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Design of Front Suspension System of an ATV

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Abstract - *The deal with this paper is to design and implementation of double wishbone suspension (front) for an all terrain vehicle for improving stability and handling of the vehicle. There are tremendous developments in suspension system. The topic is focused on designing the above mentioned suspension system considering the dynamics of vehicle along with minimizing the unsprung mass. The suspension system of an all terrain vehicle needs to be durable, light weight, efficient and less expensive. For achieving these requirements design analysis is must, which we analyzed by using UG-NX9, ANSYS. The stability of vehicle and the ride comfort are given prominent intense in this project.*

***Key Words*: Vehicle dynamics, unsprung mass, off-road, vehicle stability, Suspension System**, **QFD**.

1. INTRODUCTION

A vehicle suspension system is a linkage to allow the wheel to move relative to the body. Suspension is the most important aspect while designing of an off-road vehicle. In off-road terrain the track consists of all kinds of obstacles that could be easily bind up the suspension of any off-road vehicle. To make the vehicle compatible to an off road condition it is necessary to design suspension system that can be handle roughest of bumps without affecting the vehicle stability and at the same time provides smooth ride to the driver.

Suspension geometry plays major role in rollover, squat and dive of any vehicle. The suspension system is in direct contact with the tires hence it is subjected to extensive forces. The vehicle suspension system is responsible for the vehicle comfort and safety as the suspension carries vehicle body & transmits all forces between the bodies.

1.1 OBJECTIVES

Suspension system is installed in off-road vehicle for following purpose.

- To provide good ride and handling performance.
- To provide safe vehicle control and free of unwanted vibrations.
- To reduce wear of the tyre.
- To prevent the road shocks from being transmitted to the vehicle.
- It helps to keep the tyres in contact with road.
- To protect the vehicle itself and any cargo from damage.

1.2 DESIGN RESEARCH

- Study of independent suspension type
- Material selection based on QFD
- Design of wishbone in NX-9
- Analysis and optimization of design components
- Conclusion

2. FRONT SUSPENSION

Considerations weight of an ATV, flexibility in suspension, ground clearance and ride comfort for achieving these all objectives we chosen double wishbone type suspension.

2.1 DOUBLE WISHBONE SUSPENSION

Double wishbone suspension is the type of independent suspension. Independent suspension is a broad term for any automobile suspension system that allows each wheel on the same axle to move vertically (i.e. reacting to a bump in the road) independently of each other.

Double wishbone suspension system consists of two lateral control arms (upper and lower arm) usually of unequal length along with a coil over spring and shock absorber. When the vehicle is in a turn, body roll results in positive camber gain on the inside wheel. The outside wheel also jounces and gains negative camber due to the shorter upper arm. We design the suspension arms in such manner that it balance these two effects to cancel out and keep the tire perpendicular to the ground.

The double wishbone suspension can also be referred to as double a-arms or short long arm (SLA) suspension if the upper and lower arms are of unequal length.

The suspension designer attempts to balance these two effects to cancel out and keep the tire perpendicular to the ground. This is especially important for the outer tire because of the weight transfer to this tire during a turn. Between the outboard ends of the arms is a knuckle with a spindle (the kingpin), hub, or upright which carries the wheel bearing and wheel.

The selection was done based on the following basic parameters.

- Load bearing capacity
- Flexibility

- Cost
- Technical aspects- Camber, Stiffness, Rolling
- Availability of parts and components

Advantages

- It gives good ride quality.
- It doesn't affect steering on larger deflection of wheel.
- It provides large distance for resisting rolling action.
- It provides smooth and comfort ride.
- Rear wheels remain stable.
- It helps to maintain proper ground clearance.

Disadvantages

- Expensive
- Increased cost
- Complicated design

3. MATERIAL SELECTION

Material selection for the wishbone is primary need for design and fabrication. The strength of the material should be well enough to withstand all the loads acting on it in dynamic conditions. So by applying QFD criteria initially, three materials are considered based on their availability in the market- AISI 1018, AISI 1020 and AISI 4130.

The main criteria were to have better material strength and lower weight along with optimum cost.

Table -1: Material selection by QFD

Properties	AISI 1018	AISI 1020	AISI 430
Carbon content	0.18	0.4	0.12
Tensile strength	440 MPa	465 MPa	430 MPa
Yield strength	320 MPa	415 MPa	350 MPa
Cost (Rs/ft)	108	140	102

Quality Function Deployment is a systematic approach to design based on a close awareness of customer desires.QFD is a way to assure the design quality while the product is still in the design stage. Based on this we have chosen AISI 1020 for the wishbones.

Stress calculation

Allowable stress for AISI 1020 is $\sigma = \frac{Syt}{fs}$

Assume factor of safety 1.5 as AISI ductile material

$$\sigma = \frac{350}{1.5} = 233.33 \text{ MPa} \quad (1)$$

The designed wishbone is safe when induced or maximum stress is lesser than the allowable stress

4. DESIGN METHODOLOGY

The front suspension systems geometry were designed by considering system separately, however, it is important to make sure that the front and rear suspension characteristics are consistent with each other in order to optimize the full vehicle suspension performance. The following parameters are considered for the front suspension systems.

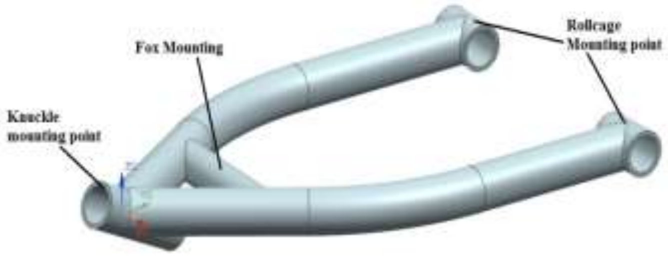

Fig-1 Front suspension

Lateral Roll Centre Position

The roll axis of the vehicle is formed by connecting the front and rear roll centre points. The lateral positions of the front and rear roll centers have to follow the same pattern over wheel travel, otherwise the roll axis will not be perpendicular to the centerline of the vehicle and the vehicle will be subject to yaw.

Roll Stiffness

The roll stiffness is designed so that the front suspension is always stiffer than the rear. Higher roll stiffness in the front allows the vehicle to have an over steering characteristic during cornering.

To design the suspension we consider the wheel base and wheel track and roll centre which decides the wishbone lengths, tie rod length and the geometry of wishbones. Roll centre and ICR is determined because it is expected that all the three elements- upper wishbone, lower wishbone and tie rod should follow the same arc of rotation during suspension travel. This also means that all the three elements should be displaced about the same centre point called the ICR. Initially, wishbone lengths are determined based on track width and chassis mounting. These two factors- track width and chassis mounting points are limiting factors for wishbone lengths. Later, the position of the tire and the end points of upper arm and lower arm are located.

Table -2: Parameters

Suspension Parameters			
Wheel base	1524 mm	Motion ratio	0.65
Wheel track	1371.6 mm	Wheel rate	10.33 N/mm
CG height	532.38 mm	Spring rate	24.45 N/mm
Ground clearance	373.3 mm	Shock travel	5”
Unsprung mass	47.5 kg	Roll centre	227.3 mm

5. ANSYS OF WISHBONE

The front lower wishbone was tested as the strut is attached on the lower wishbone due to which most of the load acts on the lower wishbone. The two hinge points and ball joint were considered as fixed points and a load of 2586.59 N (load on spring) was applied at the strut attachment point The material of the wishbone is used AISI 1020.Tubing used with wall thickness 3mm.

Load Applied- 2586.59 N

Factor of Safety- 1.5

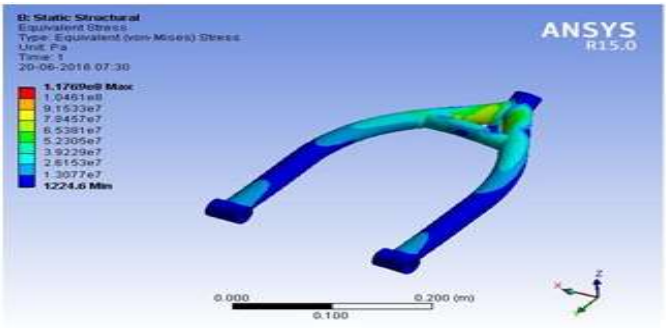

Fig -2: Ansys of static structural equivalent stress Equivalent stress-117 MPa

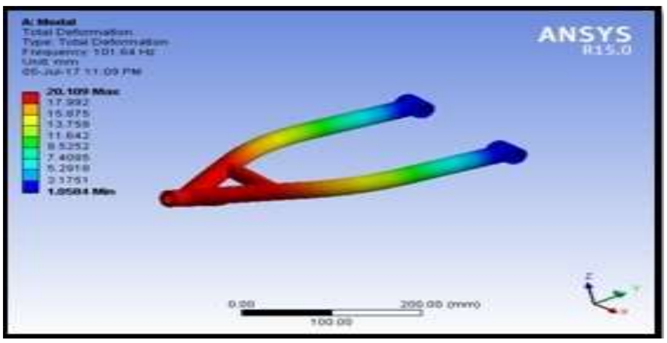

Fig -3: Ansys of structural total deformation Deformation - 20mm.

6. CONCLUSION

According to design we have fabricated front suspension for better performance of an ATV by considering all prominent design parameters. After initial testing it seems that all desired properties achieved as considered while designing. The suspension system can be further modified for decreasing weight and cost.

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