

The Design and Development of an All-Terrain Vehicle Suspension System Utilizing Double Wishbones

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Abstract

The suspension system is a critical component of every vehicle. It is responsible for the vehicle's safety throughout its manoeuvre, as well as providing stability and a comfortable ride for the occupant. Recent suspension system advancements have mostly focused on enhancing vehicle comfort and handling while preserving cost and space feasibility as a production restriction. The goal of this project is to design and construct a double wishbone suspension system for an all-terrain vehicle that minimises sprung and unsprung mass while lowering vibration amplitude while considering vehicle dynamics. As an aim, this will preserve ride quality, ride stability, and flexibility on off-road racetracks while giving comfort to occupants.

Keywords: *ATV Vehicle, Vehicle dynamics, Un-sprung mass, Suspension system*

INTRODUCTION

A double wishbone suspension system is an independent suspension system in which the wheel is located by two wishbone-shaped arms. Each wishbone or arm has two points of attachment to the chassis and one knuckle joint. To regulate vertical movement, the wishbone is

equipped with a shock absorber and coil spring. Two lateral control arms, generally of unequal length, as well as a coil over spring and shock absorber, make up a double wishbone suspension system. Body roll causes positive camber increase on the inner wheel while the vehicle is in a turn.

Outside wheel jounces as well, gaining negative camber.

Recent study on the Double Wishbone Suspension System has revealed that the majority of effort has been restricted to the design and development of suspension systems without optimising parameters such as sprung and un-sprung mass, cost and material, and so on. We worked on lowering vehicle vibration while preserving ride quality and stability on an off-road track, taking into account optimal sprung and unsprung mass, material, and cost to give flexibility and comfort to the rider while riding the ATV.

DESIGN

For the design and calculations of a double wishbone suspension system, numerous parameters such as suspension kinetics and suspension kinematics are taken into account.

Suspension kinetics

Suspension kinetics affects suspension performance when the vehicle is moving. Kinetics takes into account the vehicle's mass, driving force, braking force, and reaction forces generated by uneven ground surfaces.

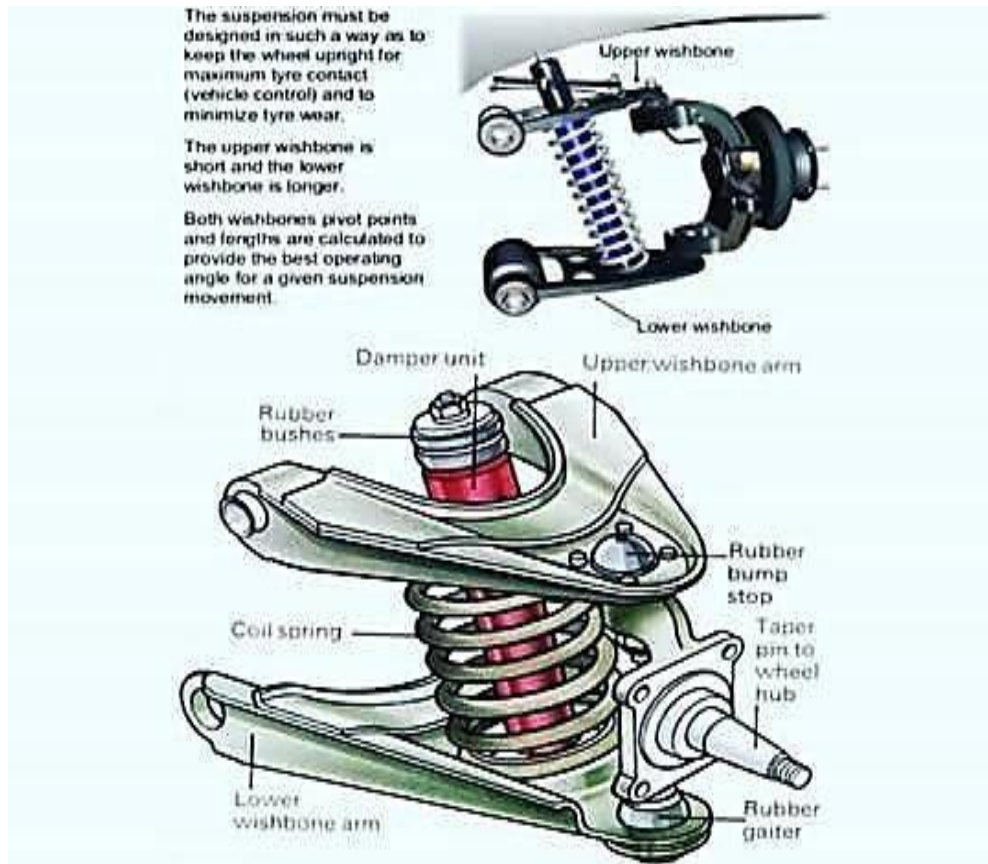


Figure 1: Double wishbone suspension.

Suspension kinematics

The orientation of a tyre as a function of wheel travel and steering angle is described by suspension kinematics.

ground. An ATV must have enough riding height to protect the vehicle body from damage caused by tough terrain, such as rocks. See Figure2

Ride Height

When a vehicle is filled with people, the ride height is the distance between the lowest section of the sprung mass and the

Motion Ratio

The spring travel per unit wheel travel is known as the motion ratio. It is never more than or equal to one. See Figure 3

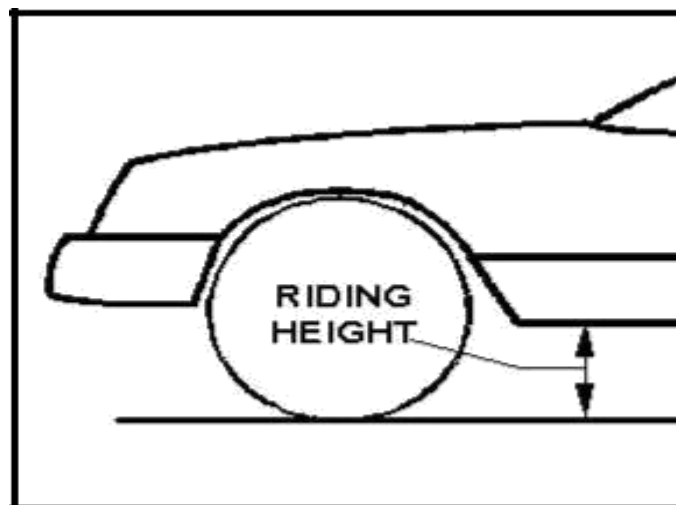


Figure 2: Ride height.

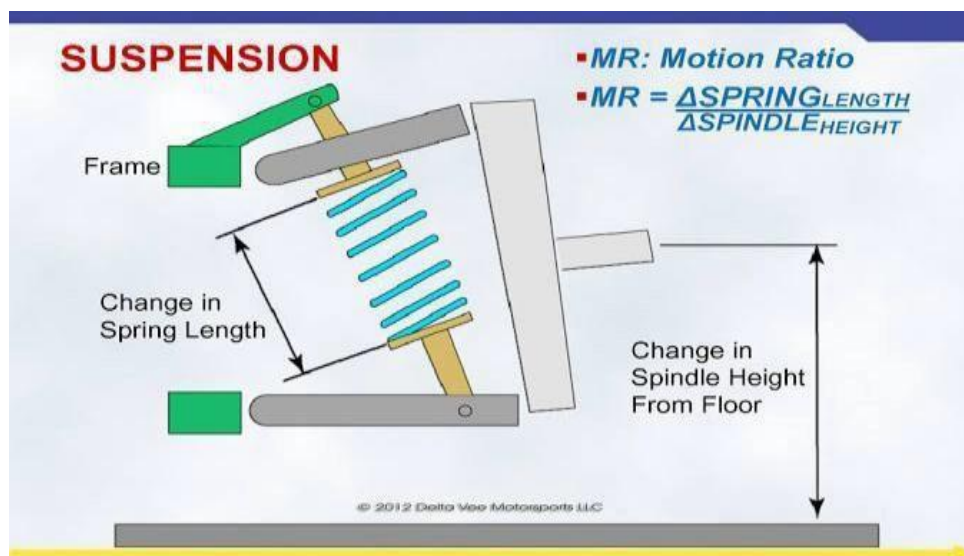


Figure 3: Motion ratio

ANALYTICAL APPROACH

Total Sprung Mass

The weight of the roll cage, the driver, the engine, the steering wheel, the steering rack, and the braking system are all considered sprung mass. 235Kg

Total un sprung mass

Unsprung mass refers to the weight of the wheels, uprights, knuckles, A-arms, Hubs, shock absorbers, and trailing arms less the sprung mass. 65 kg

Total Weight

Sprung mass + Unsprung mass gives the total weight of the vehicle. Total weight: $235+65 = 300\text{kg}$

Kerb Weight

The weight of the vehicle excluding the driver's weight Kerb weight: $300 - 60 = 240\text{kg}$
(Drivers weight is considered as 60kgs)

Track Width

There is no exact method for determining the vehicle's track width, but some fundamentals must be considered.

- Up to what value the rules will allow?
- What is the predominant track type the on which vehicle is to be run?
- Is low speed tight circuits are of concerns?

- Is top speed thus top frontal area is important? Front track width: $52''\text{inches} = 1320.8\text{ mm}$
- Rear track width: $54''\text{inches} = 1371.6\text{ mm}$

Static Ride Height

If the ride height is too low, the vehicle may be struck at the bottom when going over a bump, and if it is too high, the COG will rise, which is not a desired situation. The ride height for our vehicle is derived by evaluating the ride heights of several commercial ATVs. Static ride height: $12''\text{inches} = 304.8\text{mm}$

Tire Diameter

The tyre diameter selection criteria are determined by two elements.

1. Vehicle torque
2. Braking disc and calliper that gets fitted inside rim Tire diameter: $23''\text{inch} = 584.2\text{ mm}$

Wheel Travel

Wheel travel is defined as the vertical movement of the wheel from top to bottom.

Table 1: Wheel travel of several vehicles

Types of cars	Wheel travel
Off road	± 12
Passenger	± 4
Formula & sport	± 2 to 4

Ride frequency

It may be thought of as the body moving up and down on the spring without being damped.

Once the static deflection has been calculated, the ride frequency may be calculated.

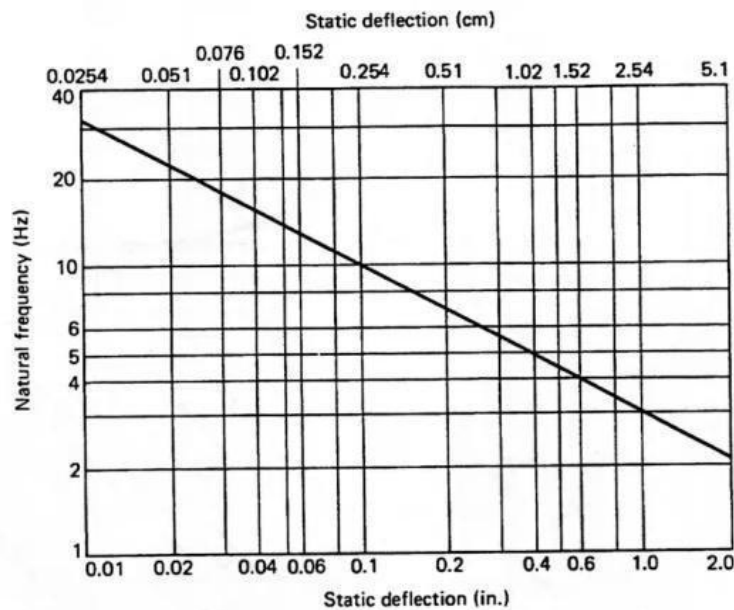


Figure 4: Ride frequency v/s static deflection.

Table 2: Different ride frequencies

Types of car	Ride frequency
Passenger	30-50 cpm
Indy car	95-120 cpm
Sports car	70-90 cpm

In order to preserve the vehicle's stability, the rear ride frequency is set greater than the front. When the car hits a bump, the front wheels begin to tremble, and after a period of time, the rear wheels begin to vibrate. If the rear wheel's riding frequency is higher, both wheels will stabilise at the same time.

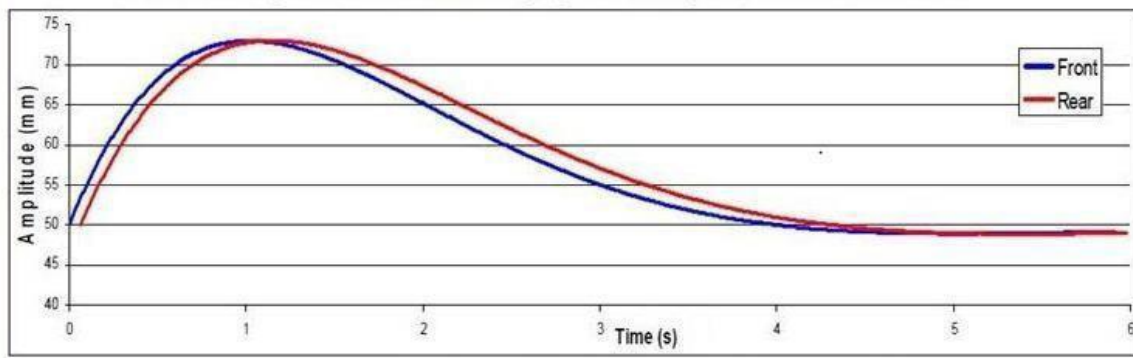


Figure 5: Normal graph of both wheels ride frequency.

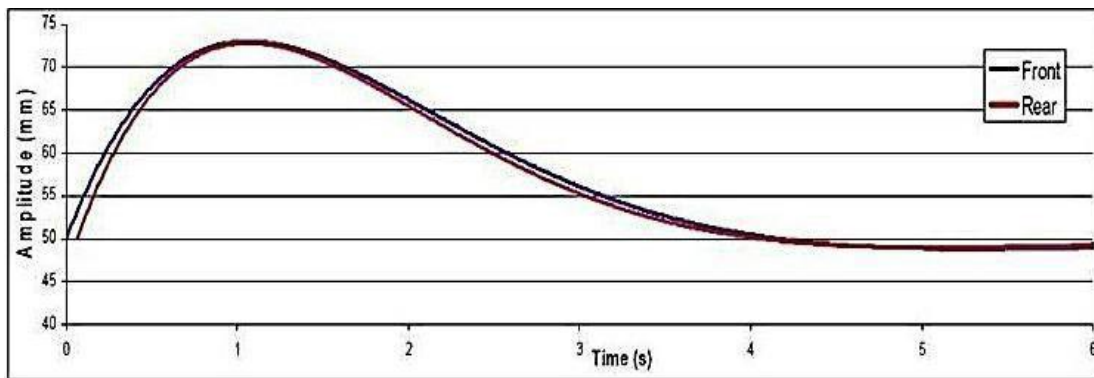


Figure 6: Graph when rear ride frequency is greater than 10%.

Spring constant

It's the amount of force delivered per unit of deflection. Its unit is N/mm or N/m, and it is also known as spring stiffness. This is an important feature of suspension since it affects its shock absorption capability. Automobiles are subjected to continuous fatigue loading. As a result, instead of utilising a generic formula to estimate spring stiffness, we employed riding frequency.

Table 2: Front suspension calculation.

Parameters of	Value
Front Mean coil	80mm
Shear stress	339
Total number of coil	12
Maximum force for	2680
Wire diameter	10mm

Table 3: Rear suspension calculation

Parameters of Front	Value
Rear Mean coil diameter	96 mm
Shear stress	339 N/ ²
Total number of coil	12 turns
Maximum force for rear	3380 N
Wire diameter	12 mm

Roll Centre Height

When a vehicle is in motion, it rolls around like an axis, which is known as the roll centre height.

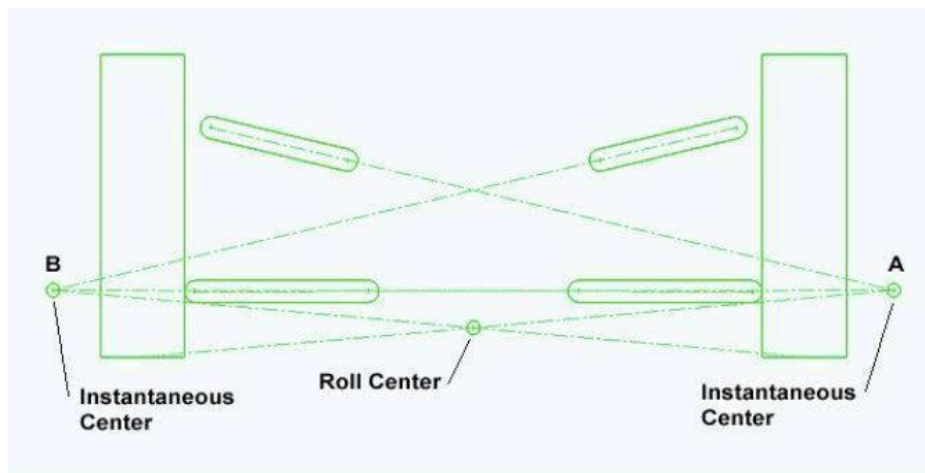


Figure 7: Roll Centre Height Roll Centre height at front – 162.5mm Roll centre height at rear – 175.8mm

Camber Gain

As seen from the front, camber is the angle formed by the vehicle's vertical axis and the vehicle axis of the tyre. Camber has a significant impact on vehicle sliding in turns. Negative camber is favoured for off-road vehicles. When turning, the body rolls in the opposite direction of the turn. This increases the force on the exterior suspension components, causing them to

compress even further. Negative camber is converted to zero camber, forcing the tyre to sit flush against the ground and increasing grip. The static camber of this system was supposed to be roughly -1 degrees, which is identical to the 2014 vehicle. Over the suspension's travel, expect to notice roughly 9 degrees of variation.

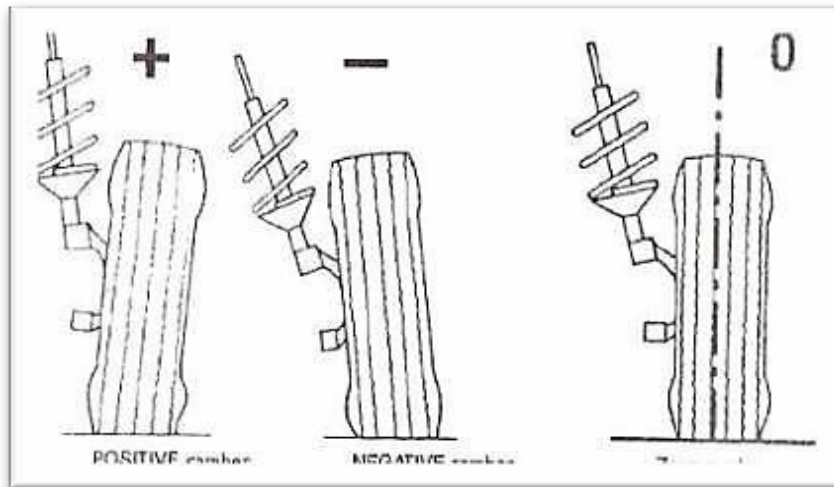


Figure 8: Pactorial image camber gain

SOFTWARE MODELING AND ANALYSIS

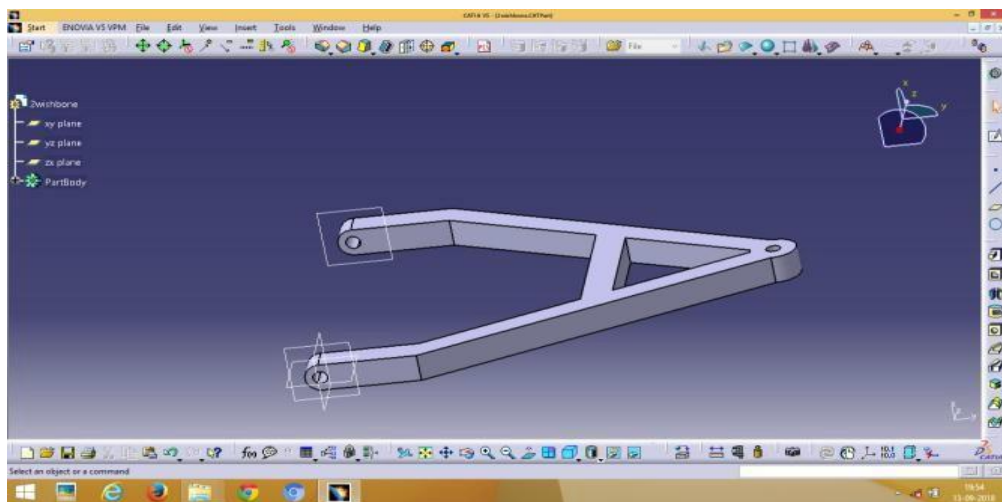


Figure 8: Design model of A-arm (CATIA).

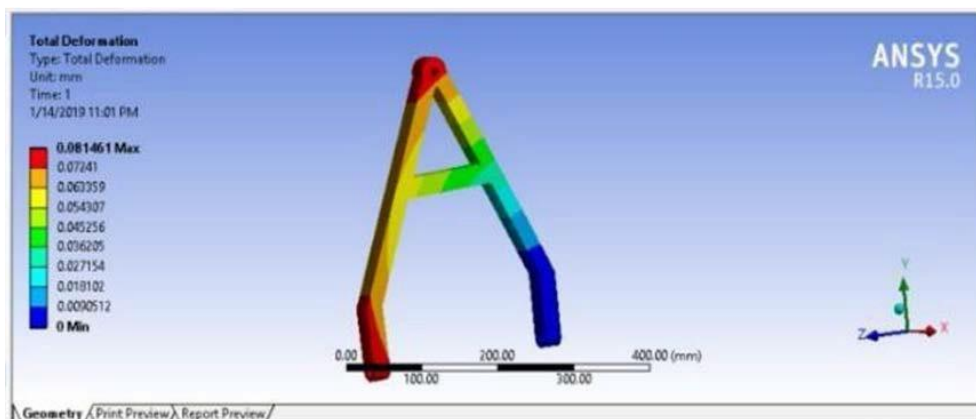


Figure 9: Deformation of A-arm

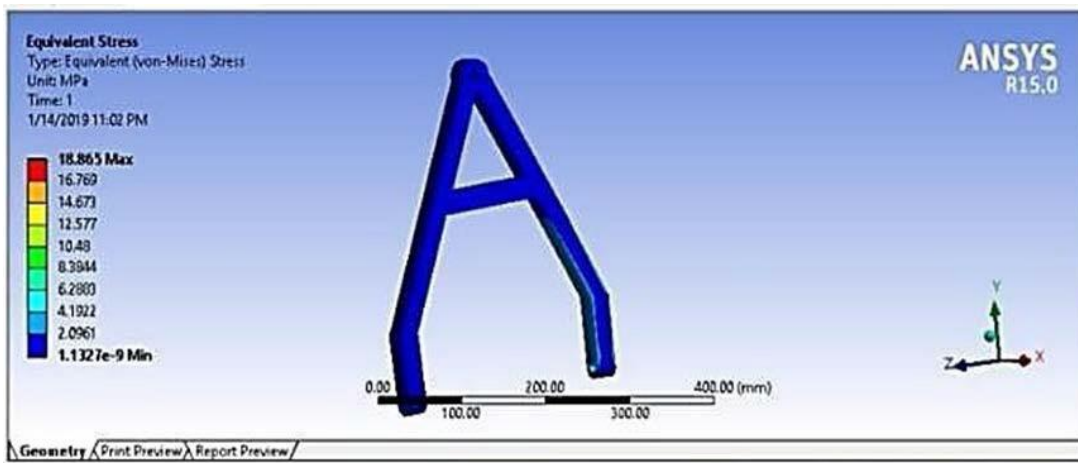


Figure 10: Stress Analysis of A-arm.

CONCLUSION

We aimed to decrease vibration, enhance ride quality and stability of the vehicle, and provide comfort to the occupant by optimising regulating parameters such as sprung and un-sprung mass, material, and cost.

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