Electricity Generation via shock absorber employing rack and pinion

Prof. Tushar Nikumbh, Lecturer in mechanical department. MIT Polytechnic Pune, tushar.nikumbh@mitwpu.edu.in

Prof. Naresh Choudhari, Lecturer in mechanical department. MIT Polytechnic Pune, naresh.chaudhari@mitwpu.edu.in

Garv Patel, Dept of mechanical engineering. MIT Polytechnic Pune, Garvspatel1@gmail.com

Piyush Zope, Dept of mechanical engineering. MIT Polytechnic Pune, piyushzope16@gmail.com

Maharudra K, Dept of mechanical engineering. MIT Polytechnic Pune, chinmaykamaneswami@gmail.com

Yash Gadave, Dept of mechanical engineering. MIT Polytechnic Pune, gadhaveyash02@gmail.com

Abstract - energy is the prime necessity of survival of each and every organism in the universe. Everything happening in the environmentis a result of the flow of energy in one or other forms. Energy can be converted into a number of forms that can be measured invarious ways. In this busy and fast moving world, population is multiplying continuously and the conventional sources of energy are getting exhausted at a great pace. The substantial usage of energy has led to an energy crisis over a few years. In order to overcome this problem, we need to execute the techniques of optimum use of conventional sources for conservation ofenergy. One such technique is explained here.

Keywords: Shock absorbers, Power generation, Rack and pinion, Electricity, Energy, Electro-mechanical unit, Non conventional sources, Kinetic energy, Mechanical energy.

I. INTRODUCTION

Because of rapid growth and improvement in technology, as well as an increase in the style of life, the number of automobiles on the road is rapidly increasing. This has resulted. This has resulted in a significant increase in energy consumption, waste generation, and other challenges such as environmental contamination. As a result, we must devise methods to conserve energy and non-regular sources to distribute it. EVs have recently gained popularity due to their lower energy consumption and lesser pollution. Yet, due of the inadmissible battery limit and constant quality, EVs are underutilized. When a vehicle is driven on any road surface, it experiences shocks as a result of road abnormalities. A suspension system is installed in a vehicle to dampen the relative movement between the wheels and the body of the vehicle, resulting in improved handling and comfort for the passengers. A typical suspension system consists mostly of a spring curl and a damper. A damper is a device that converts vibrations into heat and distributes it to the surrounding area. This dissipated heat energy is generated by the vehicle's fuel energy. As a result, a significant amount of fuel energy is squandered. A regenerative shock absorber can recover this lost energy. A regenerative shock absorber is a device that may

sufficiently lessen the shocks experienced by cars by converting the active energy from the shocks into useful electrical energy rather than dispersing it into dissipating heat energy. This important electrical energy may be stored in batteries for later use. It may also be used to boost the dampening capacity of the shock absorber or to run the vehicle's hardware to increase the vehicle's eco-friendliness.This priceless electrical energy can be stashed away in batteries for some time in the future. It may also be used to boost the dampening capacity of the shock absorber or to run the vehicle's hardware to increase the vehicle's eco- friendliness.

 DOI : 10.35291/2454-9150.2023.0080

II. REVIEW OF THE PRESENT STATE OF TECHNOLOGY

The diagram below depicts the basic technique for recovering dissipated energy using a regenerative shock absorber. A regenerative shock absorber is supposed to deliver three things: riding comfort, driving safety, and efficiency.

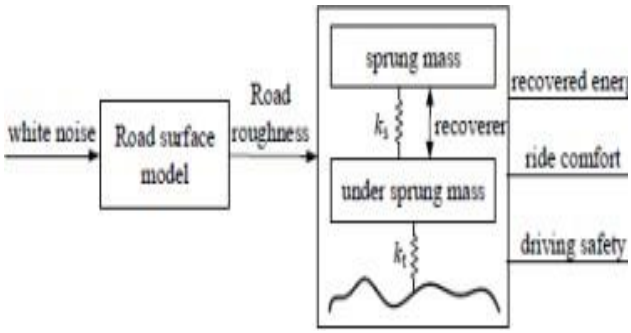

Figure 1.

Throughout three decades, researchers have been working to recover the active energy lost through the vehicle suspension system. There are several standards and architectures of regenerative shock absorbers accessible, all of which have been created by numerous experts.

We are utilizing a system in which regeneration is accomplished through the use of a rack and pinion gear arrangement that converts the reciprocating action of the shock absorber to the rotational motion of the dynamo or alternator.

As the shock absorber receives a shock from unevenness or bumps on the road, the rack with the pinion swings up and down, turning the pinion connected to a dynamometer or an alternator. Applicability, and how well they fit a coherent and balanced technical program.

III. ENERGIES INVOLVED IN THIS METHOD

Three types of energy are used in this conversion to create electricity.

A. Kinetic Energy

Kinetic energy is the energy that a body possesses as a result of its motion. The kinetic energy of a mass m movingat a speed v is 1/2 mv2. An object's kinetic energy is proportional to the square of its speed. The amount of an object's kinetic energy (scalar quantity) completely describes it.

B. Mechanical Energy

The energy connected to an object's motion and locationis known as mechanical energy. When an object is movingor when it is in a position of zero potential energy, it has mechanical energy. When work is done on an item, it gains energy. Mechanical energy is the energy obtained by the things on which work is performed.

C. Electrical Energy

Electrical energy is defined as energy that is stored in charged particles that are in an electric field. Electric fields are the regions or zones that surround these charged particles by enclosing them. Since charged particles create the electric fields, they also compel other charged particles to travel in the electric field.

Figure 2.

IV. MECHANISM USED

The rack and pinion mechanism is employed in the assembly. It turns rotational motion into reciprocating motion. The rack is the device that generates reciprocating motion, and the pinion rotates as a result of this reciprocating motion. The weight of the vehicle travelling over the speed breaker causes the rack to be shifted vertically, causing it to reciprocate (M. Ramadan et al, 2015). As the rack reciprocates, the pinion rotates. The rack is the flat, toothed portion, whereas the pinion is a gear.

Advantages of rack and pinion mechanism

- This unit provides excellent mounting ease.
- Gear losses are limited at 5%.
- The rack and pinion mechanism has an approximate efficiency of 95%.

V. EQUIPMENT REQUIRED FOR THE

A. Rack and pinion

A rack and pinion is made up of two gears that turn reciprocating motion into rotating motion and vice versa. The rack is the flat, toothed portion, whereas the pinion is agear (A. Kaur, et al, 2013).

 DOI : 10.35291/2454-9150.2023.0080

Figure 3.

B. Generator or Dynamo

It is a device which converts mechanical energy into electrical energy. For this energy conversion, the generator or dynamo uses rotating coils of wire and magnetic fields.

Figure 4.

Battery

It is a mechanism that stores the energy produced by the generator. The energy is stored in the battery as chemical energy (N. Kumar, et al, 2016). This energy can be used whenever it is needed.

VI. WORKING

Electricity generation via shock absorber employing rack and pinion with synchronous motor is a more advanced version of the system described earlier. The system uses a shock absorber, a rack and pinion mechanism, an electrical generator, and a synchronous motor.

The working of the system can be described in the following steps:

- The vehicle moves forward, and the shock absorbercompresses and extends as it passes over bumps and rough terrain.
- The shock absorber is connected to a rack and pinion mechanism, which converts the linear motion of the shock absorber into rotational motion.
- As the shock absorber compresses, the rack and pinion mechanism rotates the pinion gear, which inturn rotates the generator shaft.
- The rotation of the generator shaft produces electrical energy, which is then fed to a synchronous motor.
- The synchronous motor is a type of electric motor that is designed to operate at a fixed speed. It uses a rotating magnetic field to produce torque on the rotor, which causes it to rotate at the same speed asthe magnetic field.
- The rotation of the synchronous motor is synchronized with the frequency of the electrical energy produced by the generator. This allows the motor to convert the electrical energy into mechanical energy, which can be used to drive thevehicle.
- The mechanical energy produced by the synchronous motor is transmitted to the wheels of the vehicle, which provides additional power to theengine and reduces the fuel consumption.
- As the shock absorber extends, the rack and pinion mechanism rotates the pinion gear in the opposite direction, which produces additional electrical energy. This energy is fed back to the battery or used to power other electrical devices in the vehicle.

In addition to the steps mentioned earlier, there are some important components and features of the electricity generation via shock absorber employing rack and pinion with synchronous motor system:

- In order to achieve the synchronization between the generator and the synchronous motor, the system may include a power electronics converter that controls the frequency and voltage of the electricalenergy produced by the generator. The converter can also regulate the amount of electrical energy supplied to the synchronous motor.
- The synchronous motor may be connected to the wheels of the vehicle through a gearbox or a differential, which allows the motor to transmit the mechanical energy produced to the wheels at the appropriate speed and torque.
- The electrical energy produced by the generator can also be used to charge the battery of the vehicle, which can provide power to other electrical devices and systems in the vehicle, such as lights, air conditioning, and entertainment systems.
- The electricity generation via shock absorber

 DOI : 10.35291/2454-9150.2023.0080

employing rack and pinion with synchronous motor system can be combined with other energy harvesting and regeneration technologies, such as regenerative braking and solar panels, to further increase the efficiency and sustainability of the vehicle.

- The system can be designed to operate in different modes depending on the driving conditions and the power requirements of the vehicle. For example, the generator and synchronous motor may be used to provide additional power during acceleration or climbing hills, while the engine may be used for cruising or low-speed driving.

Overall, electricity generation via shock absorber employing rack and pinion with synchronous motor is a more efficient way to convert the kinetic energy of a moving vehicle into electrical energy and then into mechanical energy. This system can help to reduce fuel consumption and greenhouse gas emissions, while also providing additional power to the engine and improving theperformance of the vehicle.

VII. POWER CALCULATIONS

The amount of electrical power generated by the rack and pinion system is dependent on several factors, including thevelocity of the rack and pinion mechanism, the number of turns in the coil, and the strength of the magnetic field. Theequation for calculating the electrical power generated by the rack and pinion system is:

P = (B * l * v * N * A) / (2 * pi)Where:

P = electrical power generated (in watts)

B = magnetic field strength (in teslas)l = length of coil (in meters)

v = velocity of rack and pinion (in meters per second)N = number of turns in the coil

A = cross-sectional area of the coil (in square meters)pi = 3.14159

Once the electrical power is generated, it needs to be converted to a usable form. The efficiency of the conversion process depends on the type of inverter used andthe design of the synchronous motor. The synchronous motor's efficiency can be calculated using the following equation:

η = (Pout / Pin) * 100Where:

η = efficiency (in percent) Pout = output power (in watts) Pin = input power (in watts)

Overall, the amount of electrical power generated by this system depends on several variables and would require specific information on the system's design to provide accurate calculations.

VIII. ADVANTAGES

1) We can generate yearly electricity using this way without relying on other factors.

2) Electricity generation occurs in a reasonable and non-traditional manner, which helps to maintain conventional energy sources for our near future requirement.

3) Because no fossil fuels are used, power is created through renewable ways.

4) Energy generation with reduced pollution (A. S. Fawade, 2015).

5) Ease of building, established technology, and tupkeep.

6) This approach requires a smaller floor area and does not block traffic.

7) It is inexpensive and simple to install.

8) Because of its high efficiency and energy recovery requirements, this technology appears to be promising.

IX. CONCLUSION

Electricity generation via shock absorber employing rack and pinion with synchronous motor is a highly advanced technology that offers numerous benefits for vehicles in terms of fuel efficiency, performance, and sustainability. The system is designed to convert the kinetic energy of a moving vehicle into electrical energy, which is then fed into a synchronous motor to produce mechanical energy that candrive the wheels of the vehicle.

The system employs a shock absorber, a rack and pinion mechanism, an electrical generator, and a synchronous motor to operate. The shock absorber compresses and extends as the vehicle moves over bumps and rough terrain, and this linear motion is converted into rotational motion by the rack and pinion mechanism. The rotation of the pinion gear drives the generator shaft, which produces electrical energy that is then fed into the synchronous motor. The synchronous motor converts the electrical energy into mechanical energy that can drive the wheels of the vehicle, providing additional power and reducing fuel consumption.

The system is highly customizable and can be optimized for different types of vehicles, driving conditions, and power requirements. It can be combined with other energy harvesting and regeneration technologies to further increase its efficiency and sustainability, and can be designed to operate in different modes depending on the driving conditions.

In conclusion, electricity generation via shock absorber employing rack and pinion with synchronous motor is a highly innovative and efficient technology that has the potential to revolutionize the automotive industry. It offers

 DOI : 10.35291/2454-9150.2023.0080

numerous benefits in terms of fuel economy, performance, and sustainability, and can help to reduce the environmental impact of vehicles while also improving their overall performance and driving experience. With further research and development, this technology could become a standard feature in future vehicles, helping to create a more sustainable and efficient transportation system for generations to come.

X. FUTURE SCOPE

The use of shock absorbers and rack and pinion systems for electricity generation has the potential for several future applications and advancements.

One potential future scope for this technology is the use of regenerative shock absorbers in electric vehicles.

Regenerative shock absorbers would allow electric vehicles to recover some of the kinetic energy lost during braking and use it to generate electricity. This could help to extend the range of electric vehicles and reduce the need for frequent charging.

Another potential future scope is the use of this technology in low-power applications, such as powering sensors or other small electronic devices. These devices could be placed in areas where it is difficult or impractical to run electrical wires, and the shock absorber system could provide a sustainable power source.

Additionally, advancements in the design and efficiency of synchronous motors could help to improve the overall efficiency of this system. New materials and designs could help to reduce losses and improve the power output of the motor.

Finally, the integration of energy storage systems, such as batteries or supercapacitors, could help to store and release the electrical energy generated by the shock absorber system. This could help to smooth out fluctuations in power output and provide a more reliable and stable power source.

India is regarded as a developing nation and hence due to growing population, the needs will increase which will indirectly increase the consumption of electrical energy (A. K. N. Reddy, et al, 1994). Electricity can be produced from wide range of resources but however, their cost is commercially high and hence the concept proposed in this paper would be useful in future for electricity production as the cost forelectricity production is comparatively less.

XI. REFERENCES

[1] Pei S.Z., “Design of Electromagnetic Shock Absorbers for Energy Harvesting from Vehicle Suspensions”, Master Degree Thesis,
Stony Brook University, 2010.

[2] Segel L, Lu X P, “Vehicular Resistance to Motion as Influenced by Road roughness and Highway Alignment”, Australian Road
Research, 1982, 12(4), pp. 211-222.

[3] Browne A, Hamburg J. On road measurement of the energy dissipated in automotive shock absorbers[C]//Symposium on Simulation and Control of Ground Vehicles Transport. Syst. 1986, 2: 167-186.

[4] Yu C, Wang W, Wang Q. Energy-saving Potential of Energy Suspension Suspension for Hybrid Vehicles [J]. Journal of Jilin University (Engineering), 2009, 39(4): 841-845.

[5] Yu F, Cao M, Zheng X. Feasibility Study of Energy Reactive Vehicle Active Suspension[J]. Journal of Vibration and Shock, 2005, 24(4):27-30.

[6] Yu F, Zhang Y. Regeneration Active Suspension Technology[J]. Journal of Agricultural Machinery, 2010, 41(1):1-6.

[7] Nakano K, Suda Y, et al., “Application of CombinedType Self Powered Active Suspensions to Rubber- tired Vehicles”, JSAE Annual Congress, 2003, 6, pp.19-22

[8] H su P, “Power recovery property of electrical active suspension systems”, Proceedings of the Inter Society Energy Conversion Engineering Conference, Washington DC, USA: IEEE, 1996, pp. 1899-1 904.

[9] Kawamoto Y, Suda Y, Inoue H. Modeling of electromagnetic damper for automobile suspension[J]. Journal of System Design and Dynamics, 2007,1(3): 524-536

[10] Zhang W, Guo X, Fang Z. Experimental study on the energy
recovery potential of energy-feed suspension [J]. Vibration, Test & Diagnosis, 2015, 35(2): 225-230.

[11] X. Tang, T. Lin, and L. Zuo “Design and Optimization of a Tubular Linear Electromagnetic Vibration Energy Harvester,” IEEE/ASME Transactions on Mechatronics, vol.19, no.2, pp. 615 –622, 2014

[12] I. Martins, J. Esteves, G. D. Marques, and F. P. da Silva, “Permanent-magnets linear actuator applicability in automobile active suspensions,” IEEE Transaction on vehicular technology. vol. 55, no. 1, pp. 86-94,2006.

[13] Jones W., “Easy ride: Bose Corp. Uses Speaker Technology to Give Ears Adaptive Suspension”, IEEE Spectrum, 2005, 42(5): 12-14.

[14] J. Prudell, M. Stoddard, E.Amon, T. K. A. Brekken, and A. von Jouanne, “A permanent-magnet tubular linear generator for ocean wave energy conversion,” IEEE Transactions on Industrial Applications, vol. 46,no. 6, pp. 23922400, 2010.

[15] CENTROID Servo Motor Dimensions. (2013, Jun.). [Online]. Available: www.centroidcnc.com/servo-dimensions.html

[16] X. Lin and G. Xuexun, “Hydraulic transmission electromagnetic energy-regenerative active suspension and its working principle,” Int. Workshop on Intelligent Systems and Applications, pp. 1-5, 2010.

 DOI : 10.35291/2454-9150.2023.0080