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Design and fabrication of portable device for power generation from suspension system of two wheelers

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ABSTRACT

From ancient period to present transportation has played a very important role lots of advancement in technologies is being taken place so far and many of new researches are undergoing to increase the performance of the transportation facility. The wheel from the past taken a shape of vehicle and vehicle in present engineers are always looking for a way to make vehicles such as cars, bikes, buses more convenient for transportation but several experiments has been done so far just to increase the efficiency of engine so that the vehicles can be fuel efficient. Everything has been done now researches are being going to recover the energy losses during operation of vehicle and one of the way is to reduce the frictional losses because frictional losses are undesirable and unwanted and cannot be zero at any condition hence there are several ways to recover this frictional losses and convert it into useful energy. One of the ways is to use this frictional energy from suspension system and convert it into useful energy. Our aim is to fabricate a device which will be capable of generating electricity from vehicle shock absorbers using mechanism of rack & pinion arrangement with dynamo motors hold in position with aluminum angle bar. As shock absorber compressed and released when the sudden shocks or pod hole or uneven surface comes in contact with the tyre it gives bumps and tends to move the front fork shock absorbers inward The device is connected to the front fork shock absorber so that when the vehicle is over a bump it will move the racks on the down side and the pinions are mounted on the shaft of the motor and meshed with the racks the motor will generate electricity and voltage which can be measured with multimeter. And the process continues and electricity production cycle will repeat this produces energy can be used to luminate the headlights, taillight, horn, indicators, operating windows, charge the battery.

Keywords- Suspension system, Dynamo, Rack and pinion.

INTRODUCTION

As number of vehicles over the past few decades has increased and the increase of clean energy demand, the energy dissipation of a vehicle on different parts has been investigated. The suspension system is one of the most important components of a vehicle. It consists of tires, springs, linkages, shock absorber, struts, and other parts according to the specification of the vehicle. A shock absorber is a part of the suspension system that is 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 by the fluid inside shock absorbers). Ideally, a shock absorber is a damper that is designed to damp shock impulses generated in a moving vehicle. On application, the shock absorbers of a vehicle undergo linear movements that are otherwise not utilized as such. The idea of saving energy came into light from the 20th century. Since then the concept of energy efficiency has gained attention in the automobile industry. Therefore, unlike traditional energy-regenerative suspension, which can only absorb vibration passively, the energy regenerative suspension system is being introduced which can be used to store in the form of electrical energy.

A regenerative suspension system can be used in the suspension assembly to attenuate or eliminate the energy generated by the excitation vibration in the vertical direction. This system can be used to convert mechanical energy into electromagnetic energy through a rack and pinion mechanism, and the electromagnetic energy is stored by energy storage elements, which can reduce vibration and recover excess energy. After extensive research of over 40 years, the system has been introduced in hybrid and pure electric vehicles, and it greatly improves fuel economy as a whole. Considerable research has been conducted on the energy recovery potential of vehicle suspension.

However, the specific value of energy recovery differs. For example, [1] indicated that the energy recovery of the entire vehicle suspension system is only 46W, whereas [2] reported that the energy of 7500W can be recovered in the suspension of a passenger vehicle. Therefore, the amount of energy that can be extracted follows the type of setup that is used. This paper relates to the idea of developing a suspension based kinetic energy recovery system that uses a simple rack and pinion assembly to convert the reciprocating linear motion of the suspension and into rotary motion, which can be used for generation of electricity via a generator. Recently, regenerative shock systems caught the eye of the many researchers due to the potential to reap dissipated energy, thanks to its feasibility and accessibility. Large amount of energy is released by the road vehicles due to the undesired vertical motion caused due to bumps, and far of that's dissipated in conventional shock absorbers as they dampen the vertical motions. A conventional automotive shock dampens suspension movement to supply a controlled action that keeps the tire firmly on the road. This is done by converting the K.E. into heat , which is then absorbed by the shock's oil. Kinetic energy of an oscillating object is converted to electrical energy by an electric shock absorber. In a conventional mechanical shock absorber this kinetic energy is dumped in the form of thermal energy. According to the studies only 10 to 16 percent of the available fuel energy is used to drive the vehicle i.e. to overcome the air drag and road friction. Along with the engine cycle efficiency one important mechanism is the dissipation of kinetic energy due to undesirable vibrations and vertical motion of the vehicle [3]

OBJECTIVE

1. To study existing solutions and theoretical papers available on the internet.
2. To fabricate a model which can directly produces energy from shock absorber damps or bumps.
3. To build budget friendly or low cost model that will be solve the existing current problems as standard as possible.
4. To fabricate electricity generator device from shock absorber damps from locally available materials.
5. To experiments and analysing our proposed model on different road conditions and performance evaluation.
6. To evaluate the performance of our fabricated device with actual trails on vehicle shock absorbers.
7. To fabricate a device using our proposed idea which will recover waste energy during frictional movement of shock absorber system and convert it into electricity.

METHODOLOGY

a) Study of existing solutions given by authors in theoretical papers available.
b) Study of various methods used for waste energy recovery system from suspension system.
c) Experimentally determine the energy generating capacity of our model and comparing it with actual energy generated.
d) Manufacture energy generator from shock absorber suspension system.
e) By setting up our system in two wheeler front fork shock absorbers will carry out actual readings for various road conditions & then compare the results of both Theoretical and actual readings with our device. The broader significance of this study lies in enhancing the recovery of waste energy in during damping in suspension system.
f) Our system will consist of four Brushed Dc 12v motors connected in series with pinion mounted on motor shaft moving over fixed rack when the displacement in shock absorber is achieved on road bumps while riding the vehicle.
g) All the components of the project will be mounted on angle bars with nut and bolt

LITRETURE REVIEW

In the paper titled " A Review on Energy-Regenerative Suspension Systems for Vehicles", the authors Zhongjie Li, Lei Zuo*, JianKuang, and George Luhrs , WCE 2013, July 3 - 5, 2013, This paper deal with mechanical motion rectifierwhich convert the oscillatory vibration into unidirectional rotation of the generator.[5]
In the paper titled " Power Generating Shock Absorber ", the authors Meghraj P.Arekar , Swapnil Shahade Volume 4, Special Issue 3, March 2015: Designed 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). [4]

In the paper titled "Design of Electromagnetic Shock Absorbers for Energy Harvesting from Vehicle Suspensions", the authors Pei Sheng Zhang 2010: This paper discussed about the different type of suspension system. Also the rank and pinion arrangement in vehicle suspension. [13]

Rahul UttamraoPatil, Dr. S. S. Gawade, "Design and static magnetic analysis of electromagnetic regenerative shock absorber" This paper discusses electronic equipment systems are precision system. There are some vibrations and impact in moving vehicles for road environments..[6]

Ravindra Bhoite , Somanath Jadhav , Akshay Jape , Vikram Phadatare , Amardip Jadhav "Energy Generation by Suspension System 2015" In this project they have developed a suspension energy generation unit by using rack and pinion method. It is less costly than the hydraulic unit. Here, when the suspension works, the rack is set moving in a reciprocating motion. Due to this, the pinion starts rotating. The rotation ofthe pinion is then amplifiedinto rotation of a higher rpm by using the gear box. At the end of gear box we have attached the generator which generates the electricity.[7]

R. B. Goldner and P. Zerigian with J. R. Hull, in "A Preliminary Study of Energy Recovery in Vehicles by Using Regenerative Magnetic Shock Absorbers"SAE Internationals 2001 set up a periodic road bump simulator test stand, This was in the form of a grinder that had one of its grinding wheels replaced by an aluminum disk which had a rounded, adjustable height, "bump". Which is a schematic of the test stand with a (non-optimized) model magnetic shock absorber is a permanent magnet to produce electricity.[8]

Chirangivee.K.R in "Design and Fabrication of Power Generating Shock Absorber" 2016 this device consists of two components in the form of piston and cylinder arrangement a hollow cylinder with surface coil assembly and a magnet assembly that uses vibrational energy from the vehicle's suspension to move up and down inside it to generate the electricity using shock bumps. [9]

Kashif Wani,"SUSPENSION BASED KINETIC ENERGY RECOVERY SYSTEM" November–December 2016 made circuit that works by picking up the signals from the suspension movement and convert it into electricity.[10]

Himanshu S. Rewatkar, Vicky R. Gedekar, Kunal L. Parate, "Power Generation by Using Suspension System",2017 In this project authors have to develop a suspension energy generation unit by using belt and pulley Here, The pulleys are mounted on the shaft of the DC motors. As the pulleys get rotated the shaft of the motors also get rotated which generate electricity. [11]

Suhail A. Wani, " Kinetic Energy Recovery System for Vehicle Suspension",2020 The authors regenerative shock absorber converts this kinetic energy into electricity instead of heat through the use of a Linear Motion Electromagnetic System. Shock absorbers are installed between chassis and wheels to suppress the vibration, mainly induced by road roughness, to compensate for bumpy roads and provide riding comfort. [12]

CONSTRUCTION

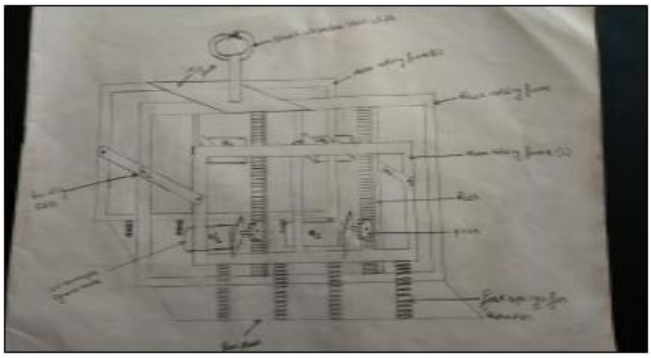

Fig. Construction of project model

1. The proposed model consist of four 12v DC brushed motor with 10000 RPM connected in series and the pinion is connected on the shat of the motor. The motor is hinged on the angle bars with the help of the motor holder elbow with nuts and bolts.
2. The model consist of three angle bar frames on which two frame hold motors and the third one holds the racks in position meshed with the pinion mounted on motors shaft.
3. The guiding slit or metal strip are used to hold the four motor mechanism frame in position from both side.
4. The front fork springs are attached to the motor frames to adjust the the height according to the displacement height during actual working condition and using spring force to back on original position when displaced down due to the bump.
5. The mechanism holding cup clips are fixed on the top and bottom of the frames to be actually fixed on the shock absorbers.
6. The sprigs are hinged on the metal plates shown as base plate and top plates.

WORKING

When the sudden shocks or pod hole or uneven surface comes in contact with the tyre it gives bumps and tends to move the front fork shock absorbers inward and hence motion is linear direction achieved. The device is connected to the front fork shock absorber so that when the vehicle is over a bump it will move the racks on the down side and the pinions are mounted on the shat of the motor and meshed with the racks the motor will generate electric and the springs attached to the motor frames are also pushed in opposite direction causing it to contraction and the energy stored in the spring will take the mechanism back to its original position voltage which can be measured with multimeter. And the process continues and power production cycle will repeat this produces energy can be used to luminate the headlights, taillight, horn, indicators or charge the vehicle battery.

DESIGN AND CALCULATIONS

Power calculations

1. The use of 12V motor is being done in the project (4) quantity in series connection to charge 12V battery for voltage required in series connection
   Vs = v1+v2+v3+v4
   = 12+12+12+12
   Vs = 48V
   But in actual practice the Vs is the voltage required to run 4 motors in series.
2. The rpm of motor is 10000rpm and maximum operating ampere is 10amp/hr
   So, Unit watt consumption = V x I
   Bg = 12 x 10
   = 120 watt/hr
3. The battery in the automobile are commonly vary from 12V 5amp to 12V 25amp in case of four wheeler the capacity of battery for 2 wheeler is (V x I)
   Capacity = 12 x 5 (Assuming 5 amp battery)
   = 60watt/hr
4. Assuming that the four series motor system generates 2V in one actuation & 0.1amp
   Capacity = 2V x 0.1 amp
   = 0.2 watt per actuation on road bump
5. Assuming case of power generation capacity if shock absorber come across 40-30 shocks or bumps the power generation would be actual during Breaking, Acceleration, Speed breaker and sudden shocks.
   Probably vehicle would come across 80-100 bumps so power generation would be Pgb = 0.2 x 80 = 16 watt will be generated.
6. So time required to charge the 2-wheeler batter would be

$$\frac{Bg}{Pgb} = 120/16$$

= 7.5 hrs

So the system almost takes 7.5 hrs or 1600 bumps or shock to charge the battery to full capacity.

TESTING AND RESULTS

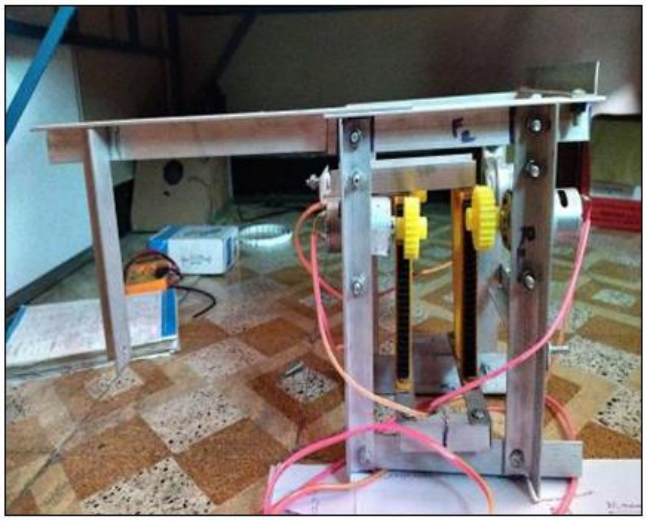

Fig Actual project

The actual project consist of four 12V motors connected in series with rack and pinion mechanism which tends to move linearly when subjected to shock or bumps the mechanism is connected to bike with shaddle. The rack is attached to the movable part of the shock absorber which tends to move and and pinions are stationary in position hence meshing and movement of rack and pinion mechanism.

Mounting of project mechanism

Fig Mounting of project

RESULT TABLE

Sr. no	Pitch movement of shock absorber in cm	Power generated in volts	Load on vehicle in Kg
1	2	0.12-0.20V	80
2	4	0.25-0.30V	80
3	6	0.45-0.50V	80
4	8	0.54-0.69V	80
5	10	0.72-0.92	80
6	12	0.92-1.08V	80
7	Full length	1.2-1.5V	80

Fig Testing result of low pitch moment

RESULTS

During testing it has been observed that the average power generation rate is 0.5V per shock or bump.

1. The rate of power generation depends upon the pitch moment of shock absorber and no of shocks or bumps come across vehicle.
2. The rate of power generation depends upon the depth of bumps or shock pods it has been observed that the higher will be the depth of shocks or bumps faster the power generation.

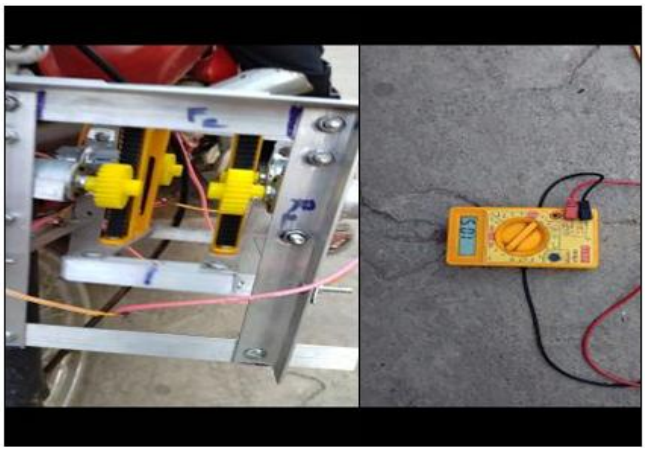

Fig Testing result of high pitch moment

3. The maximum voltage generated is 1.5V on the total length of the rack and pinion and 0.1-0.2V on the minimum move of the shock absorber.

ADVANTAGES

a) The device is comparatively efficient and stores electric energy in battery of the vehicle.
b) Shock absorbers play a vital role in stability and handling of the vehicle hence it does not imparts the handling and stability of the vehicle.
c) It has no maintenance cost.
d) The "electricity generation from suspension system" is much more flexible than other energy recovery techniques.
e) It is easy to implement like no kind of skill is necessary to attach the mechanism to vehicles.
f) Light in weight as aluminum is used in fabrication.

DISADVANTAGES

a) Complicated manufacturing process.
b) Not applicable for all types of two wheelers shock absorber system.
c) As the system take some extra space while installation so vehicle needs to be operated under certain speed limit.
d) This project contains lot of implementation and use of wiring hence a small mistake can damage electronic circuitry.

APPLICATIONS

a) This device can be implemented only in moving suspension technology systems and preferable for electric vehicles as it is successfully tested on electric vehicles.
b) This device in pairing with other techniques such as energy generation from braking system also implemented to increase the vehicle performance.
c) Commercial vehicle loaded with heavy weight are most preferable as a small deflection of suspension can generate large amount of electricity.

CONCLUSION

We conclude our project, from the testing results it has been observed that the average power generation from the bump or shock is 0.5V for heavier shocks it generates voltage ranges from 1.2V to 1.5V the testing has been carried out on the road bump or road shock pitch depths independent of load applied and vehicle suspension energy

generation is very efficient and useful in converting the kinetic energy from the movement of the vehicle, especially the suspension, which usually goes waste, to electric energy that can be used to fulfill needs of the auxiliaries in the vehicle. Currently the batteries of automobiles are charged by specific alternator which is attached to IC engine shaft. So that the fuel used in automobiles is also consumed for rotating the alternator to charge the battery this consumption is found to be 4% of total consumption. By newly designed suspension, If we install this regeneration system on both wheels then we can generate high amount of electric power. This high amount of electric power can be used for the working of Tail light, Head light, Indicators or Horn of vehicles. This suspension system will be mostly useful for two wheeler. During testing of project it has been also observed that for a small number of teeth of gear we can get the maximum voltage and current.

FUTURESCOPE

In future this technique can be implemented as a rotary permanent magnets sets inside shock absorber system considering the weight of the bikes.

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