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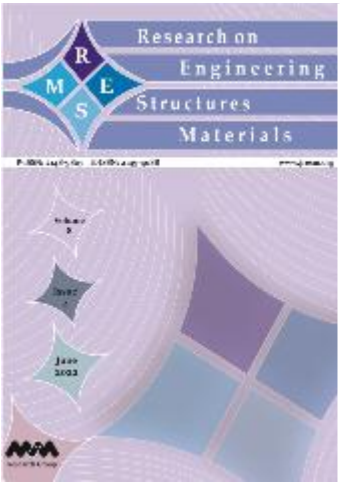

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Online Publication Date: 5 March 2023

URL: http://www.jresm.org/archive/resm2022.589me1212html

DOI: http://dx.doi.org/10.17515/resm2022.589me1212

Journal Abbreviation: *Res. Eng. Struct. Mater.*

To cite this article

Behara NSR, Rao PS. Vibration energy harvesting using telescopic suspension system for conventional two-wheeler and EV. *Res. Eng. Struct. Mater.*, 2023; 9(3): 687-707.

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Research Article

Vibration energy harvesting using telescopic suspension system for conventional two-wheeler and EV

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Article Info

Article history:

Received 12 Dec 2022
Accepted 27 Feb 2023

Keywords:

Mechanical Vibrations; Electric Vehicles; Energy harvesting; telescopic Suspension system; Air pollutants; Electronic devices

Abstract

Energy harvesting (EH), a fairly recent technological advancement, is the technique of capturing and converting environmental energy sources—such as load, mechanical vibrations, temperature changes, light energy, wind energy, and so on—into extremely small amounts of power within a specified voltage range. When there is no accessibility to conventional power sources, energy harvesting is employed to power electronic devices. In addition to reducing vibration brought on by road imperfections, an energy-harvesting telescopic shock absorber can collect energy that would otherwise be wasted in suspension vibration. It can act as an energy generator as well as a controlled damper. In order to increase the effectiveness of energy harvesting, this research indicates analyzing and testing a telescopic shock absorber structure that has the benefit of lowering spring vibrations and resisting unneeded spring motion. Focusing on energy harvesting and vibration analysis in shock absorbers is the main objective of this effort. The first telescopic suspension system, which consists of a spring, rack, and pinion, was created using Solid works 20 and then every portion was examined using Ansys Workbench. The spring, rack, and pinion were then practically constructed on a two-wheel bike using a rack and pinion mechanism that was created using 3D printing technology, and testing was then done to determine how much energy was harvested in terms of voltage in relation to the distance (in kilometers) travelled for different loading conditions observed how the voltage can be harvested for conventional two-wheeler and Electric Vehicle. Throughout the observation we found that the vibration harvesting in Electric bike is low compared to Conventional bike. Finally, the unwanted vibrations were harvested and boost up, stored in 5V, 12 V rechargeable dead battery which is used to recharge the mobile phone and low power electric devices.

1. Introduction

Automobiles have long been utilized as a form of transportation around the world, but their usage of exhaust gas and gasoline has resulted in environmental problems. Automobile technologies for environmentally friendly cars, such as electric and hybrid cars that use electric energy to alleviate this environmental problem, are actively being developed. Fuel economy improvements are always a focus. Energy lost by shock absorbers is a significant source of power recovery since only 10–16 % of energy production is required to actively propel cars and trucks through road friction with air drag [1]. Recent research [2] show that vehicle suspension significantly affects fuel efficiency. Regenerative shock absorbers were already developed for more than 20 years to make up for the kinetic energy lost by conventional oil shock absorbers. The two groups of regenerative vehicle shock absorbers, the subject of several investigations, can be split into two categories. The power from the relative linear movement of magnetic with coils is produced by the first, which is founded on a novel linear generating architecture. The

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DOI: http://dx.doi.org/10.17515/resm2022.589me1212

second type uses rotational permanent magnetic DC or AC converters to transform linear suspension vibration into oscillatory spinning in contrast to linear regenerative shock absorbers. Examples of mechanical mechanisms include the hydraulic transmission, ball screw, with rack and pinion.

Up-and-down suspension vibrations are transformed into bi-directional electricity generating vibrations by the rotating energy recovery absorber, which then generate power. Due to the availability of low-cost, off-the-shelf rotary rotors, they seem to be more affordable but also small. However, the unequal oscillation of the motion machinery leads to a number of problems, such as inadequate mechanical durability with subpar vibration effectiveness. For instance, even with active control at high frequency above 7–10 Hz [7,8], the ball screw mechanics investigated in [3-6] have outstanding power density, however the absorbers are too rigid to regulate at high frequency because to significant motion inertia. As a result, ride comfort is reduced. To power automobile electronics or recharge battery, the voltage should be commutated through an electrical rectifier, as the forward voltage of the diodes has a permanent impact on the circuit's effectiveness. Minimizing vehicle energy losses is necessary for increasing fuel efficiency, reducing pollutants, and fulfilling the power requirements of other systems [9–11]. In addition to improving engine and powertrain efficiency, we may recover energy lost in automobiles by recovering wasted heat 3energy [12–14], regenerative braking energy [15–17], including vibrational energy on shock absorbers [18, 19].

Although contemporary regenerative shock absorbers may recover a significant proportion of vibration energy, there are several downsides to replacing conventional shock absorbers entirely. Various elements in regenerative shock absorbers continue to pose problems for researchers. Regenerative shock absorbers can be improved by focusing on the two major issues listed below. For starters, regenerative shock absorbers are often inefficient and perform poorly in comparison to traditional shock absorbers. Second, the uses of recovered energy must be thoroughly investigated. Previous research proposed a regenerative shock absorber using a pair of gear rack structures to achieve high efficiency and apply to range-extended EVs [20]. Thus, we are using a different material for increasing the efficiency of energy harvesting and shock absorbers. Our proposed approach therefore achieves greater energy harvesting with vibration analysis with shock absorbers. The paper's primary contribution is:

- The first telescopic suspension system, which comprises of a spring, rack, and pinion, was created in Solid Works 20. This was followed by an investigation of several shock absorber materials in Ansys Workbench.
- A rack and pinion system that was modelled using 3D printing technology was used to test the telescopic shock absorber on a two-wheeler and make a comparison.
- Meshing was done in Hyper Mesh software tool for the shock absorbers.

Finally, our proposed solution outperforms all previous strategies. The research article is also included in the next section. Part 2 of the current model survey goes deep. Part 3 contains information about the proposed structure. Part 4 looks at the experimental setting for the proposed approach. Part 5 goes over the design and analysis sections in depth. Results and discussion is presented in part 6, Part 7 shows the comparative analysis and Part 8 the paper closes.

2. Literature Survey

A passive or semi-active electromechanical damper based on the linear electric motor using permanent magnets (PMs) whose electric terminals are shunted by a resistance was proposed by Karnopp [21]. According to the mechanics of the automobile, the shunt resistance may be used to modify the damping coefficient. To achieve good vibration suppression performance with little energy consumption, Suda et al. [22] built an active suspension with an energy conversion system as well as a linear DC generator based on linear electrodynamic motors.

Goldner et al [23] just completed a proof-of-concept study to investigate the possibility of using an optimised regenerative magnetic shock absorber to produce significant energy savings in automobiles. Aside from other potential applications, using such shock absorbers could improve energy efficiency in electric vehicles by turning normally parasitic mechanical power losses into stored electrical energy, allowing for longer battery recharge times.

The feasibility study of an electromagnetic damper for use as a sensor and actuator in automotive suspension applications was finished by Ebrahimi et al [24]. This electromagnetic damper is founded on the tubular, linear, brushless DC motor principle that operates in three modes: passive, semi-active, and active. The proposed damper, being a self-powered active shock absorber, has the capability of acting as both a sensor and an actuator at the same time. Even in the absence of external power, the calculated damping force appears reasonable for car suspension applications.

Zuo et al. [25] constructed and prototyped a linear electromagnetic frequencies harvester capable of producing more than 16-64 watts of electricity from all four shock absorbers with 0.2-0.5 m/s RMS suspension velocity. These versions can be used as actuators for active or semi-active control, but they are mostly used for energy harvesting. Martins et al. [26] shown the practicality of electromagnetic active suspensions by pioneering some breakthroughs in power devices, permanent magnetic compounds, and microelectronic devices.

Chen and Liao [27], as well as Sapinski [28], designed linear electromagnetic energy harvesters to power MR dampers in order to provide active/semi-active control. In order to supply energy, the second type of linear regenerative shock absorbers employs rotating permanent magnetic DC or AC converters to convert linear suspension vibrations into oscillatory spinning. Hydraulic transmission, rack and pinion, and ball screw are examples of mechanical systems. A comparison among a linear as well as a rotary shock absorber was done by Gupta et al [29]. The energy lost in shock absorbers can be recovered using regenerative electromagnetic shock absorbers, it was discovered that the rotary shock absorber may possess a higher energy density.

An energy-regenerative electrical suspension was created by Zhang et al. [30] which uses a permanent-magnet direct-current motor, a ball screw, as well as a nut as the motor actuator. The ability of the suspension to regenerate and convert vibration energy from road excitement into electric energy while keeping outstanding suspension effectiveness is its most noticeable characteristic. The performance of the DC motor is evaluated. The regeneration and vibration control features are validated through full-vehicle testing on the IST Road Lab four post rig. The results of tests conducted with an electrical device that acts as a passive suspension mechanism show the practicality of vibration energy regeneration.

Avadhany et al [31] patented that the straight movement of the piston can be turned into rotational motion using reasonable pressure driven gear, which drives the rotating engine of the generator. The vehicle's shock is lessened by the engine's electromotive power using hydraulic transmission.

Additionally, Choi et al. [32] provide vibration control of an automobile suspension system without the use of exterior power sources by using an electrorheological (ER) shock absorber that is adjustable as well as activated by an energy generator. The linear motion of the piston is changed into a spinning movement via the rack and pinion operation of the ER shock absorber. The rotational motion is accelerated by gears, which subsequently turns on a generator to produce electricity. Experiments have demonstrated a significant reduction in suspension vibration when the ER shock absorber is activated using the suggested regenerative energy method.

A unique regenerative shock absorber architecture put forth by Zhang and Zuo [33,34] has the benefit of significantly increasing energy harvesting effectiveness while reducing oscillation-induced impact forces. The model is capable of concurrently analyzing mechanical and electrical elements. The MMR shock absorber, which generates more than 15 Watts of power while travelling at 15 mph on a smooth, paved road using a rack and pinion system, is also put through road tests to show its viability.

The adoption of piezoelectric as well as electromagnetic techniques was suggested by Howells CA and Ju S, Ji C-H [35,36] for the conversion of mechanical to electrical energy. The piezoelectric design is typically utilized for small-scale vibration harvesting, including in milliwatt & microwatt harvesters like those that generate power from the motion of human bodies.

Dr. Seema Tiwari et.al [37] Some operation wastes a lot of fuel energy, which can be recovered by using a regenerative suspension system. A regenerative suspension framework can successfully retain these vibrations while reducing the amount of energy lost to the surrounding. This study examines the most recent studies on regenerative shock absorbers. It first investigates the dispersal of energy from cars and then the feasibility of recouping this scattered energy using a regenerative shock absorber. It also analyses the many unique work done on the regenerative shock absorber.

Zhanwen Wang et.al [38] proposed a high-efficiency regenerative shock absorber based on a pair of ball screws is proposed in this research for range-extended EVs. The vibration energy is captured and transformed into electricity, which is then dissipated as heat in the suspension system. The suspension vibration input module, transmission mechanism module, generator module, and power storage module comprise the regenerative shock absorber. The simulation section depicts the force-displacement loop at various amplitudes and frequencies, the angular velocity of the generator shaft at sinusoidal inputs, and the damping coefficients at various external resistances.

Cyriacus Okpalike and colleagues [39] proposed to explore the effects of building rehabilitation on ventilation and energy savings in Achara layout, Enugu City, Nigeria, a qualitative research approach was used. Using a judgmental sampling technique, the sample size was determined to be four blocks of flat residential buildings. To collect empirical data relating the window system, physical measurements, an observation schedule, and oral interviews with site employees focused on window size, area, property, and fenestration type were used. The results show a very significant difference in all analyzed variables between the as-built and modified window design systems. Its finding was based on the fact that a restored structure does not promote adequate natural ventilation, requiring more energy for cooling and lighting.

F. E. Tahiri et. Al [40] This research provides optimal control strategies for a standalone Hybrid Power System (HPS) in order to provide sustainable and optimal energy to an isolated site while improving electrical energy quality. In addition, a unique control approach for maximizing PVS power has been developed in this work. This suggested technique, which is based on the combination of the Perturb and Observe (P&O) algorithm and the Fuzzy PI Controller (FPIC), outperforms the traditional algorithm P&O, especially in the dynamic state. A supervisory control algorithm has been developed to manage the energy flows between the hybrid system's devices in order to determine the ideal operating mode in order to provide a continuous supply of the load with minimal battery usage.

A. Laabid et.al [41] The purpose of this article is to examine, evaluate, and develop options for integrating hybrid energy sources (Solar Photovoltaic PV/Batteries/Diesel Generator (DG)) in mobile service units (MSU) meant to serve rural communities. The initial goal is to assess the functioning of two previously deployed solar systems installed on truck roofs, with respective outputs of 2.12 and 3.54 kWp. We created a model of the energy conversion chain and simulated its behaviour throughout the year. The simulated findings are then compared to the measurements taken on-site. Several association possibilities are then investigated in order to propose the best combination, taking into account the surface available for PV module installation (truck roof), weight, and battery longevity.

According to the preceding study of shock absorbers on mechanical vibrations, there are many constraints for generating high energy harvest. This method offered a strategy that is explained in detail in the next section.

3. Principle and Methodologies of Proposed Technique

Motorcycles are the main application for a telescopic suspension built of steel and aluminium alloy, and because of its weight and shock-absorbing capacity, it is very effective. A rack and pinion modelled using 3D printing technology, a shock absorber made of spring stainless steel, as well as a dynamo that converts mechanical displacement into voltage stored in a rechargeable battery have all been created and attached to both ends of the rear wheel of a motorcycle with a gasoline engine. The circuit also includes a pump up device but a diode to boost the voltage of the energy that has been captured so that it can be used to power portable devices and signal lights. Results from a comparison of boost up voltage are recorded on several roadways, accounting for different loading scenarios such as kilometers.

An experimental procedure using piezoelectric material was also utilized to capture vibrations, however it failed due to strong vibrations. Numerous researchers have incorporated energy harvesting absorbers to decrease fuel usage, improve ride comfort, and improve road handling using techniques like adjustable damping and variable inverter [42–44].

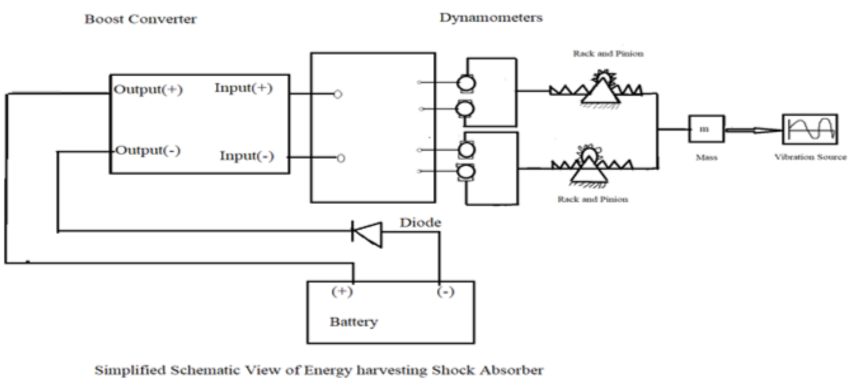


Fig. 1 Circuit diagram

The circuit diagram for the proposed approach is shown in Figure 1. In the illustration, the boost converter has two inputs and two outputs. Two outputs are linked to the battery, one of which incorporates a diode. Two inputs are transmitted to a medium to create dynamometers. The Solid works 20 version and ANSYS Workbench software were used to analyses a 3D model of a telescopic suspension system. Stress analysis has been carried out under different load conditions, while material properties of helical compression springs for various materials, such as Spring Steel telescopic shock absorbers, have been explored. We concluded by employing these materials that we monitor and harvest the voltage in rechargeable batteries, and the boost converter is used to raise the voltage, which may be used to power low electrical devices. Our ASTM A313 shock absorber material is the optimum material for bikes to load one or more people and performs well.

4. Experimental Setup

Figure 2 depicts the proposed method's experimental setup with conventional two-wheeler and electric vehicle. A diode, dynamometer, battery, and multimeter are set up with the rack and pinion in order to calculate the kilometers and load that shock absorbers support. Our method's shock absorber is made of a spring-like steel substance that retains its elasticity while having exceptional tensile qualities. This compression load shock absorber has a 250kg loading capability. We employed this kind of shock absorbers to lessen vibration and shock on machinery. The tyres are always in contact with the road due to these shock absorbers. As a result, our research shows that mechanical vibrations, such as shock absorbers, can be used to harvest energy.

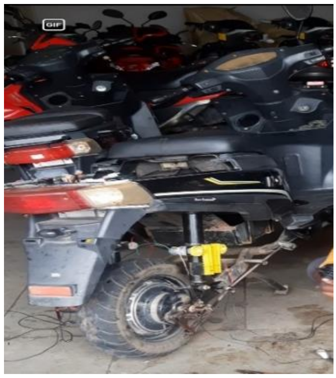



Fig. 2 Experimental setup conventional Two wheeler (Passion Pro)and Electric Vehicle (Hero NYXe5)


Fig. 3 Circuit connected for EV

4.1. Components and Its Uses

The components employed in our experiment are briefly described in this section. Diode (4007), rack and pinion, dynamometers, battery, boost converter, multimeter, and other components are used in our method. Let's take a quick look at these elements.

4.1.1. Diode 4007

Our proposed process uses a diode 4007. The 1N4007 diode is a traditional recovery rectifier with a plastic casing. In our proposed solution, this diode is coupled with a rack and pinion to handle greater current capacities. Figure4 presents the diode (4007).

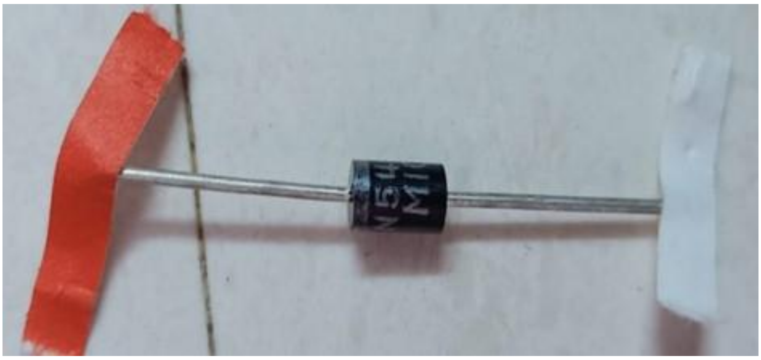
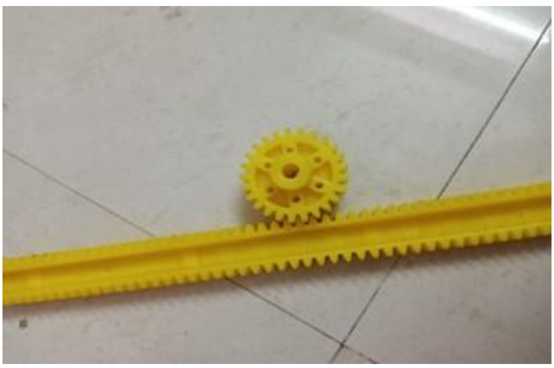


Fig. 4 Diode (4007)

4.1.2. Rack and Pinion

A longitudinal controller with a rack and pinion consists of a pinion (circular gear) that engages a rack (linear gear) to transformation of rotational motion into constant speed. In a rack and pinion drive, both linear and spiral gears can be employed. The rack and pinion is shown in Figure 5.



Fig, 5 Rack and pinion

4.1.3. Dynamometers

A dynamometer, often known as a "dyno," is a machine that simultaneously monitors the torque and speed of rotation (RPM) of an engine, motor, or other rotating prime mover to determine its instantaneous power, which is commonly shown as kW or bhp by the dynamometer. This dynamometer is used by our method to measure mechanical vibrations and to absorb power. The dynamometers utilized in our method are shown in Figure 6.

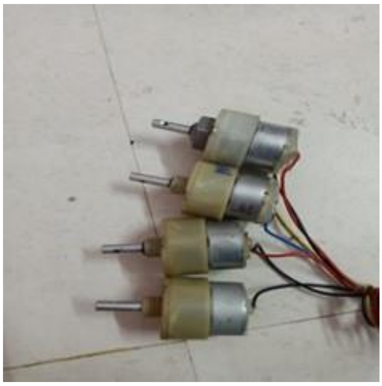


Fig. 6 Dynamometers

4.1.4. Battery

In our proposed method we are using 12V (1.3AH) battery. In order to store energy and provide a steady supply of voltage, we linked this battery to the diode and dynamometers in our experimental setup. The 12V battery for our proposed solution is depicted in Figure 7.

Fig. 7 12V Battery

4.1.5. Boost Converter

Our proposed method consumes LM6009 Boost Converter shown in figure8. A boost converter (sometimes called a step-up manipulator) is a DC-to-DC power manipulator that increases voltages while depressing power from its source to destination.

4.1.6. Multimeter

A multimeter is an instrument for measuring a broad variety of electric characteristics. A multimeter that can calculate voltage, resistance, and current is known as a volt-ohm-milliammeter because it contains voltmeter, ammeter, and ohmmeter operations. Figure 9 shows our proposed model multimeter.

We designed our innovative energy harvesting shock absorbers employing mechanical vibrations based on all of the above materials. With SOLIDWORKS 20 and ANSYS model methodologies, our method harvests an amount of energy and outperforms all existing methods.

Fig. 8 Boost Converter

Fig. 9 Multimeter

5. Design and Analyzing

SolidWorks 20 is a top end, parametric, feature-based, solidwork software that was used to develop this study. It gives mechanic designers a method for automating mechanical design that is founded on built-in intelligence and removes the element of guesswork from 3D design.

Exploded view **Isometric view**

Fig. 10 Exploded and Isometric views

Figure 10 shows the exploded and isometric views of our proposed method designed using Solid works 20. The rack and pinion, spring steel, top mount, and bottom mount components of the proposed approach make up our technique.

5.1. Design Parameters of Telescopic Suspension System

5.1.1. Design Specifications of a Shock Absorber

Our proposed approach includes a telescopic suspension system in which a Spring Body Shock Absorber is an integral part along with rack & Pinions with adjustable loading capacity is considered. The bike used in our method is Hero Passion Pro Bike 110CC and the weight of the bike is 117 kg. The following Table 1 shows the Loading descriptions of the weight for our proposed method.

Table 1. Loading descriptions

Loading Description	Considering load in kg	In N
Weight of 1 person + weight of bike	187 kg	1834.47 N
Weight of bike + two persons	257 kg	2521.17
Assuming 60% of overall vehicle weight =154.2kg=1512.7N		

Steel and Aluminum Alloy is the Telescopic Suspension Material used in this method. Spring material used is Stainless 17-7 ASTM A313 and the type is Helical Closed and Ground Type Spring. The proposed parameters and dimensions are displayed in Table 2. Also our proposed modelled is designed using these factors.

Table 2. Proposed parameters and dimensions

Parameter	Dimension
Weight of one spring	0.3849 kg
Wire diameter	5mm
Outer diameter	35mm
Inner diameter	25mm
Free length	285mm
Mean diameter	30mm
Number of active turns	24
Total coils	26
Spring Index	6
Pitch coil	11.458 mm
Rise angle of Coils	6.93 Degrees
Modulus of Rigidity G	75.68 GPa
Maximum Shear stress	725.8 MPa
Wahl Correction Factor W	1.253
Spring Rate K	9.124 N/mm
Maximum load carrying Capacity	948.278 N

5.1.2. Design Parameters of Rack and Pinion

The rack and pinion materials used in this process are Polyacetal and MC Nylon. The length of rack is 14cm and the diameter of pinion is 3cm. Teeth on the Rack and pinion is 30 and

25 respectively. Linear circle is 3cm with module 1 and pitch circle is 3.5 cm. 154.2 kg is the mass to be moved with speed 11.11m/s. Acceleration time t is 5.55 sec and the acceleration due to gravity g: 9.81m/sec2. Proposed Variables are shown in Table 3. Our technique is modelled using the Poisson's ratio, the load factor, and the lifetime factor of the rack and pinion.

Table 3. Proposed Variables

Properties	Dimensions
Poisson's Ratio μ	0.4
Load factor KA	1.5
Life time Factor Fn	1.05
Safety Coefficient SB	1.4
Linear Load Distribution Factor LKHβ	1.3

Maximum Permissible Feed Force Fu= (m.g. μ +m. a)/1000=2.3KN and Permissible Feed Force FU.tab is 9 KN (For Rack &Pinion of module:1 & of Polymer Type) from Atlanta Rack & Pinion Drive Calculation Table. Permissible Feed Force is Fu. Per: Fu tab /(KA.Fn.SB.LKHβ) =3.13KN. Fu. Per >FU (Condition is fulfilled) for our proposed method.

5.2. Analyzing Properties

When loads are applied to a body, the structure deforms as well as the weights' effects are dispersed throughout the body. The body enters a condition of equilibrium as a result of the internal forces and reactions caused by the external stresses. Meshing is done in our method using ANSYS work.

5.2.1. Meshing

Figure 11 shows that the Shock Absorber Assembly has been fully mesh. One of the most crucial elements in running a precise simulation is meshing. A mesh is composed of elements that have nodes in them that represent the geometry's shape. Meshing is done in Hyper Mesh. Hyper Mesh is a pre-processing software where you divide the model into no. Of elements and nodes for a solver to apply the mathematical functions on it.

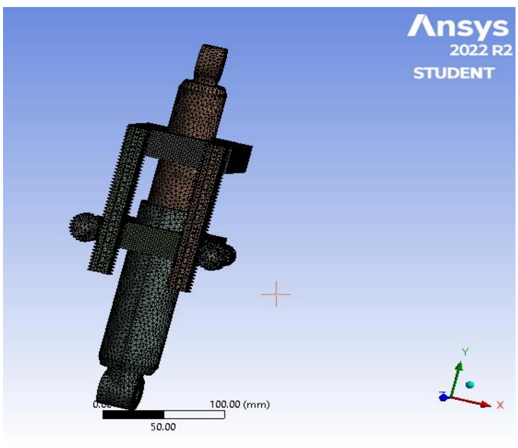


Fig. 11 Mesh model for shock absorber

5.2.2. Applying Material Properties

Material properties employed in our technique are shown in table 4 in accordance with how it is proposed to conduct the analysis for materials.

Table 4. Material Properties

Material	Density Kg/m-3	Poisson 's ratio	Young's Modulus MPa	Tensile strength MPa	Yield Strength MPa
ASTM A313	7800	0.25	2.04 E + 05	1170	965
Steel & Aluminum Alloy	5260	0.33	1.3 E + 05	2.43 E + 08	2.43 E + 08

4The bottom eye is a fixed contact, while the top eye is attached to the axle of the back wheel, in which the force is applied, in the actual installation of the shock absorber to a two-wheeler. The struts rod is in sliding motion with the upper mounting, as well as the spring is constrained within the top and bottom mounts. Our model for a shock absorber is proposed using these materials and the attribute values. The next section shows the results and discussion of our proposed method.

6. Results and Discussion

Results from a comparison of boost up voltage are recorded on various roadways, taking into account different loading scenarios such kilometers. The datasets for bike load, voltage, and distance travelled are determined by the instances below.

Conventional Bike (Passion Pro 110 CC)

Case: 1

Table 5. Bike Load (117 Kg) + one Person (70 Kg) (Driver)

S.NO	Condition(distance travelled by bike)	Initial Voltage (Volts)	Boost up Voltage (Volts)
1	Rest Condition	0	0
2	10Km	0.35 - 0.5 V	0
3	50km	2 - 2.5 V	0
4	100 km	4 – 5 V	0 – 10 V
5	150 Km	6 - 7 V	15 – 20 V
6	200 km	8.5 – 9 V	25 – 30V

Table 5 shows the weight of the bike in kilograms, the initial and boost up voltage in volts, and the distance travelled in kilometers. The bike load is 117kg and the loaded one person (driver) weight is 70kg.

Figure 12 depicts a line graph based on the Bike Load and a single person. The bike weighs 117 kilograms, while the (driver) person weighs 70 kilograms. The kms travelled in harvested voltage are 5 and the volt is 1.5V. However, we travelled 26 kilometers with a load and increased the voltage by 12V in boost up voltage. X-axis depicts the distance travelled and Y-axis depicts the voltage.

Table 6 illustrates the bike load and the measurements of two people. The bike weight is 117 kg, with one person weighing 70 kg and the driver weighing 70 kg. The distance travelled is in kilometers, while the voltages are in volts.

Figure 13 depicts a line graph created using the Bike Load and two people. The bike load is 117kg, the passenger weight is 70kg, and the driver is 70kg. The combined weight of two people is 140kg. We boost up energy by 37.5 kms with 16V and energy harvesting is done. X-axis depicts the distance travelled and Y-axis depicts the voltage.

Note: Minimum voltage to boost up is to be 5V.

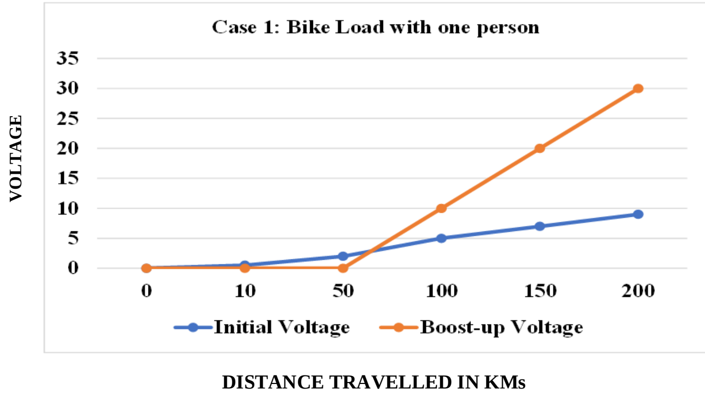


Fig. 12 A plotted line graph

Case: 2

Table 6. Bike Load (117 Kg) + one Person (70Kg) + Driver (two persons 140kg)

S.NO	Condition (distance travelled by bike)	Initial Voltage (Volts)	Boost up Voltage (Volts)
1	Rest Condition	0	0
2	10Km	1.2 - 1.5 V	0
3	50km	3.5 - 4 V	0
4	100 km	6.5– 7V	0 – 15 V
5	150 Km	9 - 10 V	20 -30 V
6	200 km	10 – 12 V	35 – 40 V

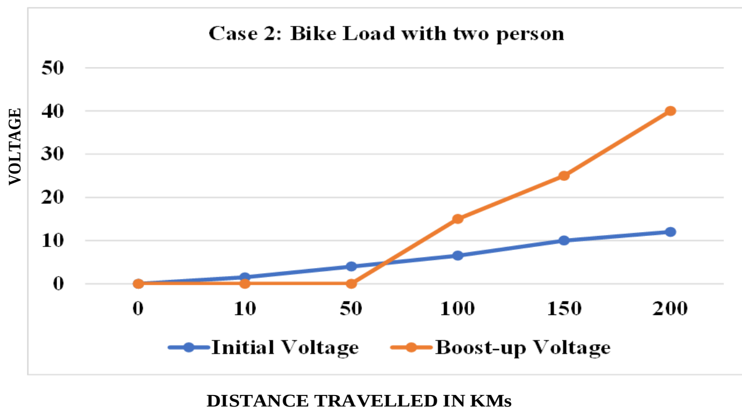


Fig. 13 A line graph

Electric bike (Hero NYXe5)

Specifications: Lithium ion 51.2 V,30AH battery

Case: 1

Table 7. Bike Load (77 Kg) + one Person (70 Kg) (Driver)

S.NO	Condition (distance travelled by bike)	Initial Voltage (Volts)	Boost up Voltage (Volts)
1	Rest Condition	0	0
2	10Km	0	0
3	50km	1-2.5 V	0
4	100 km	3-4.5 V	0 – 8 V
5	150 Km	5-7V	10-15 V
6	200 km	8.5 – 9 V	18-20V

Figure 14 depicts a line graph created using the Bike Load with one people on Electric vehicle. The bike load is 77kg, and the driver weight is 70kg. X-axis depicts the distance travelled and Y-axis depicts the voltage.

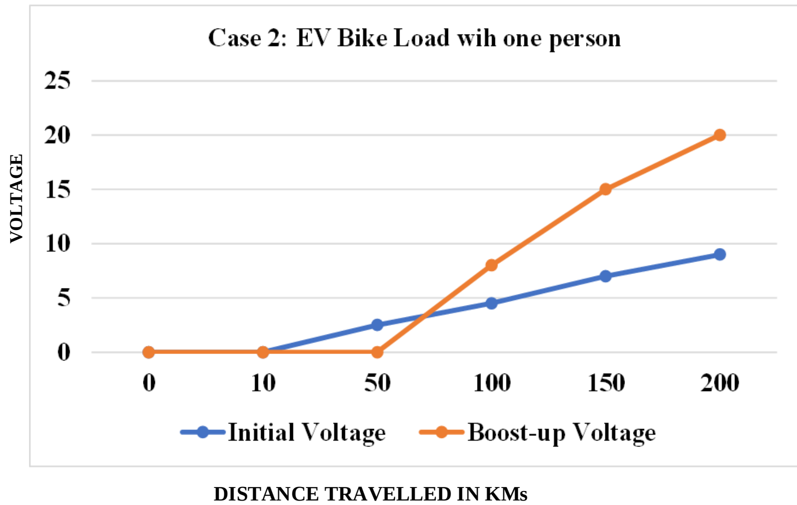


Fig. 14 A line graph

Case: 2

Figure 15 depicts a line graph created using the Bike Load with two people on Electric vehicle. The bike load is 77kg, the person weight is 70kg and the driver weight is 70kg. X-axis depicts the distance travelled and Y-axis depicts the voltage.

Figure 16 depicts mobile charging with a harvested stored rechargeable battery. The energy captured by the shock absorbers is connected to the cell phone for charging. As a result, we can store energy in a rechargeable battery and gain energy to recharge mobile phones, outperforming all other methods.

Table 8. Bike Load (77 Kg) + one Person (70Kg) + Driver (two persons 140kg)

S.NO	Condition (distance travelled by bike)	Initial Voltage (Volts)	Boost up Voltage (Volts)
1	Rest Condition	0	0
2	10Km	0	0
3	50km	0-1V	0
4	100 km	2-3 V	0 – 5V
5	150 Km	3-5V	5-10V
6	200 km	5-7V	10-15V

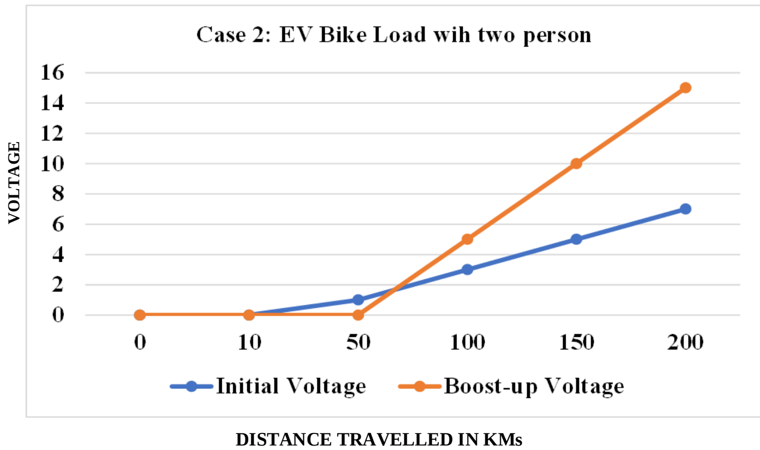


Fig. 15 A line graph

Fig. 16 Mobile **c**harging using stored harvested **r**echargeable battery

6.1. Modal Analysis

An elastic structure will oscillate around its equilibrium position if a force is applied to initially displace it from its stationary state, and then the force is removed. Free vibration is the name given to this sort of oscillation caused merely by the initial disturbance. Natural frequencies are frequencies that naturally exist, but their typical values exhibit specific deformation patterns known as mode shapes. The analysis of such free vibrations is crucial for determining the system's dynamic response. All materials are tested for their first six modal frequencies:

Table 7. Results of Modal Analysis (Freq-Hz)

Mode	Frequency
Mode 1	247.34 Hz
Mode 2	253.32 Hz
Mode 3	315.66 Hz
Mode 4	345.28 Hz
Mode 5	561.6 Hz
Mode 6	566.1 Hz

Table 7 shows the results of modal analysis for our proposed method. At mode 1 our material attains 247.34 minimum frequency and at mode 6 we gain maximum of 566.11 frequency for our material ASTM A313.

7. Comparative Analysis

This part compares all the materials used in this method to design the Spring Steel Shock Absorber for energy harvesting. We used Spring steel and its dimensions are given in the table1. In this method, we used a Von mises stress analysis for analyzing load material.

Table 8. Loading condition for shock absorber analysis

S.no	Loading Description	Considering dynamic load in double	In N
1	Bike load + 1 person	187 Kg	1834.47N
2	Bike load + 2 person	257Kg	2521.17N

Assuming 60% of overall vehicle weight =154.2kg=1512.7N. Table 8 shows the loading condition for shock absorber analysis. In this table, the load is mentioned in kilograms and numbers are mentioned in natural numbers.

7.1. Von mises Stress Analysis

Figure 17 shows Von mises stress analysis 3D modeling in Ansys for loading one person (1373.4N). A statistic that determines if a substance may give or fracture is the Von Mises stress. It is typically frequently applied to ductility, such as metals. A material will yield, according to the von Mises yield criterion, if its von Mises strain during load is equal to or higher than that of the yield point of the identical substance under simple tension. Our method employs 6.952 max tensile strength for our shock absorbers.

Figure 18 illustrates the Von Mises stress analysis for loading two persons (2521.17N) using the proposed approach. Our proposed solution employs a rack and pinion with a maximum yield of 12.762 in the shock absorber.

7.2. Deformation

We develop a method termed deformation after comparing loading people in the proposed materials. Deformation refers to the change in shape. When enough force is exerted to a metal or other structural material, the substance will change shape. Deformation of the materials is given as follows.

Figure 19 depicts the deformation when one person is loaded (1373.4N). We can get a maximum of 0.0061586 by loading one person in the shock absorbers.

Figure 20 shows the derformation of loading two persons in the shock absorber (2521.17N). For loading two people in the shock absorber we achieve maximum values of 0.011305 and minimum values tends to 0.

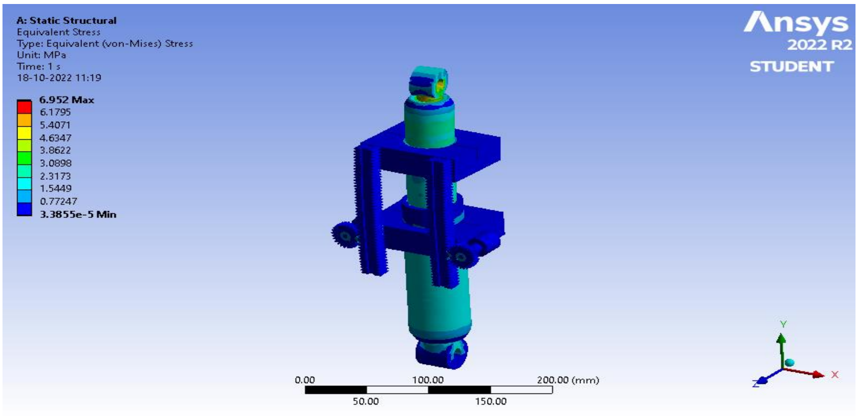


Fig. 17 Von mises stress analysis for loading one person

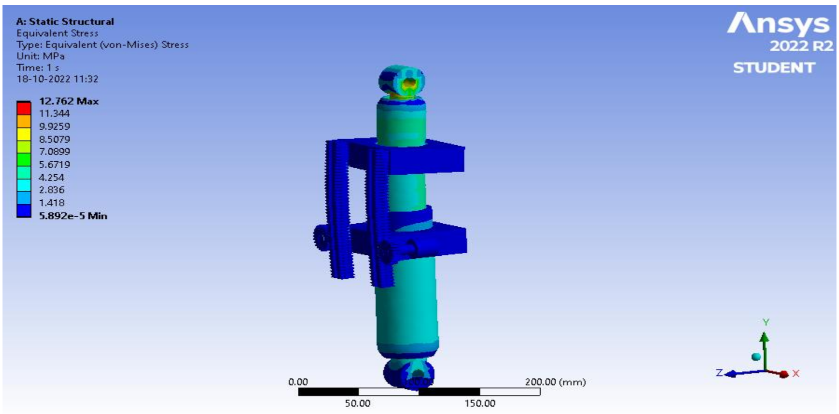


Fig. 18 Von mises stress analysis for loading two persons

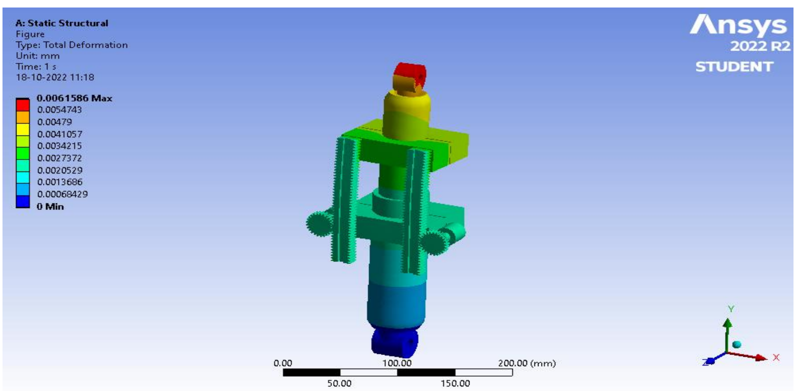


Fig. 19 Deformation for loading one person

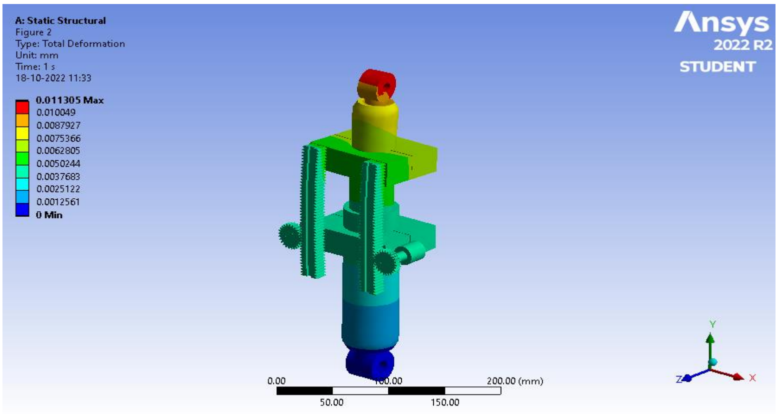


Fig. 20 Deformation for loading two persons

8. Conclusion and Future Work

In this study, we developed a brand-new energy collecting technique depends on shock absorbers' mechanical vibrations. This technique demonstrates the detailed difference between loading one or more persons in a shock absorber using a displayed line graph. In the existing paper, only the harvested power vs load is analyzed, however in our work, we monitor and harvest the voltage in rechargeable batteries, and the boost converter is utilized to raise the voltage, which may be used to power low electrical devices. Then, to compare the Spring steel, we used Solid works 20, 3D printing and ANSYS technology. Our study area's major purpose is to concentrate on energy harvesting and vibration analysis in shock absorbers. After modelling the shock absorber with Solid works 20, ANSYS Workbench was used to analyze the shock absorber for Conventional bike and Electric Vehicle for different load conditions over the distanced travelled in Kilometers. Later, the shock absorber was tested on a two-wheeler bike using a rack and pinion mechanism. Compared to Conventional the vibrations in Electric bike were low so the that energy harvesting takes over the long distance. Mesh is performed using ANSYS technology for shock-absorber and is also shown in the paper. The modal analysis for our material ASTM A313 is also performed from mode 1 to mode 6, and the maximum and minimum modes are calculated. Von Mises stress analysis for loading one and two persons and also maximum tensile strength is also calculated by using ANSYS method. Deformation is also done for loading one and two persons is also calculated in this method. Finally, the Vibrations were harvested, boosted up voltage stored in dead rechargeable battery can be used to recharge the mobile. The future scope of the work is to use the piezo electric material for vibration energy to the suspension system in convention and EV two wheelers, Four wheelers.

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