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Generating of Power Suspension Shock Absorber

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ABSTRACT: *An electromagnetic linear generator and regenerative electromagnetic shock absorber is disclosed which converts variable frequency, repetitive intermittent linear displacement motion to useful electrical power. The innovative device provides for superposition of radial components of the magnetic flux density within a coil winding array. Due to the vector superposition of the magnetic field and magnetic flux from a plurality of magnets, a nearly four-fold increase in magnetic flux density is achieved over conventional electromagnetic generator designs with a potential sixteen-fold increase in power generating capacity. As a regenerative shock absorber, the disclose device is capable of converting parasitic displacement motion and vibration encountered under normal urban driving condition to a useful electrical energy for powering vehicles and accessories or charging batteries in electric and fossil fuel powered vehicles. The disclosed device is capable of high power generation capacity and energy conversion efficiency with minimal weight penalty for improved fuel efficiency.*

Keyword: *Shock Absorber, Linear Motion Electromagnetic System, Twin Tube Shock Absorber.*

I. INTRODUCTION

In the past decade, regenerative braking systems have become increasingly popular, recovering energy that would otherwise be lost through braking. However, another energy recovery mechanism that is still in the research stages is regenerative suspension systems. This technology has the ability to continuously recover a vehicle's vibration less energy dissipation that occurs due to road irregularities, vehicle acceleration, and braking, and use the energy to reduce fuel consumption**.** Consumption; however, only 10%–16% fuel energy in the vehicles is utilized for driving to overcome resistance from road friction and air drag. In addition to thermal efficiency and braking energy, one important loss is kinetic energy dissipated by shock absorbers.

The function of vehicle suspension system is to support the weight of vehicle body, to isolate the vehicle chassis from road disturbances, and to enable the wheels to hold the road surface. Two chief elements in suspension are spring and damper. Conventionally, damper is designed to dissipate vibration energy into heat to attenuate the vibration which is transmitted from road excitation. However, the dissipated heat is from fuel or electrical power. It is a pity that so much energy is wasted. Green manufacturing, also called environmentally conscious manufacturing, is one of the most popular topics nowadays.

The future of green manufacturing technology is foreseeable, especially on vehicle industry. Since the suspension is an important source of energy dissipation, it is feasible to harvest its vibration energy and convert into regenerative energy to improve the vehicle fuel efficiency. Therefore, so called regenerative suspensions arise as the times require. Instead of dissipating the vibration energy into heat wastes, the damper in regenerative suspension will transform the kinetic energy into electricity or other potential energy and store it for late use. The stored energy can be used to tune the damping force of the damper to improve the suspension performance or to power vehicle electronics to increase vehicle fuel efficiency.

II.SHOCK ABSORBER

A shock absorber is a mechanical device designed to smooth out or damp shock impulse, and convert kinetic energy to another form of energy (usually thermal energy, which can be easily dissipated). It is a type of dashpot. A shock absorber is a device which convert mechanical energy into thermal energy. The energy transformation occurs as the shock absorbers fluid medium is forced through orifice at high velocity.

2.1 DESCRIPTION

Pneumatic and hydraulic shock absorbers are used in conjunction with cushions and springs. An automobile shock absorber contains spring-loaded check valves and orifices to control the flow of oil through an internal piston. One design consideration, when designing or choosing a shock absorber, is where that energy will go. In most shock absorbers, energy is converted to heat inside the viscous fluid. In hydraulic cylinders, the hydraulic fluid heats up, while in air cylinders, the hot air is usually exhausted to the atmosphere. In other types of shock absorbers, such as electromagnetic types, the dissipated energy can be stored and used later. In general terms, shock absorbers help cushion vehicles on uneven roads.

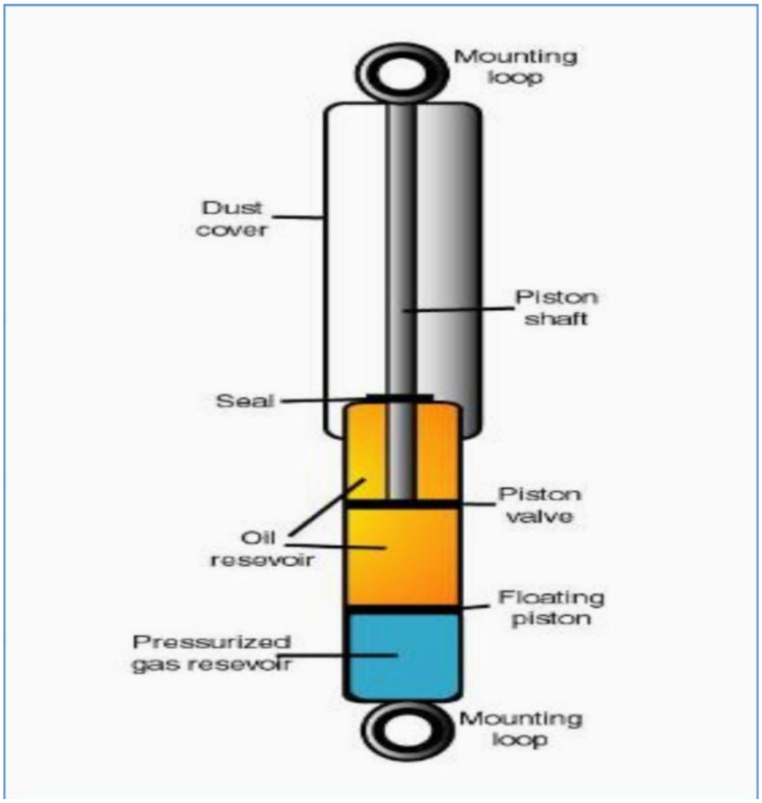

Figure 1. Shock Absorber

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2.2 VEHICLE SUSPENSION

In a vehicle, shock absorbers reduce the effect of travelling over rough ground, leading to improved ride quality and vehicle handling. While shock absorbers serve the purpose of limiting excessive suspension movement, their intended sole purpose is to damp spring oscillations. Shock absorbers use valving of oil and gasses to absorb excess energy from the springs. Spring rates are chosen by the manufacturer based on the weight of the vehicle, loaded and unloaded. Some people use shocks to modify spring rates but this is not the correct use. Along with hysteresis in the tire itself, they damp the energy stored in the motion of the un sprung weight up and down. Effective wheel bounce damping may require tuning shocks to an optimal resistance. Spring-based shock absorbers commonly use coil springs or leaf springs, though torsion bars are used in torsional shocks as well. Ideal springs alone, however, are not shock absorbers, as springs only store and do not dissipate or absorb energy. Vehicles typically employ both hydraulic shock absorbers and springs or torsion bars. In this combination, "shock absorber" refers specifically to the hydraulic piston that absorbs and dissipates vibration.

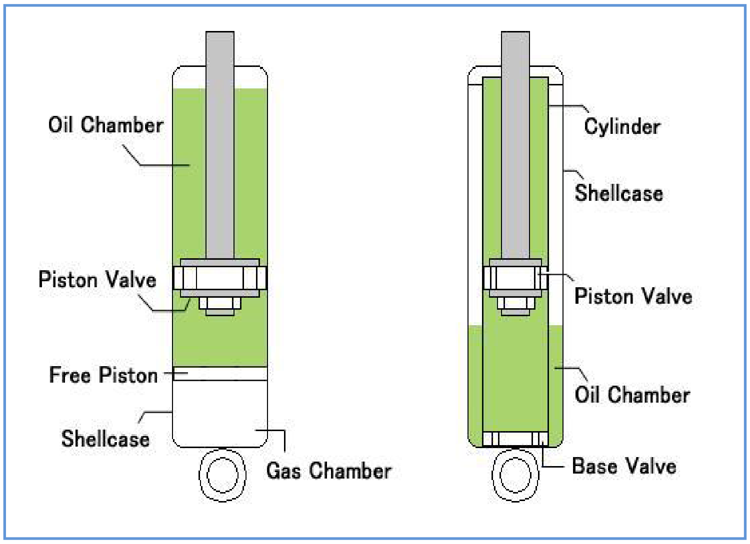

Figure 2. Mono Tube and Twin Tube Shock Absorber

2.3. Types of Shock Absorber

There are two types of shock absorber are given below.

A) Air Shock Absorber

B) Damper Shock Absorber

Air Shock Absorber

Air shock absorber consists of an air chamber, an iron piston and a fluid.

Damper Shock Absorber

A damper shock absorber consists of a single chamber or two chamber, it may be fluid field or filled with air. It is commonly used to absorb the shock during the linear motion of a vehicle.

i) **Mono Tube Shock Absorber**

ii) Twin Tube Shock Absorber

2.4 MONO TUBE SHOCK ABSORBER

The mono tube damper consists of single tube with two valves. It is mostly oil filled and used in larger vehicles. When the damper compresses when of the valve gets opened and when it extends the other valve gets open and the first one closes. The amount of the fluid released depends on the speed of the bumps it gets while moving. If it receives low speed small bumps the larger vents get opened and there is large amount of fluid is released. On the other hand if gets high speed strong bumps the smaller vent gets opened and a small amount of oil is released.

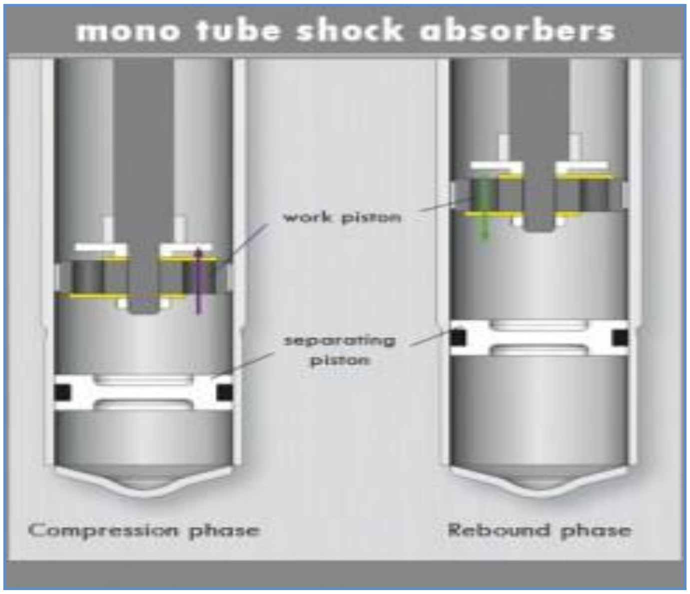

Figure 3. Mono Tube Shock Absorber

2.5 TWIN TUBE SHOCK ABSORBER

Also known as a "two-tube" shock absorber, this device consists of two nested cylindrical tubes, an inner tube that is called the "working tube" or the "pressure tube", and an outer tube called the "reserve tube". At the bottom of the device on the inside is a compression valve or base valve. When the piston is forced up or down by bumps in the road, hydraulic fluid moves between different chambers via small holes or "orifices" in the piston and via the valve, converting the "shock" energy into heat which must then be dissipated.

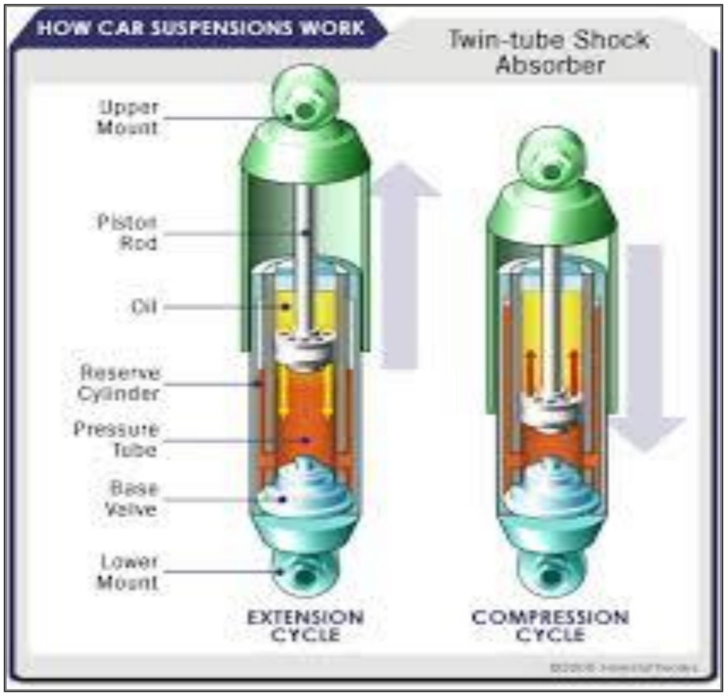

Figure 4. Twin Tube Shock Absorber

III. POWER GENERATING SHOCK ABSORBER

The Power-Generating Shock Absorber (PGSA) converts this kinetic energy into electricity instead of heat through a Linear Motion Electromagnetic System (LMES). The LMES uses a dense permanent magnet stack embedded in the main piston, a switchable series of stator coil windings, a rectifier, and an electronic control system to manage the varying electrical output and dampening load. The bottom shaft of the PGSA mounts to the moving suspension member and forces the magnet stack to reciprocate within the annular array of stator windings, producing alternating current electricity. That electricity is then converted into direct current through a full-wave rectifier and stored in the vehicle's batteries.

The electricity generated by each PGSA can then be combined with electricity from other power generation systems and stored in the vehicle's batteries to increase battery life. In non-electric vehicles the electricity can be used to power accessories such as air conditioning. Several different systems have been developed recently, though they are still in stages of development and not installed on production vehicles.

Figure 5. Power Generating Shock Absorber

3.1 Description

The mechatronic system we have chosen to model is Power-Generating Shock Absorber (PGSA) acting on an automotive chassis. The shock absorber will be used in conjunction with a spring to simulate one of the four suspension system of an automobile. When designing an automotive suspension system the key is to balance the ride of the automobile. More specifically, the suspension is meant to absorb the effects of an uneven driving surface and tilt/sway of the car.

However, excess energy loss occurs due to resistance in the damper fluid and compression of the spring. The PGSA converts kinetic energy into electricity through the use of a Linear Motion Electromagnetic System (LMES). As shown in the Figure 3.1, the absorber consists of a damper with permanent magnet stack that slide in and out of stator windings connected to two sliding blocks inside the damper casing.

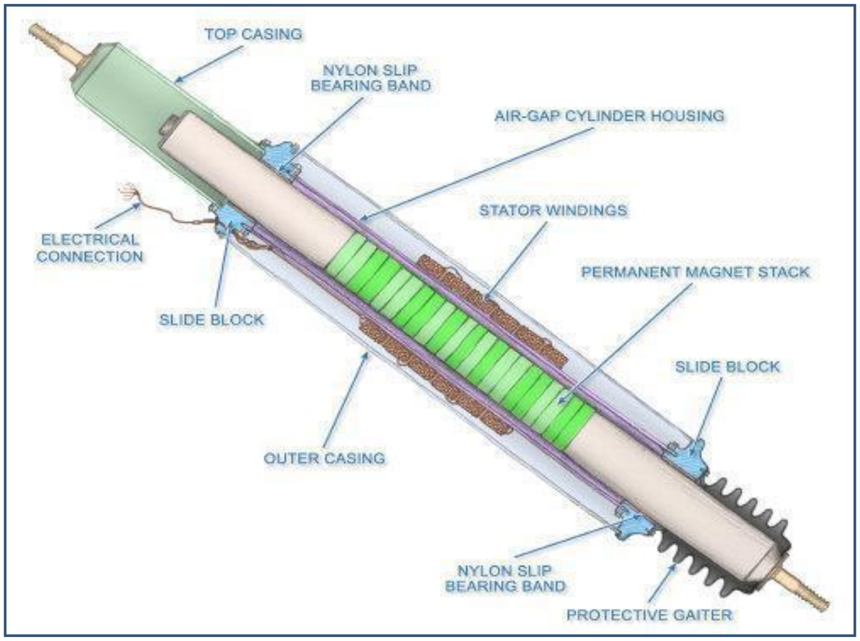

Figure 6. Example of Power-Generating Shock Absorber

3.2 Detailed view of suspension (spring + PGSA) Model

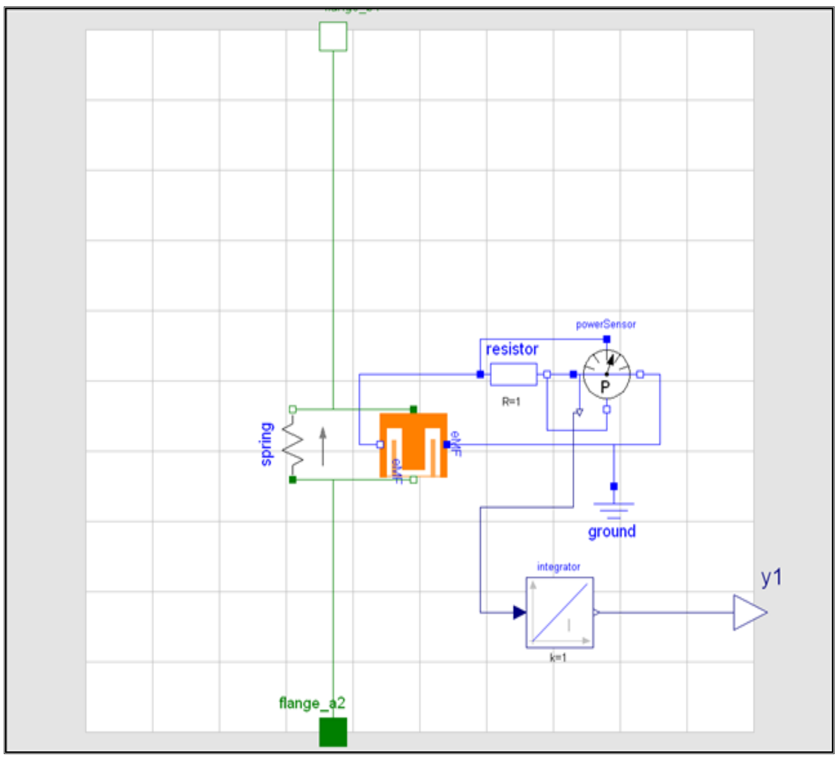

Figure 7. Detailed view of suspension (spring + PGSA) model

This model of a PGSA (Figure 3.2) uses a modified EMF. The EMF was converted for translational motion and installed opposite of the traditional application. A power sensor with an integrator measures the energy generated by the reverse linear motor. The model in Figure 3.2 is the strut-tower setup, so a spring was included to complete the model.

3.3 Model of entire car including four tires and entire suspension

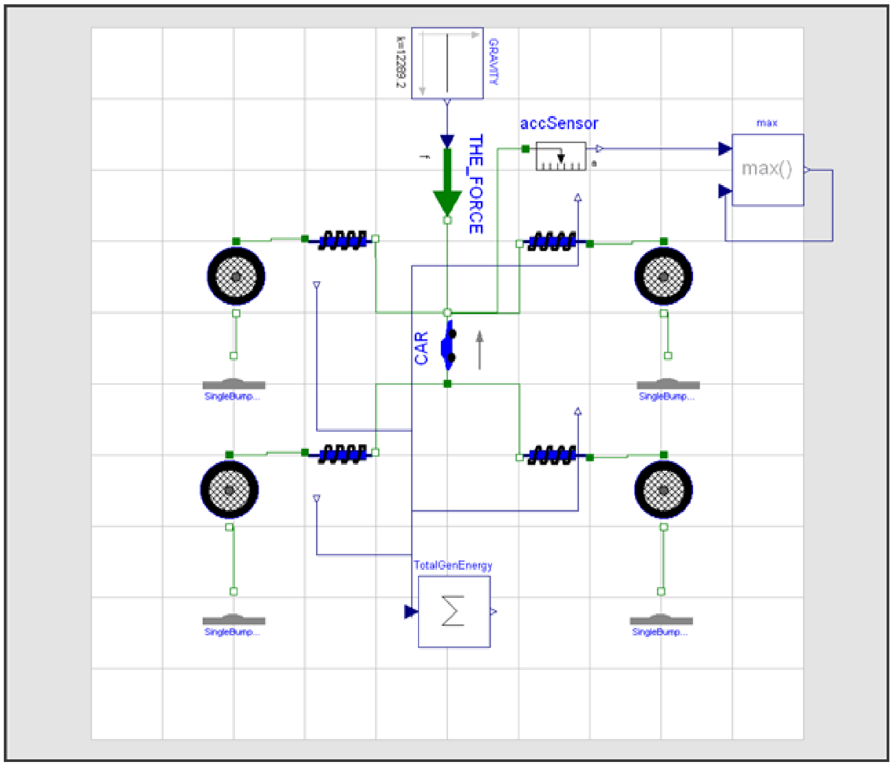

Figure 8. Model of entire car including four tires and entire suspension.

To accurately test our PGSA, we utilize four of the shock absorbers in a model of a traditional four-wheeled car (Figure 3.3). The electrical energy generated is the sum of the output from all four PGSAs. The ride quality in the car is characterized by the maximum vertical acceleration, taken by an accelerometer. The cost of the PGSA is calculated outside of Dipole in an Excel Spreadsheet. These objectives were analyzed in Model Centre.

3.4 Required Material for Construction

- Suspension systems which is a main part of assembly.
- An Electric motor which converts the magnetic effect into electricity.
- Four whell drive on which suspension system is assembled.
- Wiring of whole system through which electricity is being generated.

3.5 Construction

The LMES uses a dense permanent magnet stack embedded in the main piston, a switchable series of stator coil windings, a rectifier, and an electronic control system to manage the varying electrical output and dampening load. The bottom shaft of the PGSA mounts to the moving suspension member and forces the magnet stack to reciprocate within the annular array of stator windings, producing alternating current electricity**.**

3.6 Working

The Power-Generating Shock Absorber (PGSA) converts this kinetic energy into electricity instead of heat through the use of a Linear Motion Electromagnetic System (LMES).

Shock absorbers are installed between chassis and wheels to suppress the vibration, mainly induced by road roughness, to ensure ride comfort and road handling. Conventional rotational regenerative shock absorbers translate the suspension oscillatory vibration into bidirectional rotation, using a mechanism like ball screw or rack pinion gears. Figure 3.4 shows one such an implementation, where the rotary motion is changed by 90 degree with a pair of bevel gears for retrofit.

And electricity generated in this mechanism. That electricity is then converted into direct current through a full wave rectifier and stored in the vehicle's batteries.

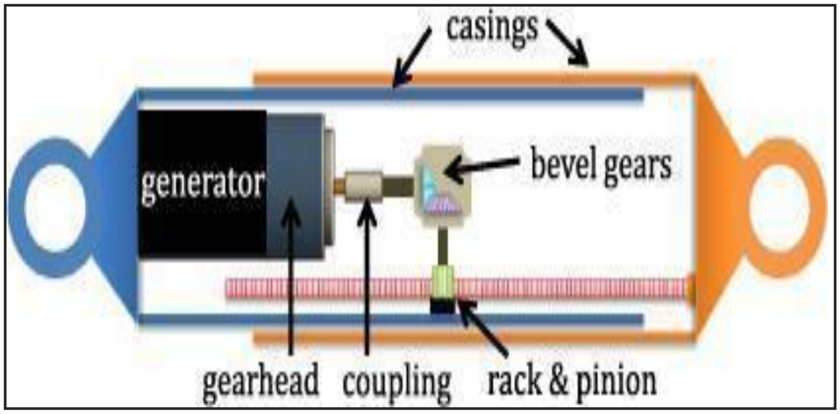

Figure 9. Traditional design of a rack-pinion based power generating shock absorber

The suspension system consist two types of cylinder. One have larger diameter and another have smaller diameter. When suspension is applied, the smaller diameter cylinder moves into the larger diameter cylinder which produces magnetic field due to repetition of movement of cylinders over coils. Then the electric motor converts the magnetic effect into electricity which is to be stored in battery.

3.7 Advantages

- Shock absorbers have a great for performance, handling and stability.
- They are best choice for work and severe use vehicles.
- High pressure gas mono tube design- 360psi to prevent aeration and shock fade. These have a lighter valving than the heavy duty units.
- Low pressure gas twin tube design- These units are good for average, everyday driving and a very good replacement for OE units.
- The "electricity generating suspension system" has a much higher energy yield than other known invention.

3.8 Disadvantages

- Problem occurred in collecting materials.
- Time consuming.
- Found some drawbacks of suspension system like rubbing in (LWV) light weight vehicles.
- In case of Induction Brakes, whole system can undergo failure because of electric motor.
- As whole system consist electric wiring so this may occur short circuit of system.
- This system consist a speed limit up to 35 km/h.

3.9 Application

Linear Motion Electromagnetic System (LMES) technology is already finding its place in ocean power generating systems. Its introduction into the automotive world is the next logical step. This technology can be applied to any type of vehicle that employs movable suspension technology and uses electricity in some form as its fuel.

To validate the given analysis and demonstrate energy harvesting from the shock absorbers, we carried out road tests using a Chevrolet Surburban SUV (2002 model). The experiment setup is shown in Fig. 4.1

Figure 10. Experiment Set of Suspension Shock Absorber

The displacement of the rear shock absorber was recorded by a laser displacement sensor from Micro-Epsilon with a sampling rate of 1000 points/s. The output voltage is recorded with a digital signal analyzer HP 35670A.

The road tests were conducted on the campus road of Stony Brook University, Stony Brook, NY, at different speeds, including 30 and 20 mi/h (or 48 and 32 km/h). The recorded voltages on an external electrical load of 30 Ω generated from the energy-harvesting shock absorber at these two vehicle speeds are shown in Figure , respectively. It is shown that the peak voltages were over 40 V. Correspondingly, the peak powers are 67.5–58.2W. The average power values are 4.8 and 3.3W, respectively, at 48 and 32 km/h (30 and 20 mi/h), or 19.2 and 13.2 W can be harvested on four shock absorbers at 48 and 32 km/h. Recall in Table I, we estimate 54.1- and 13.5-W energy dissipation on a local road at 48 and 32 km/h. The results from the road tests are encouraging, although the harvesting efficiency in road tests cannot be drawn from these values since the suspension vibration highly depends on the road conditions.

IV CONCLUSION

Conventionally, the vibration energy of vehicle suspension is dissipated as heat by shock absorber, which wastes a considerable number of resources. Power Generating Shock Absorber brings hope for recycling the wasted energy.

All types of Power Generating Shock Absorber, especially electromagnetic suspension, and their properties are reviewed in this seminar. From the perspective of comprehensive performance including vibration control ability, regenerative efficiency and application reliability, the configuration of hydraulic transmission and self-powered MR damper shows the best attraction. With improvement of technology, Power Generating Shock Absorber may become one of promising trends of vehicle industry.

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