DEVELOPMENT OF HIGH-EFFICIENCY SHOCK ABSORBERS FOR IMPROVED RIDE COMFORT IN FOUR-WHEELERS

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ABSTRACT

The energy source of vehicles is changing rapidly and significantly in recent years with the increase in renewable energy technologies especially in the case of electric vehicles (EVs). A smart solution has emerged in which the wasted energy in a vehicle's shock absorber is converted to an alternative energy for the cars themselves, and this is called an energy regenerative shock absorber. Whereas existing regenerative shock absorbers mainly focus on the methods of energy harvesting, there is no such regenerative shock absorber for use in extended range EVs. we present a novel high-efficiency energy regenerative shock absorber using super capacitors that is applied to extend the battery endurance of an EV. A renewable energy application scheme using regenerative shock absorbers for range extended EVs is designed and proposed for the first time. This system collects the wasted suspension power from the moving vehicle by replacing the conventional shock absorbers as these energies are normally dissipated through friction and heat. The proposed system consists of four main components the vibration of the suspension input module, transmission module, generator module and power storage module. The suspension vibration induced by the road roughness acts as the system excitation to the energy regenerative shock absorber. The vibration is then transmitted through the mechanical transmission module, which changes bidirectional vibration into unidirectional rotation based on gears and a rack to drive the generator module. The power storage module stores the regenerative energy of the shock absorber in the super capacitor, which is applied to the EV to improve the cruising mileage.

Keywords: *high-efficiency, shock absorbers, energy harvesting, electric vehicles*

INTRODUCTION

Shock absorber while traveling on roads surface vibration courses excessive vibration due to excitation in case renounce of spring in compression mode leads more stress is designed to absorbed vibration and shock coming from the ground or machines and dissipates kinetic energy into heat energy. This heat energy absorbed by the fluids inside the cylinder and piston of damper used in the shock absorber. Fluid for shock absorber is main research area for performance improvement in automobile applications. shock absorber tries to absorb all the forces coming on the from passenger and ground and at the same time tries to damp and reduced the spring oscillation and increase in comfort, safety, reliable and quality ride by reducing the amplitude of vibration instabilities. Shock absorber gives comfortable rides to passenger as rider which shock coming in the form of jerky and bounce motion from tire. Performance of twin tube Shock absorber is decided by Shock spring, valve of piston and cylinder and fluid inside the damper effects on changes viscosity temperature and damping force, flow velocity. Force transmissibility is the measure how the force gets transfer to the passenger at constant weight. So, by designing the new spring, and the piston valve and prepared good fluid efficient cluster have to decrease the overall transmissibility of designed shock absorber system.. The suspension also, to satisfy the damping value up to possible extent for the designed spring, with advent fluid used the vegetable oil as the main damper fluid with some of quantity of silicon oil in it. Shock Absorber Damper performance is decided by spring, piston cylinder arrangement of damper (Spring Mass-Dashpot) and Fluid inside the cylinder. Shock Absorber absorb the shock coming from tire and gives comfortable ride to the passenger (rider). Recently some investigations done on analytical modeling and optimal design of MR damper with power generation. Specially, they are capable of reversibly changing from a linear Newtonian fluid to a semi solid with in a fraction of the milli seconds and the yield strength of these semi solids controllable. No one in his study developed shock absorber damper to improve the performance of semi active suspension system and to optimize the MR damper parameter. Vehicle dynamic behaviour, ride comfort and tire-road contact are important parts of the design, construction and testing of a vehicle. Research in these areas of automotive engineering has been carried out by many authors in recent years. Some of the most comprehensive books and monographs are, and the main results and models described by their authors have been taken into account and used in this research work. Shock absorbers heat load and oil temperature are studied in the literature. There are no studies how shock absorber temperatures directly influence the vehicle ride comfort. The conditions under which the vehicles are operated depend mainly on four factors: vehicle load, road irregularities character, vehicle speed and ambient temperature. Oscillations of varying frequency and amplitude occur under these various conditions.

LITERATURE REVIEW

N Ramudu (2023) A SS, is a mechanical apparatus engineered to mitigate shock impulses and disperse kinetic energy. The function of is to absorb or dissipate energy. In a vehicle, it mitigates the impact of traversing uneven terrain, resulting in enhanced ride quality and increased comfort due to significantly diminished disturbance amplitude. When a car traverses a flat road and the wheels encounter a bump, the spring is rapidly compressed. The compressed spring will strive to revert to its standard loaded length and, in the process, will overshoot its typical height, resulting in the elevation of the body. The vehicle's weight will subsequently compress the spring below its standard loaded height. This then prompts the spring to rebound once more. The design of the spring in a SS is crucial. This project involves the design of a , incorporating a helical spring and a wave spring, along with the creation of a 3D model using CREO. Structural and modal analyses are conducted on the SS by altering the materials for the spring, specifically Spring Steel and chromium vanadium steel. The analysis is conducted by evaluating loads, bicycle weight, and configurations for one and two individuals.

Mr. SahilPatil (2022) This report provides an overview of recent research conducted on the SS of a Formula Student car. In any formula student race car, racing car, Baja vehicle, or other automobile, suspension plays a crucial part. The SS is largely employed to mitigate abrupt road shocks experienced by the driver. It is utilised to regulate longitudinal weight transfer, lateral load transfer, and to provide the precise feedback required by the driver. When constructing a SS, several aspects must be addressed, including centre of gravity, roll centre, camber, toe-in, and toe-out. The SS is optimised to enhance handling qualities. The aim of the article is to reengineer the SS of the FSAE vehicle in accordance with the revised chassis and engine configurations. design of the wheel assembly and SS components of a Formula-style race vehicle, along with assembly and simulation, utilising CAD tools like SolidWorks and simulation and analysis software such as Ansys. These systems experience various forces under both dynamic and static circumstances.

Qiping Chen (2021) This study examines internal configuration piston assembly to develop a superior vehicle. A high-precision flow grid model and a robust finite element model stacking valve are developed and evaluated utilizing fluid–solid coupling methodology. A bidirectional fluid–solid coupling method is presented for simulating and evaluating dynamic responses of a stack valve slice in a vehicle with Workbench software. The results indicate that maximum superposition valve slice is located at inner radius, whereas area of highest deformation is near the piston hole, exhibiting a maximum deformation of roughly 0.0636 mm. Upon the initial actuation of the stack vent plate, both the displacement and velocity plate will demonstrate a sudden alteration. The results computational analysis closely corresponds with test outcomes, indicating that bidirectional fluid–solid interface methodology is both precise and dependable for examining dynamic characteristics of vehicles. This holds considerable usefulness for optimum design of the inside valve system in automobiles.

Bharwad Jayesh Melabhai (2020) An independent wheel SS is currently employed in nearly all contemporary automobiles. The traditional approach employing dependent suspension is largely ineffective as it induces greater jolts in the vehicle's body. Typically, when a bump or obstacle encounters the vehicle, the SS mitigates the disturbance within the car. The dependent system is integrated with chassis and the vehicle's body frame. Consequently, with any abrupt movement, the vehicle's chassis confronts the disruption. In independent wheel vehicle suspension, the spring is linked to the wheel, effectively absorbing shocks and preventing any jolts in the automobile body. The research study included a concise literature review on the examination of the independent SS. Initially examined current suspension design according to established design protocols, followed by detecting design deficiencies using mechanism calculations. Utilizing CAD tools such as SolidWorks for investigation of a crucial component of independent suspension, leading to conclusions based on the results obtained.

Vehicle Suspension

It may be necessary to use stronger shocks than what would be optimum for the vehicle's motion alone in order to accomplish efficient wheel skip damping, as tires are more durable than springs. Although tensile shocks often make use of suspension bars, the most common types of spring-based protections are loop springs and leaf springs. Ideal springs do not act as protective devices since their only purpose is to store energy, not disperse or absorb it. Essential parts of every vehicle are the hydraulic dampers, rods for suspension, and springs. A "safeguard" is the part that is supposed to reduce and distribute vibration in this case. Tires, air in the tires, springs, , and connections all work together to allow the wheels of a vehicle to move relative to one another. This is called the SS. Although these two goals are inherently at odds with one another, SSs are necessary to strike a balance between road holding/handling and ride quality. When adjusting the suspension, it is essential to find the best setup.

Isolation from high frequency shock

As a rule, suspension components do not cause issues in the majority of applications. When the frequency increases because of road imperfections, the rubber bushings that are located between the parts serve as a multi-layer filter. The combination of the tires and springs greatly improves the setup's vibration and noise reduction capabilities. When the springs are arranged vertically, they work optimally.

Spring Seat Shocks

The spring seat design integrates components of both telescopic and strut systems. A spring seat shock functions as both a suspension element and a dampening device, similar to struts. In contrast to struts, they are not designed to withstand significant lateral loads. Spring seat shocks, constructed with components akin to traditional designs, are sealed and need extensive maintenance. Air friction dampening is generated inside an air chamber using a reciprocating piston. Upon the piston entering the chamber, compression occurs inside the chamber. Upon exiting the chamber, the piston experiences a force. Air friction damping is the most effective technique for reducing torque in environments with a relatively weak electric field. This results from the lack of electrical components in the air that diminish friction, possibly altering the electric field. The conversion of energy into another form, resulting in a reduction converts depends on the system and the physical processes involved in dissipation. In several vibrating systems, a considerable portion of energy is transformed into thermal energy.

Spring-damper system

The purpose of the automobile suspension is to separate the wheel motions from the movements of the vehicle chassis. The transmission of road surface irregularities to the vehicle chassis via the wheels must be minimised. To alleviate unwanted rattles suspension parts need suitable damping mechanisms. The oscillation and swaying of the vehicle's body significantly diminish driving comfort and safety. In the absence of a damper, the wheel would persist in oscillating when encountering an obstruction, resulting in a loss of traction. Nonetheless, the oscillation is designed to be reduced just during the spring's length. The spring's capacity must remain unchanged during compression. This function is executed by. The enhanced synchronisation of the springs and damping system optimises the equilibrium within ride comfort and road contact, hence augmenting driving safety.

METHODOLOGY

Silicon spring steel is designed specifically for applications requiring high strength, elasticity, and resistance to wear and fatigue. The addition of silicon enhances these properties, making it suitable for use in springs, leaf springs, and other high-stress components. Here's a detailed look at the material properties of silicon spring steel Silicon spring steel is a high-strength alloy with excellent hardness, elasticity, and fatigue resistance, making it ideal for demanding spring applications. Its mechanical properties are enhanced by the addition of silicon, which improves its performance under stress. However, it requires careful handling during fabrication and may need protective measures to mitigate corrosion.

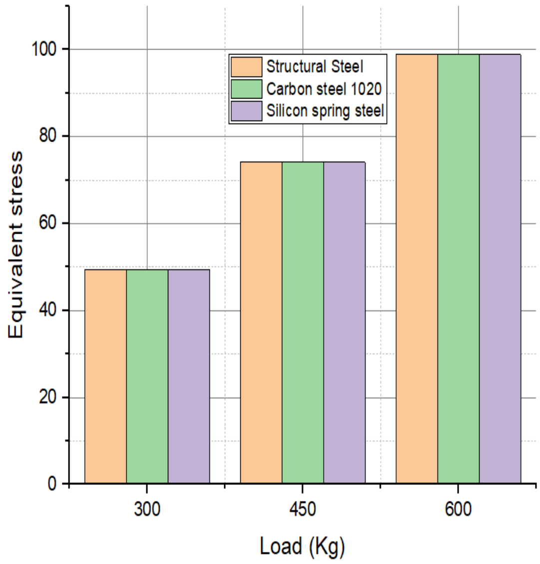
Solid Works: Solid Works is a powerful computer-aided design (CAD) software used for creating 3D models and 2D drawings. It is widely utilized in engineering, product design, and manufacturing industries for its versatility and ease of use. Here's an introduction to Solid Works modeling

RESULTS & DISCUSSIONS

Furthermore, the equivalent strain may facilitate the calculation of stress and strain inside the material, allowing for comparison with material characteristics to verify that the material is not experiencing excessive stress or strain. Silica spring steel has the largest relative strain under all loads, indicating that it possesses the lowest stiffness among the three steel kinds. This is anticipated, since silicate spring iron is often used in areas involving adaptability and tenacity.

Table 1: Equivalent stress of four wheeler at different load conditions

Load (Kg)	Structural Steel	Carbon steel 1020	Silicon spring steel
300	49.447	49.441	49.443
450	74.17	74.162	74.164
600	98.893	98.883	98.886

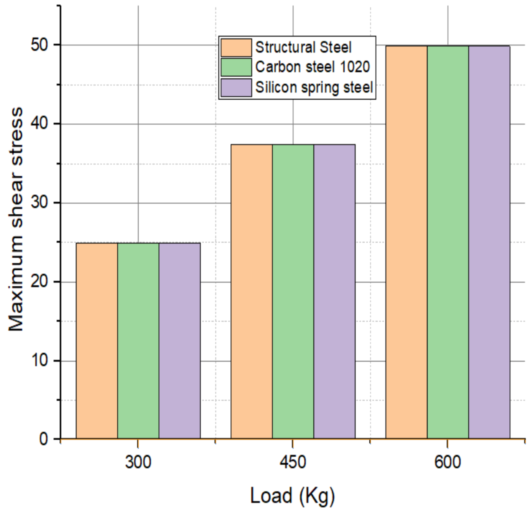


Graph 1: Validation of Equivalent stress at different materials

Authenticate the comparable stress outcomes by juxtaposing them with empirical data or conclusions derived from different analytical methods. Furthermore, the comparable stress may be used to calculate the stress and strain inside the material, hence facilitating a comparison with material properties to eliminate the likelihood of excessive stress or strain on the material.

Table 2: Maximum shear stress of four-wheeler at different load conditions

Load (Kg)	Structural Steel	Carbon steel 1020	Silicon spring steel
300	24.964	24.961	24.962
450	37.445	37.442	37.443
600	49.927	49.922	49.924



Graph 2: Validation of Maximum shear stress at different materials

The graph illustrates maximum shear stress of three different kinds of steel under varied loads. The maximum shear stress is shown on the y-axis, whilst the load in kilogrammes is depicted on the x-axis.

The graph presents the following principal observations:

Structural Steel: Structural steel has the highest shear stress under all loads. Of the three steel kinds, this one has the highest shear strength.

Carbon Steel 1020: The maximum shear stress of carbon steel 1020 is positioned centrally within the spectrum of structural steel and silicon spring steel. Under increasing load, its maximum shear stress increases more rapidly than structural steel but less rapidly than silicon spring steel.

Silicon spring steel has lowest maximum shear stress under all loads, making it the least shear-resistant three types of steel. This is expected, since silicon spring steel is often used in applications requiring flexibility and strength.

The graph indicates that the shear strength of steel varies with its composition. Structural steel has the maximum strength, followed by carbon steel 1020, and lastly, silicon spring steel.

CONCLUSION

In conclusion, Silicon Spring Steel is ideal material for high-performance and rigorous applications because to its exceptional fatigue resistance, high strength, and notable corrosion resistance. Carbon Steel 1020 offers an ideal balance of properties and cost-effectiveness for standard applications. Structural steel, although an economical option, may need additional safeguards against corrosion and fatigue. Thoroughly assessing the application's precise requirements may significantly impact the performance, longevity, and cost-efficiency via material selection. Silicon Spring Steel is the ideal material for applications, offering exceptional fatigue resistance, high strength, and notable corrosion resistance. Structural steel is inadequate for high-performance applications owing to its subpar strength and heightened deformation. Mechanical devices that distribute kinetic energy and reduce shock impulses are termed SSs. They may either absorb or dissipate energy. By reducing the amplitude of disturbances, it improves ride quality and comfort in vehicles, hence lessening the effects of navigating uneven surfaces. The spring swiftly compresses when a vehicle's wheels strike a bump on a level surface.

The body will rise compressed spring seeks to return to its original length, finally exceeding its typical height. The spring will be crushed under its usual loaded height as a result of the vehicle's weight. The spring is consequently pushed to regenerate. Repeatedly conducting the oscillation process lowers vertical movement control to an unacceptable level, resulting in an unpleasant experience and hindering vehicle manoeuvrability.

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