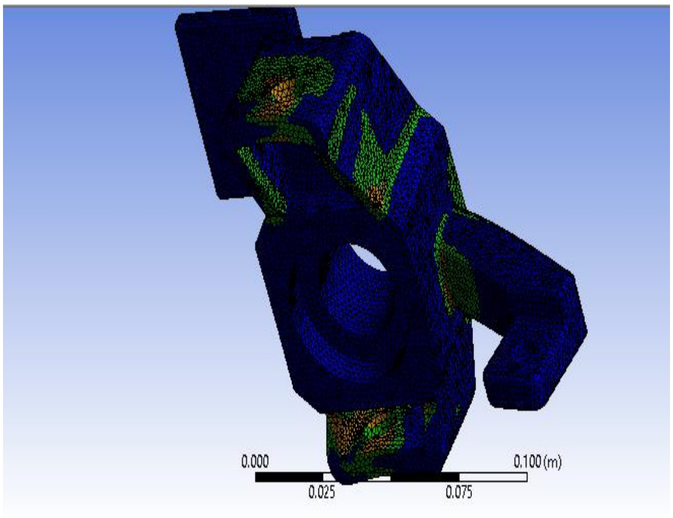

Fig -10: FEA analysis of front upright

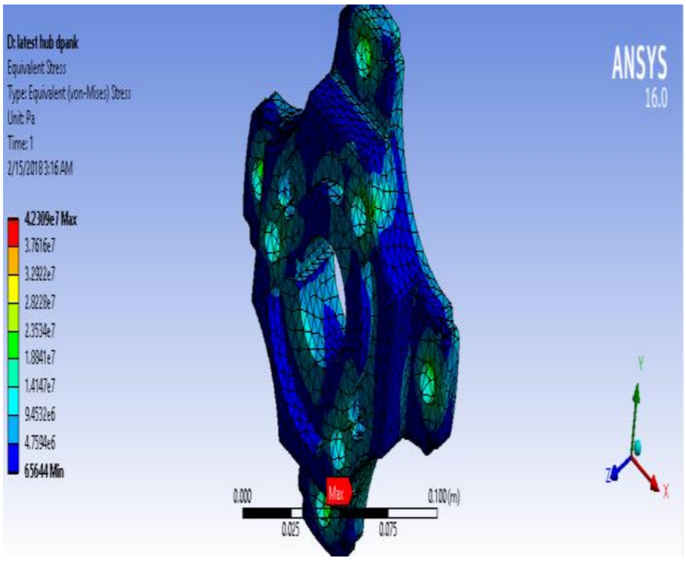

Fig -11: FEA analysis of front hub

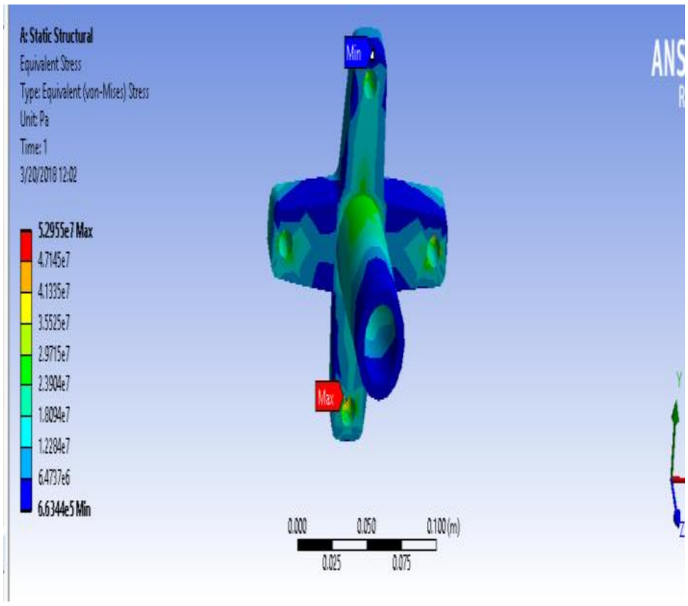

Fig -12: FEA analysis of Rear hub

5. CONCLUSIONS

After the designing and analysis of suspension system various results were obtained. Position of Center of gravity and roll center obtained from the front and rear suspension geometry for better stability and comfortable ride for driver.
Distance from ground level = 12.5"
Roll center at front = 9.43''
Roll center at rear = 8.27"

To sustain the static and dynamic load on vehicle following parameter are obtained by designing for suspension:

Table -4: Result Table

GENERAL SPECIFICATIONS	
Wheelbase	56"
Front Track	52"
Rear Track	48"
Target weight	170kg
SUSPENSION SPECIFICATIONS	
FRONT	
Type	**Double Wishbone SLA**
Travel	10"
Camber	-4degree
Caster	4degree
Kingpin Inclination	7degree
Scrub Radius	2"
Roll Centre Height	9.43"
Tire(in)	23*7R10
Ride frequency(Hz)	1.2
REAR	
Type	**Semi-trailing Arm**
Travel	6"
Ride frequency(Hz)	1.7
Roll Centre Height	8.27"
Tire(in)	23*7R10

The paper describes about designing and analyzing suspension of an All-Terrain Vehicle (ATV) and their integration in the whole vehicle. The ATV has been outlined and examined in view of the actualities of vehicle elements. The essential goal of this paper was to distinguish the plan parameters of a vehicle with a legitimate investigation of vehicle progression. This paper likewise encourages us to consider and dissect the system of vehicle suspension outlining and to distinguish the execution influencing parameters. It likewise comprehends and beat the hypothetical challenges in vehicle plan.

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