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SUSPENSION SYSTEM FOR AN ALL-TERRAIN VEHICLE: A REVIEW

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Abstract— Suspension System of an All-Terrain Vehicles is mainly distinguished from an On-Road Commercial Vehicles in terms of its all-terrain capability due to its large travel and Ride Quality; also it has to face various ground conditions such as mud, ice, rocks, bumpy tracks etc. Hence it needs to be Robust enough to sustain in such frequently occurring Undulations. Suspension systems of commercial vehicles are designed considering normal road conditions. While designing suspension system of an ATV, various terrain conditions have to take into consideration. This paper gives the review of suspension systems for ATV.

Keywords— ATV (all-terrain vehicle), Camber, Kinematics, Kinetics, Roll centre, Suspension System.

INTRODUCTION

An ATV (All-Terrain Vehicle) also is a vehicle that rides on low pressure tires with large wheel travel unlike On-road commercial vehicles. As the name implies, it is designed to tackle various kinds of terrain that Mother Nature has created. Suspension system is an integral part of any vehicle as it provides stability, safety and comfort. The suspension system can be considered as a muscle of vehicle due to its strength and flexibility. The main objective of providing suspension system is to provide comfort by isolating passengers from the shocks transmitted through irregular ground surface, maintain traction on all terrains and also to enhance the ride quality of vehicle [1]. It must also keep the tires in contact with the road, regardless of road surface. The suspension system comprises of two components viz. linkages and shock absorber. The linkages define the path traced by wheel with respect to chassis, during its travel on irregular surfaces. The shock absorber as the name suggests damps the impact of shocks and vibration transmitted through ground surface which in-turn prevent discomfort to the driver and passenger. The purpose of this paper is to give review about basic fundamentals of suspension system.

Types of Suspension System

The suspension system is classified into two main types [1]-

- Dependent Suspension System.
- Independent Suspension System.

Dependent Suspension System

This type of suspension system acts as a solid link between two wheels such that any movement of one wheel is transmitted to the other wheel. Also, the force is transmitted from one wheel to the other. Dependent suspension system is not suitable for ATVs where motion of the two wheels is needed to be independent.
Following are the examples of dependent suspension system-

1. Leaf Spring Suspension.
   Used in Heavy duty vehicles (trucks, bus, etc.)
2. Push and pull rod Suspension.
   Used in F1 cars.
3. Anti-Roll Bar Suspension.
   Used in passenger and luxury vehicles.

Independent Suspension System

This type of suspension allows the wheel to travel without affecting the motion of opposite wheel. This is widely used suspension system in passenger cars, luxury cars and ATVs because of its advantages over dependent suspension system.
Following are the examples of independent suspension system-

1. Macpherson Suspension.
   Used in front suspension of most of the commercial cars.

2. Double Wishbone Suspension.
   Used in ATVs.
3. Trailing Arm Suspension.
   Used in rear suspension of most of the commercial cars.

Suspension Kinematics

Suspension Kinematics describes the orientation of tire as a function of wheel travel and steering angle [5]. The motions of the tire are highly dependent on type of suspension.
Several parameters are considered while designing kinematic characteristics:-

1. Wheel base, wheel track
2. Wheel Alignment
3. Rolling characteristics
4. Anti-properties.

Wheel base

The wheel base is a distance between the front and the rear axle of the vehicle. Larger the wheel base lesser the pitching tendency of vehicle and vice versa. Wheel base influences the frequencies of front and the rear suspension according to 'Olley's criteria' [4].

Wheel Track

The wheel track is a measure of the distance between the centre of the tire contact patches at the front and rear of the vehicle when viewed from front. The wheel track changes with wheels travel through the suspension travel. Wheel track directly relates with the rolling of the vehicle, higher the wheel track lesser is the rolling of the vehicle and vice versa [4].

Roll Centre (RC)

Roll centre is the point in the lateral plane of vehicle about which the vehicle rolls. There are two roll centers in vehicle, one at front suspension and other at rear. The line joining both the RCs is called roll axis. During cornering the load transfer takes place about roll axis. The roll moment depends on the location of RC and Centre of Gravity (CG). The RC is located centrally in lateral direction. Thus while designing suspension only vertical position of RC with respect to CG is considered. The orientation of roll axis contributes to the over-steering and under-steering of vehicle [2].

Camber Gain

During cornering it is the normal tendency of outer tires to have a positive camber and inner tires to have negative camber. This increases the vehicle's rolling tendency. Thus suspension geometry is designed in such a way that during cornering when weight is transferred to outer wheel, the suspension compresses and achieves a small negative camber and compensates positive camber during cornering and provides vehicle stability [2]. The opposite condition will happen at the inner wheel.

Anti-properties

The path of wheel as a function of suspension travel in longitudinal plane determines the anti-property of suspension.
Anti-dive geometry reduces the pitching tendency of vehicle while braking thus reducing diving tendency of vehicle. Anti-squat geometry reduces the pitching tendency of vehicle while acceleration thus reducing squatting tendency of vehicle [6].

Suspension Kinetics

Suspension kinetics influences the performance of suspension while vehicle is in motion. Kinetics takes into consideration the mass of vehicle, driving force, braking force and the reaction forces coming from irregular ground surfaces. It also determines the ability of suspension to absorb shocks, driver comfort and ride quality of vehicle [5].
While designing suspension system following Suspension Kinetics characteristics are considered,

1. Ride Height
2. Motion Ratio
3. Spring Rate
4. Sprung and unsprung mass

Ride Height

Ride height is the distance between lowest part of sprung mass of vehicle and the ground when vehicle is loaded with passengers [2]. For an ATV it is necessary to have enough ride height to prevent vehicle body from any damage due to rough terrain. Eg. Rocks.

Motion Ratio

The motion ratio is the amount of spring travel per unit wheel travel [3]. It is always less than or equal to 1.

Spring Rate

Spring rate is the force per unit deflection of spring. This is one of the integral properties of suspension as it deals with its shock absorption capacity.

Sprung and Unsprung Mass

The mass of the vehicle supported by shock absorber is called sprung mass [3].
Eg. Frame, Engine, Powertrain etc.
The mass of the vehicle not supported by shock absorber is called Unsprung mass [3].
Eg. Wheels, Tyres, Hubs etc.

For having good suspension it is desired to have maximum sprung mass and minimum unsprung mass so as to minimize the vibrations transferring from ground.

CONCLUSION

From the above literature survey we studied all the parameters contributing to the design of suspension system for an automobile. For an ATV the values of such properties vary from commercial vehicles. Thus taking into consideration all the parameters and assuming some data the designing of suspension system for an ATV was initiated.

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