SUSPENSION SYSTEM: REVIEW ABOUT COMPONENTS, PRINCIPAL AND CLASSIFICATION

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ABSTRACT

Vehicle suspension is used to achieve good driving stability and passenger comfort regardless of road surface. The suspension system of an automobile or a vehicle is the arrangement or a device which not provide the cushioning but also prevents the vehicle's engine from the road surfaces by providing the sufficient desired distance. I this article it is discussed about the general review about the suspension system.

I. INTRODUCTION

The automobile chassis is mounted on the axle, not directly but through some form of springs. This is done to isolate the vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. All the parts which perform the function of isolating the automobile from the road shocks are collectively called a suspension system [1].

It must also keep the tires in contact with the road, regardless of road surface. The suspension of modern vehicles needs to satisfy a number of requirements, whose aims partly conflict, because of different operating conditions [2]. However, in active suspension systems, which benefit from an active actuator, it is possible to attain acceptable ride comfort and safety simultaneously. In other words, an AS system is used to improve ride comfort without loss of controllability [3]. Human sensitivity to transmitted vibrations in the objective ride comfort evaluation is usually formulated as a standard Ride Index (RI) obtained by applying frequency filters to the transmitted vibrations and combining the weighted accelerations [4].

One of the performance requirements is advanced suspension systems which prevent the road disturbances to affect the passenger comfort while increasing riding capabilities and performing a smooth drive [5]. While the purpose of the suspension system is to provide a smooth ride in the car and to help maintain control of the vehicle over rough terrain or in case of sudden stops, increasing ride comfort results in larger suspension stroke and smaller damping in the wheel hop mode [6].

Fig.1 Schematic Quarter Car Model, [7]

Broadly speaking, suspension system consists of a spring and a damper. The energy of road shock causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper, which is more commonly called a shock absorber [1].

In this review, an automatic suspension system for a quarter car is explored to highlight the different technological processes used for suspension systems such as shown in Fig.1 [5].

II. CLASSIFICATION OF SUSPENSION SYSTEM

Suspension systems are classified into three categories namely

1. Active suspensions,
2. Semi-active and
3. Passive [8].

2.1 Active Suspensions

The active suspension systems are complex, bulky and expensive and therefore, they are not commonly used in commercial vehicles. Issues related to the design and control aspects in active suspension systems appear to be the real challenges. An excessive power is required that results in heavy loads on the engine[8]. An active suspension has an actuator that allows improve the passenger comfort due this element is placed in parallel with the damper and the spring between the car body (sprung mass) and the wheel (un-sprung mass). Typically, active suspension systems include actuators that supply additional force[9]. These additional forces are determined by a feedback control law using data from sensors attached to the vehicle. Various control strategies such as adaptive control presented by Nugroho et al. [10], fuzzy control in Ranjbar-Sabrine et al. [11] and optimal control developed by Paschedag et al. [12] have been proposed in the past years to control the active suspension system.

2.2 Semi Active

A semi-active system has the ability to modulate the damping coefficient of damper but the direction of damping force is dependent on the relative velocity across the sprung and un-sprung masses [8].The system incorporates a damper that can modulate its damping coefficient. Semi-active systems are classified as systems where the characteristics can be changed rapidly (typically in less than 100 milliseconds) [13]. The development of electrorheological (ER) and magnetorheological (MR) fluids has boosted research in the field of semi-active suspensions [13]. Nowadays, the mentioned conflicting requirements cannot be met with passive suspension systems; therefore, the application of active and semi-active suspensions is mandatory [14]. It was in early 1970s that active vehicle suspension systems were developed focusing on the optimization of trade off between ride quality and road handling [15]. Semi-active suspension enables smooth changes of damper coefficient [16]. It can be nearly as effective as fully active suspension in improving ride quality [17]. Semi-active control devices potentially offer the reliability of passive devices, yet maintain the versatility and adaptability of fully active system [18]. Magnetorheological damper is a good example of device for semi-active suspension [19-20]. Active suspension contains the power controlled actuator located between the wheels and vehicle body, for instance linear electric motor or hydraulic servomechanism.

Compared with passive suspensions, active suspensions can improve the performance of the suspension system over a wide range of frequencies [19]. Semi-active suspension is a better choice than active suspension at the cost of ride comfort and road handling but there is not a significant degradation of the performance [15]. Semi-active technology can materialize the variation of damping between the softer and harder limits in accordance with the situation as compared to the passive system [21].

2.3 Passive

A passive system comprises a damper and a spring having fixed characteristics [8].

III. OBJECTIVE OF SUSPENSION

The objectives of suspension system are as follows [1]:

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the occupants from road shocks.
- To preserve the stability of the vehicle in pitching or rolling, while in motion.

IV. BASIC CONSIDERATION

There are various basis considerations and mainly of them are as follows [1]:

4.1 Vertical loading

When the road wheels comes across a bump or pit on the road, it is subjected to vertical forces, tensile or compressive, depending upon the nature of the road irregularity. These are absorbed by the elastic compression, shear, bending or twisting of the spring.

4.2 Rolling

The C.O.G. of the vehicles is considerably above the ground. Due to this reason, while taking the turns, the centrifugal force acts outwards on the C.O.G. of vehicle, while the road resistance acts inward at the wheels. This gives rise to a couple turning the vehicle about a longitudinal axis. This is called rolling.

4.3 Side Thrust

Centrifugal force during cornering, cross-winds, cambering of the road etc., cause a side thrust to be applied to the vehicle. Such forces are usually absorbed by the rigidity of the leaf springs or by fitting panhard rods.

4.4 Road Holding

The degree to which a vehicle maintains contact with the road surface in various types of directional changes, e.g. dip, squat, cornering, etc., and in a straight line motion is called road holding.

4.5 Ride and Handling

Ride is the qualitative ability of a vehicle to provide a smooth, comfortable drive on a bumpy road. Handling is the ability of a vehicle to safety accelerate, brake and corner.

4.6 Unsprung Weight

Unsprung weigh is the weight of the vehicle components between the suspension and the road surface. This includes rear axle assembly, steering knuckle, front axle in case of rear axle suspension, wheels, tyres and brakes. Thus it is seen that greater the weight of unsprung parts, greater will be the energy stored due to vibrations and consequently greater shocks.

V. COMPONENTS

A suspension system mainly consists of

1. Springs.
2. Shock absorbers.

5.1 Springs

Springs are mechanical device, used for absorb the energy of shocks, vibrations of the irregularities present on the road surface.

5.1.1 Function of Suspension Springs

Springs are placed between the road wheels and the body. When the wheel comes across bump on the road, it rises and deflects the springs, thereby storing energy therein. On realising, due to the elasticity of the spring material, it rebounds thereby expanding the stored energy. In this way the spring starts vibrating, of course, with amplitude decreasing gradually on account of internal friction of the spring material and friction of the suspension joints, till vibrations die down [1].

5.1.2 Types of Suspension Springs

There are various suspension springs and the suspension spring mainly two types are used in vehicle as follows[1]:

5.2.1.1 Leaf Spring

Semi elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For car also, these are widely used for rear suspension. The spring consists of a number of leaves called blades. The blades vary in length and the longest blade has eyes on its ends, called as master leaf [1].

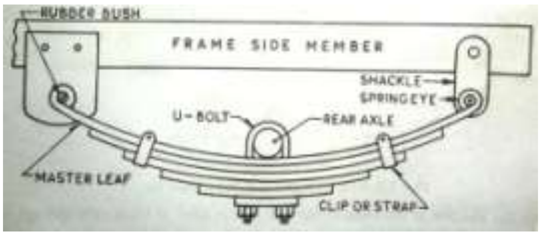

Fig. 2 Rear Leaf Spring [1]

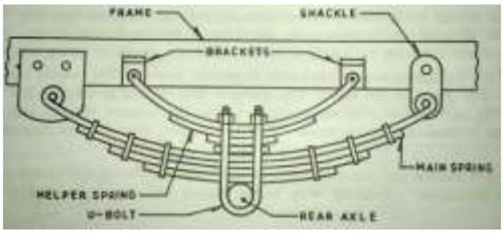

Fig. 3 Helper Spring [1]

Helper springs are provided on many commercial vehicles in addition to the main leaf springs. They allow for a wide range of loading [1].

5.2.2.2 Coil Spring

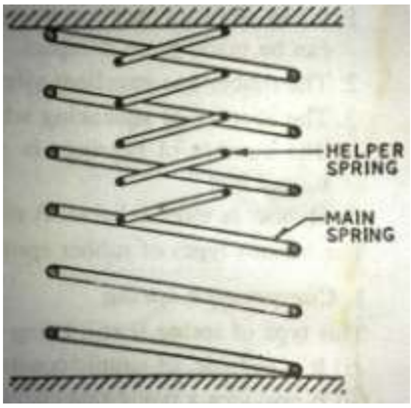

Fig. 4 Helper Coil Spring [1]

Mainly used with independent suspension system, as they can be well accommodated in restricted spaces. Coil springs don't have noise problems nor do they have static friction causing harshness of ride as in case of leaf springs. It takes the shear as well as bending stresses. A helper spring is also sometimes used to provide progressive stiffness against increasing load.

5.2 Shock Absorbers

1. A springing device must be compromise between flexibility and stiffness. If it is more rigid, it will not absorb road shocks efficiently and if is more flexible it will continue to vibrate even after bump has passed. So we must have a damping of the spring to prevent excessive flexing.

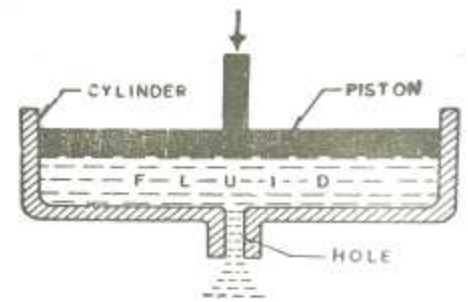

Fig. 5 The Principle of Operation of Hydraulic Shock Absorber [1]

5.2.2 Type of Shock Absorber

There are mainly two types of shock absorber are used, are as follows [1]:

5.2.2.1 Telescopic Type Hydraulic Shock Absorber

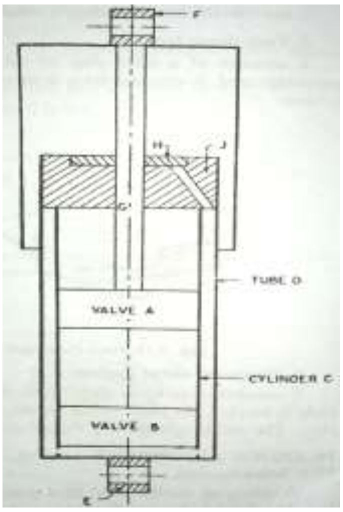

Fig.6 Telescopic Type Shock Absorber [1]

The principle of operation of a hydraulic shock absorber is that when a piston forces the fluid in a cylinder to pass through some hole[fig. 5], a high resistance to the movement of piston is developed, which provides damping effect [1].

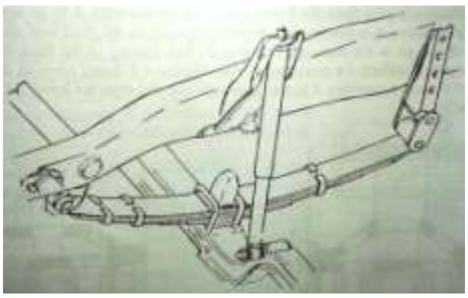

Fig. 7 Telescopic Shock Absorber Mounted on Vehicle.

(Courtesy-Swaraj Mazda Ltd., INDIA) [1]

This type has additional advantages that the damping is proportional to the square of the speed. In this type of shock absorber the tubular shape of early telescopes used in ancient times. Thus it is called as telescopic type shock absorber [1] .

5.2.2.2 Lever Arm Type Shock Absorber

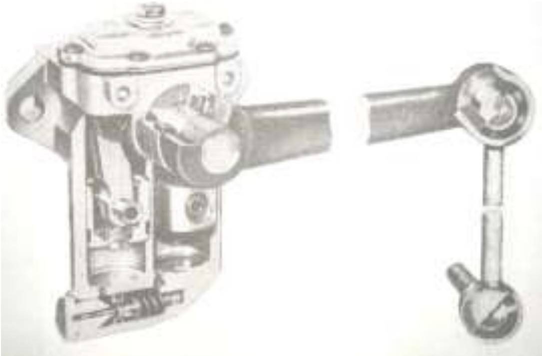

Fig. 8 Lever Arm Type Shock Absorber

(Courtesy-Armstrong Patents Co. Td., England)

Lever arm type of shock absorber has also been employed in certain vehicles. The advantage is that the large deflections are possible. It consists of two pistons operating in two adjacent chambers filled with oil and connected through holes which are covered or uncovered by means of a valve. The up and down movement of the lever arm due to road shocks causes one piston to move up and the other down, thus causing the oil to flow through the oil holes, which absorbs the energy of vibrations and their damping [1] .

VI. CONCLUSION

The suspension system provides the vehicle acts as a safety member by providing the desired height and the cushioning against the bumps or irregularities present on the road surface.The suspension system absorbs the energy generate due to road irregularities or bumps, pits etc., and these energy are transferred from the vehicle to the earth or road.

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