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A Study on Parameters Affecting the Performance of Vehicle Damping System

Swati Vasant Kolekar¹, Pravin A. Dhawale²

P.G. Student, Department of Mechanical Engineering, FTC, College of Engineering and Research, Sangola,
Maharashtra, India¹

Assistant Professor, Department of Mechanical Engineering, FTC, College of Engineering and Research, Sangola,
Maharashtra, India²

ABSTRACT: when designing a suspension system for a car it involves brainstorming about the tires, linkages, springs (dampers) and other things that are connected with the tire and the vehicle itself. In today's automobile industry, everyone focuses more on how comfortable the vehicle rides and of course, its suspension design. The suspension is more likely designed to allow the movement of the wheels to meet the expectation towards the dynamic requirement and various combinations. It is also important to know that suspension contributes in a critical part of vehicle's handling and safe braking, driving pleasure and ride quality. That is why suspension designs are truly valuable in every car.

This paper focuses on various parameters which affects the different damping systems used to damp vibrations of the vehicle specially semi active damping systems.

KEYWORDS: Suspension, Damper, Magnetic Damping, Magnetorheological (MR) fluids.

I. INTRODUCTION

Damping systems are classified into three categories namely passive, semi-active and active suspensions. Passive, active and semi-active vibration control methods are used to provide external damping for aerospace, automotive and civil engineering applications. Passive systems use viscous fluids, viscoelastic materials or tuned masses as dampers to dissipate energy without the use of actuators and external power supply. However, such systems are most effective only in a narrow frequency range. Active damping systems can produce desired response characteristics for a variety of disturbances by using actuators to provide an active force to the vibrating structure. However, active systems are often limited in their use because their actuators require a large external source of power. A semi-active damping system addresses the limitations of the passive and the active system by integrating tunable control into a passive device by replacing force actuators with continually adjustable control elements which are capable of modifying a dampers energy dissipation rate in response to excitation conditions. A side benefit of semi-active control systems is that, in the case of a power failure, the passive components of the control still offer some degree of protection, unlike a fully active control system [1].

II. PARAMETERS AFFECTING VARIOUS DAMPING SYSTEMS

Following are the some of the parameters which have to be considered while designing a damping system, which has effect on the performance of the system.

i. Weight on vehicle: The available upward (compression or bump) and downward (rebound) range of movement within the vehicle's suspension system, is known as suspension travel. Increased weight decreases the available compression travel for normal suspension operation thus increasing the frequency and severity of contact with

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the bump stops. This causes harsh ride characteristics, ineffective suspension control and increased risk of premature wear and tear of steering and suspension components.

ii. Weight of the vehicle: In a vehicle with a suspension, such as an automobile, motorcycle or a truck, sprung mass (or sprung weight) is the portion of the vehicle's total mass that is supported above the suspension, including in most applications approximately half of the weight of the suspension itself. The sprung weight typically includes the body, frame, the internal components, passengers, and cargo, but does not include the mass of the components suspended below the suspension components (including the wheels, wheel bearings, brake rotors and/or Continuous tracks) which are part of the vehicle's unsprung weight.

The larger the ratio of sprung weight to unsprung weight, the less the body and vehicle occupants are affected by bumps, dips, and other surface imperfections such as small bridges.

iii. Desired ground clearance: Ground clearance is the position of the vehicle body (sprung mass) above the basic ground level. It's an important parameter in off-road vehicle. For a certain car's weight, there is a certain amount of mechanical down force act on tires, and therefore the grip of tires is constantly changing during running condition. The whole weight of vehicle is concentrated at a point known as a center of gravity point. The center of gravity of a vehicle is calculated by taking the sum of its moments divided by the overall weight of the vehicle. The moment is the product of the weight and its location as measured from a set point called the origin. At the lower ground clearance, the location of centre of gravity point near to ground level. This reduces weight transfer during cornering, accelerating, and braking and increase the vehicle performance. Also, by lowering the front end and raising the rear end, high speed stability can be improved. [2].

iv. Spring materials: One of the important considerations in spring design is the choice of the spring material. Springs are usually made from alloys of steel. The most common spring steels are music wire, oil tempered wire, chrome silicon, chrome vanadium. Other materials can also be formed into springs, depending on the characteristics needed.

Some of the more common of these exotic metals include beryllium copper, phosphor bronze, Inconel, Monel, and titanium. Titanium is the strongest material, but it is very expensive. Next come chrome vanadium and chrome silicon, then music wire, and then oil tempered wire. The stainless and exotic materials are all weaker than the rest [3].

Following are the parameters which are important in designing a magnetic damping system.

i. Magnetic materials: Magnetic materials are categorized based on their magnetic behaviour, which is mainly determined by their electronic structures. The categories include diamagnetic, paramagnetic, ferromagnetic, and anti-ferromagnetic materials. Ferromagnetic materials have a large positive susceptibility to an external magnetic field, high magnetic permeability, and high magnetic saturation, when compared to other materials [4]. Ferromagnetic materials are able to retain their magnetic properties after the external field has been removed. A magnet is ferromagnetic material that attracts certain metals.

ii. Magnetorheological fluids: Magneto rheological fluids (MRF) are smart materials consisting of silicon oil and very small soft-magnetic particles. In a magnetic field, the viscosity and the flow behaviour of the fluid are considerably changes. MRF damper is a device to give damping by the shear stress of MR fluids. A Magneto rheological fluids damper has the property whose damping changes quickly in response to an external magnetic field strength [5].

iii. Electric current: Input current has a significant effect on variations in amount of damping force. As the current (Magnetic field) increases damping force increase. The yield point shear stress of the magneto rheological fluid changes with electric current. When the fluid is in the presence of an applied magnetic field, the suspended metal particles align according to the field lines. Viscosity of the fluid increases according to the intensity of the magnetic field. When this occurs at the right instant, the properties of the damper change helps in attenuating an undesired shock or vibration.

iv. Size of particles: The particles absorb the kinetic energy of the structure and convert it into heat through inelastic collisions between the particles themselves and between the particles and the walls of the enclosure [6]. With increase in volume fraction of ferromagnetic particles, the shear stress of MR fluids with "mixed sized particles" gives better performance compared to the MR fluids containing "small sized particles" and "large sized particles" at higher shear rate [7].

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v. Temperature: Magnetorheological dampers face change of temperature due to generation of heat in coils attached in the piston head. Fluid viscosity has a direct relation with temperature, so the MRF viscosity is affected. As the MR dampers performance is related the MRF viscosity so the dampers performance is also affected by the temperature [8].

vi. Packing ratio: The packing ratio has an effect on damping. Under transient excitation, as the number of particles increases, the impact effect dominates the friction effect up to 50% packing ratio, beyond which the friction effect dominates the impact effect for all locations of the particle impact damping. However, the amount of damping due to the friction effect is smaller than that of the impact effect; this is due to the low frequency range. Under forced excitation, the effective packing ratio can be between 25% and 50% depending upon the excitation frequency and magnitude of the excitation force [9].

vii. Material of piston: The use of magnetic piston gives the magnetization of both particles and pistons hence improve the damping efficiency until the magnetization saturates. If both the particles and pistons are free of magnetic hysteresis, their demagnetization can reverse the damping system to its original un-magnetized status; i.e. the entire system is reversible during the process of magnetization and demagnetization. As a result, the damping rate is predictable, which ensures well-characterized tunability. In contrast, for the case with a non-magnetic piston, the damping system achieves the highest efficiency when particles are not magnetized, and the efficiency decreases with increasing magnetization. Under the tip of the non-magnetic piston, a void forms whose size increases as magnetization increases and reduces the damping force and thus the efficiency.

viii. Shape of piston: The shape of piston also affects the performance of a magnetic damper. The pressure drop increases with increase in the velocity of the piston. Maximum pressure drop is observed in case of single stage with filleted piston end model. The model with filleted ends gives optimum pressure drop with respect to magnetic flux density as well as flow rate. This implies that higher loads can be carried by the damper even with a small capacity [10].

III. CONCLUSION

This paper focuses on various parameters that are important while designing various Damping systems such as Active, Passive and semi-active damping systems used in vehicle or other structures to minimize the vibrations. It can be concluded from above study is that input current has a significant effect on variations in amount of damping force in case of magnetic damping system.

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