Electricity Generation Using Vehicle Suspension

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Abstract- *Regenerative shock absorber is a type of suspension system which converts linear motion & vibration into useful energy, such as electricity. Conventional shock absorber simply dissipates this energy in the form of heat. In our project, we use shock absorber, belt & pulley arrangement and dynamo. As the effect of shock absorber, the telescopic link moves up and down. Linear movement of belt will rotate the pulleys which are mounted on dynamo shaft. So, dynamo shaft will rotate along with pulleys. Dynamo rotation led to generation of energy. And this energy is used to charge the battery.*

I. INTRODUCTION

According to first law of thermodynamics, "Energy cannot be created, nor destroyed. It can only be changed from one form to another". So we should be very careful while dealing with the energy. But most people do not feel it necessary or essential to save energy for future. Conservation of energy is not natural & takes a lot of time. So our aim is to utilize maximum kinetic energy generated from the suspension of a vehicle which is getting waste.

Electricity is something that people cannot live without in the modern day. Without it, life will be so much difficult and slow. We need to learn how to value electricity and learn how to produce it from renewable sources. We propose a design plan that converts the mechanical energy in vehicles to electrical energy much more efficiently. The electricity generated can be used to recharge the small battery which can be further used for functioning of the vehicle accessories.

In 2005, David Oxen writer of Boiling Springs, PA, presented a design for an electricity generating shock absorber. Experimental Bosch suspension systems have generated electricity. Problems have included the devices being too large, too expensive, and too inefficient in converting electricity or just poor shock absorbers because they dispensed with the spring or had the wrong damping characteristics.

We have worked on utilization of suspending mass of a vehicle through regeneration system with the help of shock absorber. Shock absorbers are having reciprocating motion in it. This shock absorber is extended with a mechanism which will help to convert reciprocating motion into rotary motion. It will be used to generate electricity using the real-time motion available in suspension system of a two-wheeler or four-wheeler.

In the constructional part, this electricity generating device is a mechanical link assembly, in which there are two sets of links- one is an outer set of links, which is fixed and other is inner set of links, which is collapsible one. The outer set of links supports permanent magnet DC generator, which are in physical contact with the collapsing or inner set of link of the link assembly. This link assembly can be mounted along with the suspension system of the vehicle. In two wheeler, two such types of electricity generating devices are used and in four wheeler, four such electricity generating devices are used. We are aggregating one such electricity generating device for one wheel's suspension unit. When the vehicle is in running condition there is always relative motion between wheel and the chassis thereby there will be relative motion between the two links of the electricity generating device, hence the permanent magnet DC generator are actuated and thus electricity is generated. This electricity can be used to charge the small battery.

II. LITERATURE REVIEW

The research about energy recovery from vehicle suspensions began more than ten years ago, first as an auxiliary power source for active suspension control, and later also as energy regenerating devices in their own accord. During the past ten years, energy recovery from vehicle vibrations has achieved great commercialization success in hybrid or electric vehicles[11]. Some earlier efforts to recover energy from suspension are Lei Zuo, et al. have worked on a prototype design of Electromagnetic energy harvester for vehicle suspension. In that paper they have designed, characterized and tested a prototype retrofit regenerative shock absorber. Gupta et al, (2003) has studied the available energy from shock absorbers as cars and trucks are driven over various types of roads. They fabricated two prototypes of regenerative electromagnetic shock absorber: a linear device and a rotary device and installed them in vehicle to study energy recovery[8]. Goldner, et al. (2001) have carried out a proof-of-concept - to evaluate the feasibility of obtaining

significant energy savings by using regenerative magnetic shock absorber in vehicles. They proposed electromagnetic (EM) shock absorbers to transform the energy dissipated in shock absorbers into electrical power. P. Zhang et al. have presented comprehensive assessment of the power that is available for harvesting in the vehicle suspension system and the tradeoff among energy harvesting, ride comfort, and road handing with analysis, simulations and experiments. Zhen Longxin and Wei Xiaogang have modeled the structure and dimensions of a regenerative electromagnetic shock absorber in CAD software package. S. Mirzaei. et al introduced a passive suspension system for ground vehicles based on a flexible Electromagnetic Shock Absorber (EMSA). They designed and provided a model of passive suspension. Bart Gysen et al., have studied design aspects of an active electromagnetic suspension system for automotive applications which combines a brushless tubular permanent-magnet actuator with a passive spring. N. BabakEbrahimi, presented the feasibility study of an electromagnetic damper, as senor/actuator, for vehicle suspension application. They have optimized geometry of shock absorber to achieve higher electromagnetic forces and magnetic flux induced in the system.

III. FABRICATING COMPONENTS

Sr. no.	Components	Details	Specification	Quantity (Nos.)
1	Dynamo Motor	4 -12 Volt	-	4
2	Horizontal Plates	85 mm X 105 mm	8 mm thick wooden plate	4
3	Vertical Plate	80 mm X 40mm	8 mm thick wooden plate	2
4	Flat Belt	35mm X 300 mm	1 mm thick rubber belt	1
5	Rectifier	-	Full Wave	1
6	Stud rods	5 mm diameter X 230 mm length	Stainless steel	8
7	Pulleys	5 mm diameter	Plastic	8

3.1 Components Specification table

IV. CONSTRUCTION& WORKING

4.1.construction

It has a simple construction, it consist of 3 parts;

1]Fabrication of plates
2]Stud Structure
3]Motors Arrangements

1]Fabrication of plates

There are four wooden plates of dimension 85mm x 105mm x 8mm, say A, B, C, D. Four holes of 6mm diameter are drilled on the plates at 10mm from each edges. As there are four corners, four holes are drilled on all four plates. Now take two plates from it, say plate B & C. Again, four holes with same diameter as the previously drilled plate, to form another stud structure. The holes are drilled in such a way that length between the newly drilled holes is minimum to that of the previously drilled holes. Consider the newly drilled holes as [i], [ii], [iii], [iv] & previously drilled holes as [1], [2], [3], [4]. They are arranged in such a way that [i], [ii], [iii], [iv] are nearly 10mm from [1], [2], [3], [4] respectively. Here, two plates are ready with eight holes (i.e. plate B & C) & two

plates are ready with four holes (plates A & D).There are two wooden vertical plates with dimensions 80mm x 40mm x 8mm, material is removed from these vertical plate, according to circumference of motor as we have to mount four motors on it . So two vertical plates are fabricated with four motor sized holes, i.e. two holes on each plate.Now all the plates are fabricated and are ready to use . The given figures shows the fabricated plates.

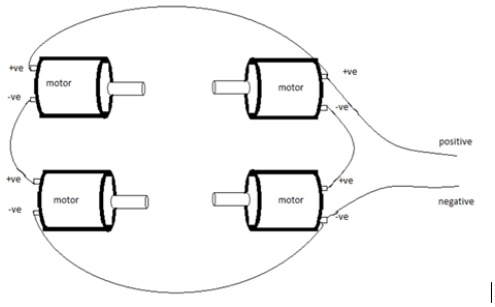
2]Stud Structure:

For two stud structure , eight stud rods are taken. They are of 5mm diameter and 230mm in length. The stud rods have threads at its both ends in order to fix it.Now the plate A and plate C are connected to each other passing through plate B , with the help of four stud rods. These four studs are fixed at plate A & plate C with the help of nuts. The stud rods pass through holes [1], [2], [3], [4].

Similarly, plate D and plate B are connected to each other passing through plate C, by inserting four stud rods through holes [i], [ii], [iii], [iv];These four studs are fixed at plate B and plate D by using nuts.Here two stud structures are formed, where first structure is formed by using plates A & C. And second structure is formed by using plates B & D.

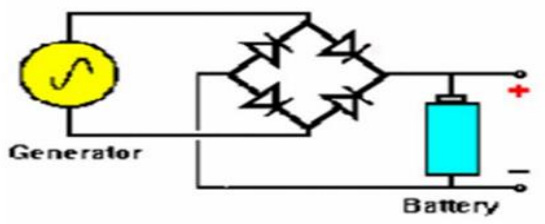
3]Motors Arrangements:

All the motors are arranged in such a way that two motors have same principle axis of shaft and are of opposite faces. Similarly other two motors are arranged in same manner . So we have two motors having faces in same direction & two motors having faces in opposite direction.



4.3 Motors in Series Combination

All four motors are fixed at two vertical plates, i.e. two motors on each plate. The motors are fixed in the holes of vertical plate either by releasing glue along circumference at meeting section or by interference fit.After mounting all the motors on vertical plates, the vertical plates are attached to plate C by means of nail or screw.The motors are connected in the series combination, in order to collect higher voltage. The two outcoming wires are connected to input of full wave bridge rectifier and the output of full wave bridge rectifier is collected for further purpose. For e. g: charging of battery, etc.A flat belt which is of rubber material is rolled over the pulley in such a way that two motor are on one side of the belt & remaining two on the other side of the belt. The belt is fixed to the plate B and plate D.



4.4 Circuit diagram with bridge rectifier

4.2.Working of Project

When the electricity generation model is mounted on the vehicle, it moves linearly due to the movement of suspension of vehicle. So the initial working position of the model is as shown in figure.When the suspension works, the model moves linearly. Also the flat belt moves linearly with the model. The belt is of rubber material, as it rolled over the pulley. The movement of belt allows the pulley to rotate. The pulleys are mounted over the generator shaft. In this way linear motion is converted into rotational motion.

Inside the motor, when shaft rotates between two magnets, it cuts the magnetic flux lines. Due to this the

electrons in the coil gets triggered & starts flowing & generates current. The current is in the alternate wave form.So, in order to get maximum output, the AC waves are converted into DC waves. The direct current have contineous waveform as shown in figureFor converting AC to DC , full wave bridge rectifire is used. The output of motors is connected to input of rectifire.The bridge rectifire rectifies the alternating current & convert it into direct current. This direct current is then used for different purposes of vehicles.According to different linear motions, different outputs can be obtained. Maximum linear motion results in maximum current generation, i.e. linear motion is directly proportional to current generation.The electricity generation model's peek position is shown in the figure below.

4.3.Model Calculations

Charging voltage required -

Charging voltage is between 2.15 volts per cell (12.9 volts for a 12V 6 cell battery) and 2.35 volts per cell (14.1 volts for a 12V 6 cell battery). These voltages are appropriate to apply to a fully charged battery without overcharging or damage.

Ampere hour

Ah is a constant value for any given battery. Thus a battery rated for 35Ah should provide 1 amp for 35 hours, 2 amps for 17.5 hour, 5 amps for 7 hours , and so on.

Since Ah= I*t

To completely charge a battery of x Ah connected with a charger capable of providing y amps current should take x/y hours ideally to charge completely .But it never goes this way, no. of charge and discharge cycle up to which a battery follows stated relation is fixed and hence time taken to fully charge increases. Factor affecting are type of battery, its age (new or order). Voltage parameter comes into play in developing potential difference between charger and battery so as to enable flow of current from charger to battery.

Voltage rating of charger must greater than voltage of battery so as to create a minimum potential difference b/w battery & charger is 1v. Higher the potential difference=more current can flow=quicker the charging. Current delivery capacity of charger must charge battery in minimum of 4 cycle(battery of 12ahis to charge with max of 3 amp charger)Summing the details more than 35 hours required to complete charge.

Charging time-

Battery charging time in hours and needed charging current in amperes

Charging Time of Battery = Battery Ah ÷ Charging Current

T = Ah ÷ A

And

Required Charging Current for battery = Battery Ah x 10%

A = Ah x 10%

Where

T = Time in hrs.
Ah = Ampere Hour rating of battery
A = Current in Amperes

Example: Calculate the suitable charging current in Amps and the needed charging time in hrs for a 12V, 120Ah battery.

Solution:

Battery Charging Current:

First of all, we will calculate charging current for 120 Ah battery. As we know that charging current should be 10% of the Ah rating of battery.

Therefore,

Charging current for 120Ah Battery = 120 Ah x (10 ÷ 100) = 12 Amperes.

But due to some losses, we may take 12-14 Amperes for batteries charging purpose instead of 12 Amps.

Suppose we took 13 Amp for charging purpose,

then,Charging time for 120Ah battery = 120 ÷ 13 = 9.23 Hrs.
But this was an ideal case…

Practically, it has been noted that 40% of losses occurs in case of battery charging.

Then 120 x (40 ÷ 100) = 48 …… (120Ah x 40% of losses)
Therefore, 120 + 48 = 168 Ah (120 Ah + Losses)
Now Charging Time of battery = Ah ÷ Charging Current

Putting the values;
168 ÷ 13 = 12.92 or 13 hrs. (in real case)

Therefore, a **120Ah battery** would take **13 Hours** to fully charge in case of the required **13A** charging current.

In reference to above calculations, actual voltage available in our project is 4 volts max. and battery used in our project is of 2.15 volts.

So as per the calculations, required charging voltage is 3 volts and charging current found to be 132 milli amps.

Since our output voltage is not continuous and not even of constant magnitude, the charging time is also roughly around 2.5 times more than in actual case with constant voltage.

V. RESULT

5.1.Cost Estimation

Sr. No.	Component	Unit Cost (Rs.)	Quantity	Total Cost
1	Horizontal Wooden Plates	100	4	400
2	Vertical Wooden Plates	50	2	100
3	Rectifier	10	1	10
4	Stud Rods	10	8	80
5	Dynamo motor	130	4	520
6	Belt	10	1	10
7	Pulleys	7	8	56
8	Nut and Bolts	50	-	50
9	Background Structure	500	-	500
10	Miscellaneous (paint, wires, attaching tags, etc.)	300	-	300
	Total			**Rs.2026 /-**

5.1. Component Cost Estimation Table

5.2 Advantages and Disadvantages

5.2.1. Advantages

- There is generation of electricity without polluting the environment.
- It works on the mechanical motion caused by vehicle suspension; hence, no external source require for energy generation.
- with help of charge generating system the batteries are charged during running of the vehicle.
- Simple in construction there by low in maintenance because there are less moving parts in the system
- Will work with almost all type of electric vehicle as every vehicle require suspension system and the system being very easy to install there fore can be affixed to various vehicles easily.
- Do not increase unspring weight as the system's generator's are mounted on fixed link and the device is mounted between chassis and the suspension system.
- It is more reliable for light purpose in suspension bicycles.
- Low Noise & Low Vibration & Control for charging.

5.2.2. Disadvantages

- As the number of generating components & size of components is minimum, so power generation is restricted i.e. it can be used for lighting purpose only.
- On smooth road power generation is less.
- It will make the suspension system complex.
- As whole system consists of electric wiring, so there are chances of short circuits.

VI. CONCLUSION & FUTURE SCOPE

6.1.Conclusion

Energy Generation using vehicle suspension is very efficient and useful in converting the Kinetic Energy in 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, regeneration system presently using alternator is detached from the engine and attached to the suspension system. It can give better results than alternator by recovering the maximum amount of energy from the suspension. It will definitely extend the range of electric vehicles.

6.2. Future Scope

The scope for this project is that it is simple in construction and design and has low in price. It is easily mounted on the chassis of the vehicle. It is able to generate sufficient electricity for different accessories of vehicle.

We can increase power of system by increasing the size and number of generators. By increasing the no. of DC motor, generation of power get increases which are used to charge high voltage battery. If we mount the system on each suspension & common output is taken then we can get the higher value of power generation.

The size of this system is little bulky, so the design can be improved as per requirement, and size can be minimize as per the mountable conditions.

Further improvement in the suspension design makes it suitable for any two wheelers. This system can be used on to the mono suspension system by making suitable design. By modifying this system, we can implement this on to the electric car.

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