DESIGN AND DEVELOPMENT OF REGENERATIVE DAMPERS IN SUSPENSION

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Abstract: Each and every automobile in service or being developed in the industry is benchmarked on the basis of its efficiency in real time conditions. This setup is developed on a complete new damper and spring setup which can be used in all sorts of suspension systems and in turn provides a feedback loop of voltage which can then be used charge the batteries and upscale the efficiency of bikes by (5-6)% & and for HUV or Sedans by (2-4)% (can even go higher) depending on the terrain. In this setup we harness the mechanical energy into electrical where earlier it was left as heat and vibrational losses. This setup is as cost effective as the earlier dampers where as providing an efficient output in minimal cost increase due to its novelty. The other Features include Electronic height adjustment & on demand suspension softness or stiffness.

1. INTRODUCTION

The automobile Industry uses the basic principle of converting the stored energy into mechanical work. Here the stored energy can be in the form of batteries or any Fuel, but the core analogy is the same where the input energy to power output conversion process does not utilize 100% energy provided due to thermal & resistive loses depending upon the power terrain but there two main loses that can be rectified; The braking and vibrational loses which both convert the mechanical energy into heat and vibrations as "energy can neither be destroyed nor created".

This conversion of mechanical energy into other form is utilizable into the form of electrical energy and has been well developed and properly being used in the automobile industry for braking purposes, but no such analogy or setup has been developed for the shock absorbers being used in all sorts of mechanical and automobile applications.

So, in our project we have tried our best to harness the lost energy into useable form i.e., Electric voltage generated is used to recharge the batteries provided via the power terrain. The most common problem encountered with this type of setup is the voltage developed due to the vibrations of the shock absorbers is not efficient to create a voltage above 1.8V (maximum voltage). And this voltage produced is not even in a continuous supply these are pulse voltages which cannot be readily used to recharge the batteries, we use capacitors and LC alternators which would make the current supply unidirectional and pulses can be smoothened via the capacitors.

Even after such arrangements we don't get a feasible system to supply a constant voltage forth charging the whole Battery packs, thus now we now need to charge individual Cells of the battery at an optimum voltage of 1.2V industry standard range from (1.2 to 1.8)V cells in a battery pack thus the whole battery pack would be charged in parallel and when the turn comes for the Output voltage it is discharged in Series thus we get the best of both the worlds, This whole setup can be managed via the BMS (battery management system).

This whole setup is made on the principle of Lenz Law and, The Dampers are made such that instead of using high viscous oils we use a low viscosity Shocker Fluid (oil), and further provide the additional help in damping through the magnetic piston and copper wire coil windings with N no. of turns and this voltage induced in up and down movement is then further made to use through the electrical setup in cycles, as this motion is TO & FRO.

2. NEED OF DEVELOPMENT

In today's world the conventional energy sources used to move the automobiles and EVs all get their majority of power source from nonrenewable energy source and thus have (35-40)% in IC engines and above 85%+ in EVs thus we need to improve the efficiency by reducing the loses and so there is impudent market need to improve these powertrains as even with EVs they take a lot of electrical energy to move therefore we should use system where the maximum energy is utilized in work done.

3. LITERATURE REVIEW

As this is still a novel and in constant development initiative by the auto industry and researchers so not much of research data is available for the public as well many recent and ground breaking research has been done in China and that data is also hard to get.

So here we have described the history and the direction where the regenerative shock absorbers are heading by many brilliant minds;

In [1], Dr. Ahmad K, Alam M, their study emphasizes on the implementation of the energy present in the suspension system by replacing the Shock Absorber with a Energy transfer system Involving Hydraulic cylinder, Hydraulic Motor and Dynamo. The energy which is usually lost as heat due to

friction in conventional Suspension is used to drive a dynamo through Hydraulic System designed in this paper and electricity is generated.

This approach involves design and simulation of regenerative suspension system with specialized hydraulic device and comparison of the system with regenerative suspension system involving Rack and Pinion.

In[2], Jackowski Z, Bavetta R (2010), Anderson Z, he completed the same prospect via a complex assembly of Hydraulic fluid passing through an hydraulic motor to turn its shaft. The hydraulic motor shaft is connected to an electric generator to generate electricity. Flow characteristics of hydraulic circuits are selected to provide suspension system damping for appropriate wheel control. The regenerative shock absorber of the invention includes an hydraulic circuit arrangement so that energy may be harvested during both compression or relaxation of the shock absorber. In this embodiment, upon compression or relaxation of the shock absorber, the resulting pressure differential across the hydraulic motor will induce rotational motion of its output shaft. This output shaft is directly connected to a permanent magnet generator/DC electric motor. The wattage rating of the motor is selected entirely based on the vehicle's mass and spring stiffness.

In[3], Jackowski Z, Bavetta R (2013), Anderson Z According to another aspect, a regenerative shock absorber includes a shock housing that has a compression volume and an extension volume. A piston is disposed in the shock housing. In a first mode the piston moves through at least a portion of a compression stroke to pressurize hydraulic fluid in the compression volume. In a second mode the piston moves at least partially through an extension stroke to pressurize hydraulic fluid in the extension volume. The regenerative shock absorber also includes a motor/generator housing. A hydraulic motor is incorporated into the motor/generator housing and includes a first port, a second port and an output. The first port is in fluid communication with the compression volume and the second port is in fluid communication with the extension volume. An electric generator is at least partially internal to the motor/generator housing. The electrical generator coupled to the output in a manner that lacks seals associated with sliding friction. Hydraulic controls may be included to control fluid communication between ports of the hydraulic motor and the compression and extension volumes of the shock housing.

In[4], Dr. Yutaka Aoyama, Kazunobu Kawabata, Shinnichi Hasegawa, Yuji Kobari, Masaharu Sato and Eiji Tsuruta; they conducted their brief research in automated vehicle dynamic control and ride comfort actuation systems via Nissan developing a hydraulic active suspension which uses an oil pump as its power source to produce hydraulic pressure that negates external forces acting on the vehicle. As a result, the suspension system is able to control vehicle movement freely and continuously. This control capability makes it possible to provide higher levels of ride comfort and vehicle dynamics than are obtainable with conventional suspension systems. The major features of the hydraulic system include: (1) active bouncing control using a skyhook damper, (2) a frequency-sensitive damping mechanism and (3) active control over roll, dive and squat.

In[5], Dr.Cheng Cai Zhang*, Zheng Feng Jiang; Hydraulic electromagnetic energy-regenerative shock absorber (HESA) which used one permanent magnet synchronous motor (PMSM) as actuator to regenerate energy is introduced in this paper. Mathematic model which transform a three phase time and speed dependent system into a two co-ordinate time invariant system is presented. To obtain better dynamic performance, simulation models on a PMSM with field oriented control (FOC) have been carried out. Rapid torque response and stable dynamic performance are verified through the simulation results.

In[6], Avadhany, Shakeel N; This investigation seeks to investigate the relationship of kinematic fluid viscosity to the effective power transduction seen by a hydraulic motor. Applications of this research specifically relate to energy recovery from a vehicle suspension system through the shock absorbers. A regenerative, hydraulic- based, rotary shock absorber was designed and fabricated for the purposes of this investigation. The kinematic viscosities ranging from 100 cSt to 200 cSt were used in the fluid circuit and tested for maximal efficiency of the hydraulic system. Balance between shear-force losses in the fluid circuit, and effective transfer of momentum at the water-wheel type hydraulic motor demonstrates that optimized performance of the system is attained when a midpoint is reached in the kinematic viscosity of the fluid.

In[7], Dr.Oly D Paz; An electric shock absorber has been designed and analyzed to use in electric cars. It consists of a permanent magnet linear synchronous generator, a spring, and an electric accumulator. The electric accumulator consists of a controlled rectifier and a battery, and it was not evaluated in the present project. In the design calculations, the dimensions and performance parameters of the currently used mechanical shock absorbers were used as the reference. For this purpose, these shock absorbers were described first.

Five different structures of PMLSGs were studied qualitatively, and the version that best suits the operation within the shock absorber system was selected. This version was the next subject of the design calculation. It is the permanent magnet 3-phase linear synchronous generator with an internal secondary part, a slotted primary core, and a longer secondary side. The permanent magnets, which were applied, are made of a neodymium- iron-boron ($Nd - Fe - B$), produced by German Company Vacuumschmelze. The generator operates on 24 batteries via controlled 3-phase V rectifier. The designed spring that the generator operates was a hot-wound compression spring of Alloy Steel SAE 6150 Chrome Vanadium with closed and ground ends. The designed electric shock absorber was analyzed under steady-state conditions.

This allowed the determination of the performance characteristic (force- speed) that characterizes the conventional shock absorber. The results obtained from calculations indicate that the electric shock absorber has a linear characteristic. With the controller rectifier, the force-

speed characteristic can be modified and adjusted to the actual road conditions. The calculation results also show that a rated conditions, around % 40 of the oscillation energy can be converted into electrical energy that charges the battery. However, this parameter depends on the generator secondary part speed.

In[8], ; this team took the advantage of current situation and solved the problem of existing regenerative shock absorbers mainly focusing on the methods of energy harvesting, there is no such regenerative shock absorber for use in extended range EVs. In this paper, we present a novel high- efficiency energy regenerative shock absorber using supercapacitors 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 supercapacitor, which is applied to the EV to improve the cruising mileage. Higher efficiency up to 54.98% at most and 44.24% on average were achieved in the simulation and bench tests is proof that the energy regenerative shock absorber is beneficial and promising in generating energy used for renewable energy applications in extended range EVs.

WORKING PRINCIPLE

Voltage is taped using magnetic coil and further recharges individual super capacitors or battery pack charging in parallel and discharge in series, There is only two basic principle of magnetism & electricity as well voltage addition on which our project has been derived from;

1. ”According to Lenz's law, when an electromagnetic field is generated by a change in magnetic flux, the polarity of the induced electromagnetic field produces an induced current whose magnetic field opposes the initial changing magnetic field which produced it”.
2. The voltage across a system connected in parallel is same on each component of the system where as is series it gets divided or added depending upon the load or charge situation.

4. CONCLUSION

The main motive of our project was to make a feasible and reliable damper and spring setup that could be used in all sorts of automobiles from two wheelers to 16 wheelers, thus making it economically stable and improving the battery health as well available to the masses without any rare material setup. The Super Capacitor and Battery pack used in this setup is independent form the On Board Battery pack, So developing a system that can increase the efficiency of the automobiles especially in EVs as well reduce battery harassment and provide required power on demand, this system is most viable for countries having rough terrain and harsh climate conditions or developing roads.

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This and many other Chinese research are flooded with information and designs but cant be guaranteed with complete assurance due to their Chinese origin as no test reports and finding have been made on public servers so not worth mentioning, Beijing.

