Design & Construction of Power Generation system using rack and pinion Mechanism with shock absorber.

A Thesis

by

Shahadath Hossin	**ME2003022307**
Md Rakibul Islam	**ME2003022141**
Md Azad Sarker	**ME2003022205**
Md Mehedi Hasan	**ME2003022214**
AkashKumardas	**ME2003022306**

Supervisor: Niloy Sarkar

Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)

May – 2024

Design & Construction of Power generation system using rack and pinion mechanism with shock absorber.

A Thesis

by

Shahadath Hossin	**ME2003022307**
Md Rakibul Islam	**ME2003022141**
Md Azad Sarker	**ME2003022205**
Md Mehedi Hasan	**ME2003022214**
Akash Kumardas	**ME2003022306**

Supervisor: Niloy Sarkar

Assistant Professor

Submitted to the

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)

In partial fulfillment of the requirements for the award of the degree of Bachelor of Science in Mechanical Engineering

May 2024

Declaration

We do hereby solemnly declare that the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for the award of any degree or certificate

We hereby ensure that the works that have been prevented here do not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from a breach of the foregoing obligation.

Students Name & Signature

_____
Shahadath Hossin

_____
Md Rakibul Islam

_____
Md Azad Sarker

_____
Md Mehedi Hasan

_____
Akash Kumardas

Acknowledgment

First, we started in the name of Almighty Allah. This thesis is accomplished under the supervision of **Niloy Sarkar**, Assistant Professor, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestions, constructive criticism, and endless patience throughthe progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

The authors are also grateful to **Md. Mostofa Hossain**, Head of the Department ofMechanical Engineering, and all respect teachers of the Mechanical Engineering Department for their co-operation and significant help in completing the thesis work successfully.

[Authors]

Abstract

The main objective of designing the controller for a Power generation through Rack end pinion in suspension systemis to reduce the discomfort sensed by passengers which arises from road roughness and to increase the ride handling associated with the pitching and rolling movements. This necessitates a very fast and accurate controller to meet as many control objectives, as possible. The advantage of this controller is that it can handle the non-linearities faster than other conventional controllers. The approach of the proposed controller is to minimize the vibrations on each comer of vehicle by supplying control forces to suspension system when travelling on rough road. Our project is to enlighten the streets utilizing the jerking pressure which is wasted during the vehicles passes over speed breaker in roadside. We can tap the energy generated by moving vehicles and produce power by using the speed breaker as a power generating unit. The kinetic energy of the moving vehicles can be converted into mechanical energy through the rack and pinion mechanism and this mechanical energy will be converted to electrical energy using a generator which will be used for lighting the street lights. Therefore, by using this mechanism we can save a lot of energy which can fulfill our future demands.

Table of Contents

Chapter	Title		Page
	Declaration		ii
	Acknowledgments		iii
	Abstract		iv
	Table of Content		v
	List of Tables		vi
	List of Figures		vii
	Notation		X
1	**Introduction**		**01**
	1.1	Background of the project and state of the art	01
	1.2	Objective	01
2	**Literature Review**		**02**
	2.1	Introduction	02
	2.2	Literature Review	02
	2.3	Power Generation	03
	2.4	Power Generation using Suspension	03
	2.5	Advantages of Suspension Power Generation	04
	2.6	Power Generation using Speed Breaker	04
	2.7	Advantages of Speed Breaker Power Generation	05
	2.8	Summary	05
3	**Working Procedure**		**06**
	3.1	Materials and Methodology	06
	3.2	Rack and Pinion Mechanism	07
	3.3	Chain Drive Mechanisms	08
	3.4	Hydraulic Speed Breaker	09
	3.5	Components List	09
	3.6	Project Prototype	18
	3.7	Working Principle	20
	3.8	Instrument Cost Analysis	21

4	**Method of Suspension system impact test**		**21**
	4.1	Impact Test Method of Suspension system	21
	4.2	Testing Procedure	21
5		**Data Collection**	**23**
	5.1	Test Method of Suspension	23
	5.2	Product testing	23
	5.3	Collection of data	24
	5.4	Data collection (Table-01)	25
	5.5	Data collection (Table-02)	25
6		**Conclusion**	**25**
	6.1	Conclusion	**25**
	References		**26**

List of Tables

TableNo		Page
3.1	Cost analysis of instrument	20
3.9	Device Specification	20

List of Figures

Figure No		Page
3.1	Rack and pinion mechanism	07
3.2	Chain drive	08
3.4	Metal bar	10
3.5	Coil spring	11
3.6	DC generator	12
3.7	Commutator in DC Generator	13
3.8	Rack and pinion	14
3.9	Suspension System	16
3.10	Capacitor	16
3.11	LED Light	17
3.12	3.7 V Battery	18
3.13	Our Final Project Prototype	19
4.1	Working Time	22
5.1	Testing Device	23

Notation

BCE	Before Common Era
DC	Direct current

Chapter 1

Introduction

1.1 Background of the project and state of the art

A suspension or speed bump is a traffic-calming device that uses vertical deflection to slow rotor-vehicle traffic to improve safety conditions on roads. The use of vertical deflection devices is widespread around the world and they are most commonly found where vehicle speeds are statutorily mandated to be low to guarantee safety to road users. A suspension mechanism is a device that converts the impulse energy produced by the passage of the vehicle over a speed bump into the kinetic energy needed to rotate the rotor of an alternator to generate electrical Energy [1].

There has been a wide attention of researchers in the design and development of renewable energy conversion systems. Electrical energy is normally generated through thermal Energy, Mechanical Energy nuclear Energy, and Chemical Energy. Researchers over the years have devised a new method that involves mechanical vibrations. There are three categories of devices that generate electricity by vibration. These are piezoelectric generation devices, electrostatic generation devices, and the Work function energy devices [2].

Piezoelectricity is the electric charge that accumulates in certain solid materials in response to applied mechanical stress. Piezoelectric energy generation remains an emerging technology, though several investigationshave been carried out on it since the late 1990s. Elementary principles of vibration theory, reveal that the resonance of a system can be tuned by changing the stiffness or mass [3].

1.2 Objective

The objectives of this project are:

- To study about Power Generation through Rack & Pinion in suspension System.
- To design and construct a Power Generation through Rack & Pinion in suspension System, using a suspension to convert mechanical energy into electrical energy.
- To Use simple drive mechanisms such as rack and pinion assembly and chain drive mechanisms that convert vehicle bump-generated linear motion and vibration, into electricity to be used in battery charging.
- To ensure general vehicle shock absorbers or other suspension are used to simply absorb this energy converting it to electricity.

Chapter 2

Literature Review

2.1 Introduction

Power is everything in this recent world, from the beginning of science still people try to discover the sources, modify, and develop many concepts and methods for a better future. The efficiency of power generation is the key to making a country economically enriched. Energy can be converted into several forms that can be measured in various ways. Energy is important considering all sectors of a country's economy. The energy crisis is mainly due to two reasons first the population of the world has increased rapidly and second the standard of living of human beings has increased. The share of global electricity demand in developing countries jumps from 27% in 2000 to 43% in 2030. According to the International Energy Agency, the world will need almost 60% more energy in 2030 than in 2002. The count of vehicles passing over speed breakers on roads has increased these days. Such speed breakers are designed for heavy vehicles, as they increase the input torque and ultimately result in increasing the power as output. The kinetic energy of the moving vehicles at the speed breaker can be converted into mechanical energy of the shaft by using a rack and pinion mechanism. Then, this mechanical energy can be transformed to electrical energy using a generator or dynamo which can be stored with the use of a battery. Therefore, by using this arrangement a large amount of energy can be conserved which can be used to fulfill our future demands This energy saved during the daytime can be used at night to light the streetlamps [4].

This chapter is dedicated to the literature that was used and studied in the preparation of this project. The study of literature shows the understanding of information processing solutions in deciding different findings on the literature.

2.2 Literature Review

This project [5] includes how to utilize the energy that is wasted when the vehicles pass over a speed breaker. The proposed project has been designed with the help of the Rack and Pinion mechanism of converting rotational energy into electrical energy, to proper utilization of wasted energy during the passing over of the speed breaker. This method provides an efficient way to generate electricity from the kinetic energy of moving vehicles on roads, highways, etc. The power developed found 205.2864 MW and the percentage of error was found 25.90% (per year), which is very compatible with the other mechanism [5].

The method of energy harvesting using deflection produced by vehicle weight moving on the road can provide a relatively larger and continuous power to the connected load.

The developed system following mechanical motion rectifier has used a method for converting deflection produced by the weight of the vehicle passing over the speed breaker to electrical energy, which resolves the issue of regeneration of lost energy from impulsive vibration. The design approach, power calculation, and working mechanism of the energy harvester are presented. The dead load application in the lab gives a peak output of 4.6 W and a steady state output of 3.25 W.

A sedan vehicle is considered for the realization of the developed system, which ultimately gives a peak output of 18.4 W and a steady-state output of 13 W, which can be utilized to power the typical traffic lights of 12 W along with the street lights. This method of decentralized energy harvesting can lead to a grid-independent traffic signal and control [6].

A vehicle suspension system is to ease passengers' discomfort caused by road roughness and improve ride handling related to pitching and rolling motions. A modification in the present telescopic suspension system has been implemented with the usage of a spring, rack, pinion setup, and a double-fed induction generator. The pinion is further connected to the doubly-fed induction generator shaft. Due to this configuration, the rotating motion of the pinion rotates the generator. As a result of the generator spinning, electrical energy is generated, which is utilized to provide a charging current sufficient for normal-phase mobile charging [7].In this paper [8], such a shock absorber design is implemented in which the energy from the shock absorber is regenerated using a series of neodymium magnets and fed back to the vehicle battery using converters and boosters. The radial magnets are used to produce green electrical energy from the energy that is lost due to damping and different losses. Neodymium magnets, rods, metallic steel pipes, and coils are used in various symmetries to complete the research project. The rings of magnets are attached to the inner rod, which moves in linear motion within the rings of the coils. At the same time, the rings of the coils are placed inside the metallic steel pipe. This linear movement of the rod generates energy that minimizes environmental pollution and reduces carbon emissions.

2.3 Power Generation

Energy is the prime necessity for the survival of every organism in the universe. In this busy and fast-moving world, the 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. To overcome this problem, we need to execute the techniques of optimum use of conventional sources for the conservation of energy. One such technique is explained here. Nowadays power has become a major need for human life. Energy is an important input in all the sectors of any country's economy. The availability of regular conventional fossil fuels will be the main source of power generation, but there is a fear that they will get exhausted eventually by the next few decades. Therefore, we have to investigate other types of renewable sources. The day-to-day increasing population and decreasing conventional sources for power generation provide a need to think about non-conventional energy resources. Another major problem, which is becoming an exciting topic for today is pollution.

Power stations and automobiles are the major pollution-producing places. So non-conventional power source is needed to reduce this problem. We proposed a nonconventional power-generating system based on a speed breaker mechanism that generates electricity without using any commercial fossil fuels, which does not produce any polluting products [9].

2.4 Power Generation using Suspension

Fossil fuels are being consumed at very fast rate. Also, the cost of fuel is increasing at a very fast rate. So, somebody has to work on saving of the fuel consumption. We aim to demonstrate how the kinetic energy from the suspension of a car can be utilized to achieve our goal of obtaining maximum energy that would otherwise have gone to waste. We propose a design plan that converts the mechanical energy in cars to electrical energy much more efficiently than it has been done before. The electricity generated will then be used to recharge the car battery for further use for the functioning of the car. There is a wide scope for regeneration of energy like regeneration of breaking systematic.

We have decided to work on the utilization of the suspending mass of a vehicle through a regeneration system with the help of a shock absorber. Shock absorbers have reciprocating motion in them. Although the reciprocating distance is very low the suspending mass is very high i.e. the mass of the total vehicle. When a vehicle is on a normal road then also shock absorbers are working due to uneven roads, sudden breaking, or sudden acceleration. So this reciprocating motion of shock absorbers can be converted into rotary motion and through a small gearbox attached to the alternator of the automobile, electricity will be generated when shock absorbers are reciprocating [10]

2.5 Advantages of Suspension Power Generation

An electromagnetic suspension system can generate electricity through the principle of electromagnetic induction. The system consists of a moving magnet and a fixed coil, where the relative motion between the two components generates an electric current in the coil.

The suspension system will also provide you with the following benefits:

rides will be smoother and more comfortable.

- It notices more consistent and reliable handling and braking, along with better stability.
- tires will maintain improved contact with the road.
- tires and brakes will wear evenly.
- Those expensive tires will last longer.
- It achieves improved gas mileage.
- Wear on other vehicle systems will reduce

2.6 Power Generation rack and pinion

It is very significant to design a pollution-free energy generation system. suspension Power Generator (SBPG) is the most emerging technique that produces electrical power with minimum input. An experimental study to generate electricity by SBPG is described in this paper. In this system, a rack and pinion mechanism are used for the production of electricity. When a car reaches the speed breaker, the rack moves downward to generate linear to rotary motion using pinions.

The rotary motion is transferred to a DC generator which generates DC power which is stored in batteries same as in solar technology. The generated power can be used for domestic purposes or commercially, which are present near the suspension[11].

Energy is the primary need for the survival of all organisms in the universe. Everything that happens in the surroundings is the expression flow energy in one of the forms. But in this fast-moving world, the population is increasing day by day and the conventional energy sources are lessening. The extensive usage of energy has resulted in an energy crisis over the past few years. Therefore, to overcome this problem we need to implement the techniques of optimal utilization of conventional sources for conservation of energy. This paper includes how to utilize the energy that is wasted when the vehicles pass over a speed breaker. Lots of energy is generated when a vehicle passes over it. We can tap the energy generated and produce power by using the suspension as a power-generating unit.

The kinetic energy of the moving vehicles can be converted into the mechanical energy of the shaft through the rack and pinion mechanism. Then, this mechanical energy will be converted which will be saved with the use of a battery [12].

2.7 Advantages of through Rack & Pinion in suspension Power Generation

It converts rotary motion into linear motion, but sometimes we use them to change linear motion into rotary motion. This mechanism is very economical and easy to install. By making proper arrangements we may generate high power electricity from road traffic. The speed bump generator can produce power that can be used to control traffic speeds therefore it ensures the safety of the pedestrians. Speed bump generator works in all weather conditions and it is environmentally friendly.

The advantage of a suspension electricity generation unit over solar lies in its ability to generate electricity from the kinetic energy of vehicles passing over the speed breaker. This means that it can generate electricity 24/7, regardless of weather conditions or time of day, whereas solar panels only generate electricity when exposed to sunlight. Additionally, speed breaker electricity generation units can be installed in urban areas where space for solar panels may be limited, and they can complement existing renewable energy sources to diversify the energy mix. However, it's important to note that both technologies have their advantages and limitations, and the choice between them depends on various factors such as location, energy requirements, and cost considerations.

2.8 Summary

From the literature discussed above, we gained a lot of knowledge and we were inspired to do this project. We were able to do it with everyone's tireless work.

Chapter 3

Working Procedure

In this chapter, we will discuss our system methodology, system description, block diagram, circuit diagram, working principle, and instrument cost analysis.

3.1 Materials and Methodology

This project is to enlighten the streets by utilizing the jerking pressure that is wasted during the vehicle's passes over the speed breaker on the roadside. The system can tap the energy generated by moving vehicles and produce power by using the speed breaker as a power-generating unit. The kinetic energy of the moving vehicles can be converted into mechanical energy through a rack and pinion mechanism and this mechanical energy will be converted to electrical energy using a generator which will be used for lighting the streetlights. Therefore, by using this mechanism we can save a lot of energy which can fulfill our future demands.

The Methodology of this project are:

The working principle of this power generation program is to convert the kinetic energy to electric energy via mechanical energy. This can be done when the brakes are applied upon the vehicle kinetic energy is produced. After this the kinetic energy is converted to mechanical energy using a rack and pinion gear and by connecting the pinion gear to a generator shaft the energy is converted into electrical energy.

Suspension:

The suspension system in a vehicle provides the framework for the vehicle to nullify the vibrations arising from the road irregularities by reciprocation of coil springs. Kinetic energy is stored in the springs when reciprocating and the frequency of vibration is attenuated by dampers only to dissipate all the energy in the form of heat. As the quest for green engineering is at its apex, the prototype Suspension System for Power Generation is in conjunction with it while being modest in design and simplistic in functioning.

Electricity Storage:

It is very difficult to store electricity for a long time in any kind of storage. To deal with this issue a battery pack will be introduced which will help us store the electric energy into the battery pack. Also, battery packs can be useful to transfer electric energy from one place to another.

3.2 Rack and Pinion Mechanism

The process of generating power using the rack and pinion method is efficient and many authors conducted experimental studies on this process. This method has a rack that creates linear motion and a pinion that converts that linear motion into rotator motion. That rotary motions are transferred to the generator. In between a gear train or transmission system is built to transfer the energy efficiently. At the end of the transmission system there is a generator connected.

We all know the purpose of the generator that is to convert the mechanical energy to electrical energy. The power generated will depend upon the efficiency of the rack and pinion mechanism and the transmission system.

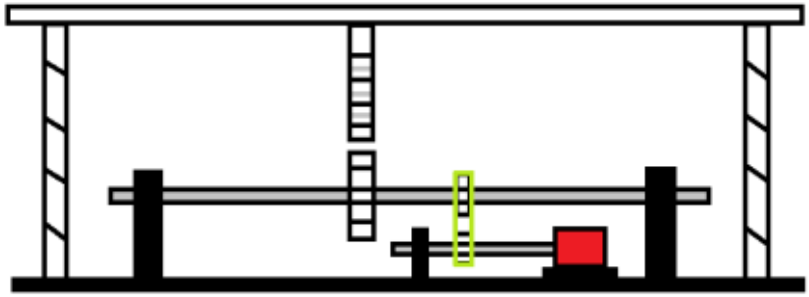


Figure 3.1: Rack and pinion mechanism [ISSN No: −2456 − 2165]

Working:

So, we see many vehicles on roads as well as speed bumps for controlling the speed of the vehicles indicating speed limit on roads. The design of the speed bump is of a special kind that is the speed bump is designed as a kind of suspension system. The speed bump is spring-supported at both ends. So, whenever a vehicle or weight passes over the speed breaker the springs under the speed breaker take the energy and get compressed. During this process, the speed breaker can generate the linear motion. As the rack and pinion mechanism is connected to the speed breaker the linear motions created by the speed breaker are taken by the rack and pinion mechanism. Sothe rack and pinion mechanism converts the linear motion to the circular motion. Circular motions are transferred to the generator by using the transmission system. The transmission system may be of different kinds i.e., gear train, belt drive, chain sprocket mechanism.

The advantages of rack and pinion in the steering system.

- The rack and pinion steering gearbox has a straightforward design.
- easy to create and inexpensive.
- It is simple to use with precision.
- The contact between the steering rack and the pinion is free of play.
- There is no loss of internal damping.
- The idler arm and intermediate rod are not required.
- It is simple to limit steering rack motion and hence steering angle.

3.3 Chain Drive Mechanisms

The Chain Drive block represents a power transmission system with a chain and two sprockets. The chain meshes with the sprockets, transmitting rotary motion between the two.

Power transmission can occur in reverse, that is, from driven to driver sprocket, due to external loads. This condition is known as back-driving.

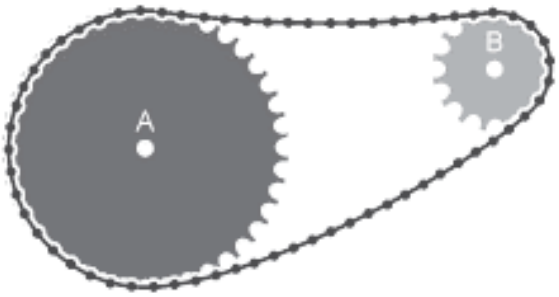


Figure 3.2: Chain drive

The drive chain is compliant. It can stretch under tension or slacken if loose. The compliance model consists of a linear spring-damper set in a parallel arrangement. The spring resists tensile strain in the chain. The damper resists tensile motion between chain elements.

The spring and damper forces act directly on the sprockets that the chain connects. The spring force is present when one chain branch is taut. The damper force is present continuously. To represent and report a failure condition, the simulation stops and generates an error if the net tensile force in the chain exceeds the specified maximum tension value.

The block accounts for viscous friction at the sprocket joint bearings. During motion, viscous friction causes power transmission losses, reducing chain-drive efficiency. These losses compound due to chain damping. To eliminate power transmission losses in the chain drive, in the Dynamic settings, set the parameters for viscous friction and chain damping to zero.

3.4 Hydraulic Speed Breaker

The hydraulic speed breaker mechanism showed better results when compared to the crank shaft mechanism. This process uses pistons to compress the oil. So that the power is supplied to the system. All the equipment may be costlier here.

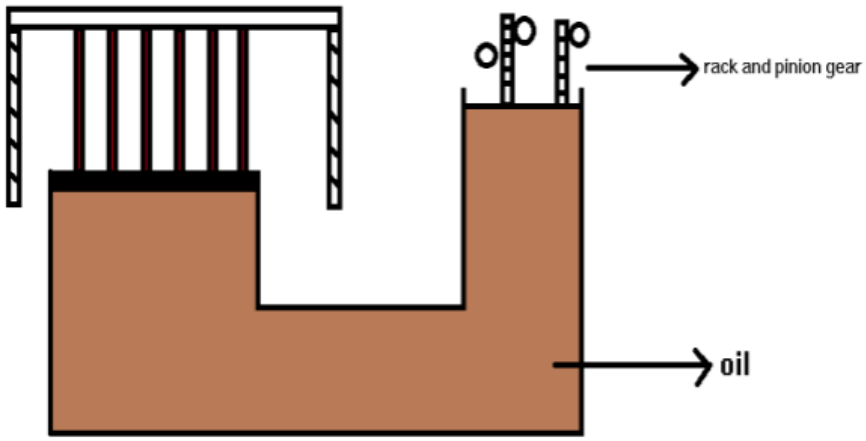


Figure 3.3: Hydraulic speed breaker [ISSN No: −2456 − 2165]

Working:

Here also the speed breaker is a spring supported at both ends so that the speed breaker can create linear motion. And pistons are provided under the speed breaker such that the speed breaker pushes down the pistons whenever a vehicle passes over it. Such that the piston can compress the oil provided under the piston. The compressed oil travels to the accumulator. The accumulator is further connected to the motor which generates torque. That torque is used to generate the electrical energy.

3.5 Components List :

- Metal Bar
- Sheet
- Coil Spring
- DC Generator
- Pinion
- Suspension system
- Wire
- Printed electronic board
- Capacitor
- LED
- DC Battery

Metal Bar

Bar stock, also (colloquially) known as blank, slug, or billet, is a common form of raw purified metal, used by industry to manufacture metal parts and products. Bar stock is available in a variety of extrusion shapes and lengths. They are generally used for support braces, ladder hangers, gate latches, duct work, overhead doors, heaters, and bracing.

The bar is a metric unit of pressure defined as 100,000 Pa (100 kPa), though not part of the International System of Units (SI). A pressure of 1 bar is slightly less than the current average atmospheric pressure on Earth at sea level (approximately 1.013 bar).

The formula for the weight of the steel bar is W=D2L/162.



Figure 3.4: Metal bar

Coil Spring

The function of a coil spring can be better understood if we visualize it as a long, thin, torsion bar wound into a coil shape. Because the coiled wire twists during the spring's compression/extension cycles, the coil spring operates on the same principle as a torsion bar. Since a coil spring occupies a relatively small space, it can be used in a variety of suspension designs including MacPherson strut, solid axle with trailing arms, independently sprung rear axle, or any SLA suspension system using a spring or coil-over shock absorber configuration.

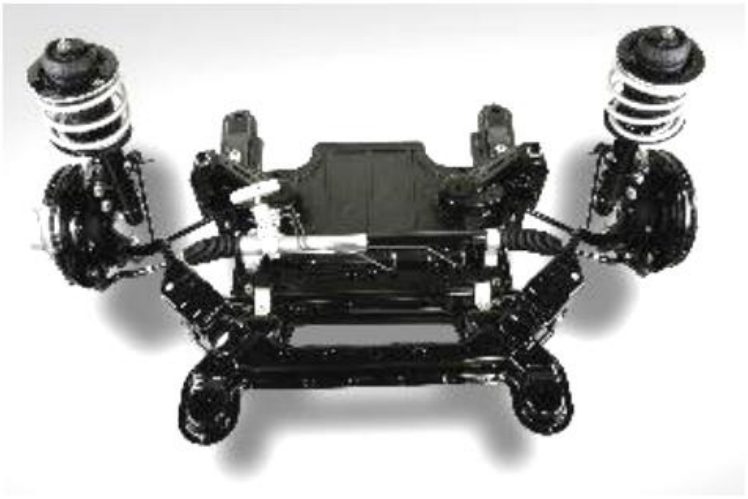


Figure 3.5: Coil spring

How Springs Work:

Springs cushion the ride of a vehicle according to the principle of sprung-to-unspring weight ratios. A farm wagon with no springs represents 100% unspring weight. In this example, if springs are installed between the chassis and axles, the sprung-to-unspring ratio might be 90% representing the chassis weight, and 10% representing the axle and wheel weight. As a vehicle gains speed, the springs begin to absorb the impact of striking irregularities in the road surface. As vehicle speed increases, a stiffer spring rate is required to keep the axles and wheels in contact with the road surface.

This is why high-performance vehicles tend to use stiffer suspension systems than regular passenger vehicles. Because a compressed spring will extend violently, shock absorbers must be used to dampen the spring's compression and extension cycles. Without dampening, a spring's violent compression and extension would cause a vehicle to lose control on a rough road surface. As rebound control deteriorates due to normal shock absorber wear, the vehicle will begin to experience poor ride, steering response, and handling control. In addition, tire wear will be accelerated due to tire scuff caused by the suspension geometry operating out of its normal range. This is why shock/strut manufacturers are adamant about the regular inspection and replacement of worn units. In general, the compression and extension characteristics of the shock absorber must match the compression and extension characteristics of the spring. Since stiffer springs don't normally experience extreme ranges of travel, less dampening or rebound control might be required for normal driving. Softer rated springs, on the other hand, may require more dampening because they tend to experience more compression and extension and, thus, make the shock absorber work much harder. For performance applications, it's essential to remember that the sway bar must also be included as part of any spring or shock absorber package.

DC Generator

A DC generator or direct current generator is one kind of electrical machine, and the main function of this machine is to convert mechanical energy into DC (direct current) electricity. The energy alteration process uses the principle of energetically induced electromotive force. The dc generator is shown below.



Figure 3.6: DC generator

When a conductor slashes magnetic flux, then energetically induced electromotive force will be generated in it based on the Electromagnetic Induction principle of Faraday's Laws. This electromotive force can cause a flow of current when the conductor circuit is not opened.

Construction

A DC generator is also used as a DC motor without changing its construction. Therefore, a DC motor otherwise a DC generator can be generally called a DC machine. The construction of a 4-pole DC generator is shown below. This generator comprises of several parts like yoke, poles & pole shoes, field winding, an armature core, armature winding, commentator & brushes. But the two essential parts of this device are the stator as well as the rotor.

Stator:

The stator is an essential part of the DC generator, and the main function of this is to provide the magnetic fields where the coils spin. This includes stable magnets, where two of them are with reverse poles facing. These magnets are located to fit in the region of the rotor.

Rotor or Armature Core:

The rotor or armature core is the second essential part of the DC generator, and it includes slotted iron laminations with slots that are stacked to shape a cylindrical armature core. Generally, these laminations are offered to decrease the loss because of the eddy current.

Armature Windings:
The armature core slots are mainly used for holding the armature windings. These are in a closed-circuit winding form, and it is connected in series to parallel for enhancing the sum of produced current.

Yoke:
The external structure of the DC generator is a Yoke, and it is made with cast iron otherwise steel. It gives the necessary mechanical power for carrying the magnetic flux given through the poles.

Poles:

These are mainly used to hold the field windings. Usually, these windings are wound on the poles, & they are connected in series or otherwise parallel by the armature windings. In addition, the poles will give joint toward the yoke with the welding method otherwise by using screws.

Pole Shoe:

The pole shoe is mainly utilized for spreading the magnetic flux as well as to prevent the field coil from falling.

Commutator : The working the Commutator is like a rectifier for changing the AC voltage to the DC voltage within the armature winding across the brushes. It is designed with a copper segment, and each copper segment is protected from each other's with the help of mica sheets. It is located on the shaft of the machine.

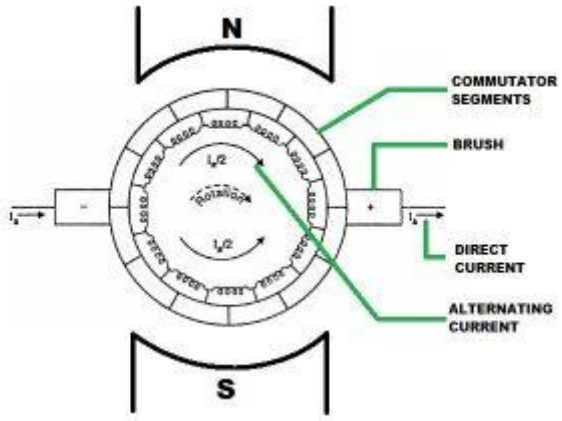


Figure 3.7: Commutator in DC Generator [https://electricallive.com/]

DC Generator Commutator Function:

The main function of the commutator in the DC generator is to change the AC to DC. It acts like a reversing switch and its role in the generator is discussed below.

The emf which is induced within the armature coil of the generator is alternating. So, the flow of current within the armature coil can also be alternating current.

This current can be reversed through the commutator at the accurate moment once the armature coil crosses the magnetic unbiased axis. Thus, the load attains a DC or unit-directional current.

The commutator guarantees that the flow of current from the generator will flow forever in a single direction. The brushes will make high-quality electrical connections between the generator & the load by moving on the commutator.

Brushes:

The electrical connections can be ensured between the commutator as well as the exterior load circuit with the help of brushes.

Working Principle:

The working principle of the DC generator is based on Faraday's laws of electromagnetic induction. When a conductor is located in an unstable magnetic field, an electromotive force is induced within the conductor. The induced e.m.f magnitude can be measured from the equation of the electromotive force of a generator.

If the conductor is present with a closed lane, the current that is induced will flow in the lane. In this generator, field coils will generate an electromagnetic field as well as the armature conductors are turned into the field. Therefore, an electromagnetically induced electromotive force (e.m.f) will be generated within the armature conductors. The path of induced current will be provided by Fleming's right-hand rule.

Rack and Pinion

A rack and pinion linear actuator is made up of a circular gear (the pinion) that engages with a linear gear (the rack). Together, they transform rotational motion into linear motion. The rack is driven in a straight path when the pinion is rotated. Moving the rack linearly, on the other hand, causes the pinion to revolve. Straight and helical gears can be used in a rack and pinion drive. Although some argue that helical gears are quieter, no concrete data supports this claim. While helical racks are less expensive, they have been shown to increase side torque on the datums, increasing operating temperature and leading to premature wear.



Figure 3.08: Rack and pinion

Types of Rack and Pinion Gears

Two gears make up a rack and pinion gears system. The pinion gear is a standard round gear, and the rack is straight or flat. The rack has teeth carved into it that mesh with the pinion gear's teeth. The differential's critical point of power transfer is a ring and pinion gear.

There are three types of rack and pinion gears.

i. **Straight Teeth:** Straight teeth have a tooth axis perpendicular to the rotation axis. Straight teeth that go straight to the gear's axis. Manual or walk-behind load movement or transfer is used.
ii. **Helical Tooth Gears:** Helical tooth gears are frequently quieter and more efficient than straight tooth gears because they allow continuous engagement over the tooth length. In the plane of rotation, helical tooth gears are similar to spur gears, but they have teeth twisted along a helical path in the axial direction.
iii. **Roller Pinion:** Roller pinion drives employ bearing-supported rollers that mesh with the rack's teeth to provide minimal to no backlash.

Application of Rack and Pinion

Gear racks turn rotary motion into linear motion. A gear rack is a small cylindrical gear with straight teeth cut onto one surface of a square or round piece of the rod that meshes with another gear rack. Gear rack and pinion are called rack and pinion. Gears can be utilized in a variety of applications.

Suspension System

Suspension is the system of tires, tire air, springs, shock absorbers, and linkages that connect a vehicle to its wheels and allow relative motion between the two. Suspension systems must support both road holding/handling and ride quality, which are at odds with each other.

Electromagnetic suspension (EMS) is the magnetic levitation of an object achieved by constantly altering the strength of a magnetic field produced by electromagnets using a feedback loop. In most cases, the levitation effect is mostly due to permanent magnets as they don't have any power dissipation, with electromagnets only used to stabilize the effect. According to Earns haw's Theorem, a paramagnetic ally magnetized body cannot rest in stable equilibrium when placed in any combination of gravitational and magneto static fields. In these kinds of fields, an unstable equilibrium condition exists.

Although static fields cannot give stability, EMS works by continually altering the current sent to electromagnets to change the strength of the magnetic field and allow a stable levitation to occur. In EMS a feedback loop that continuously adjusts one or more electromagnets to correct the object's motion is used to cancel the instability. Many systems use magnetic attraction pulling upwards against gravity for these kinds of systems as this gives some inherent lateral stability, but some use a combination of magnetic attraction and magnetic repulsion to push upwards.

Magnetic levitation technology is important because it reduces energy consumption, and largely reduces friction. It also avoids wear and has very low maintenance requirements. The application of magnetic levitation is most commonly known for its role in Maglev trains.

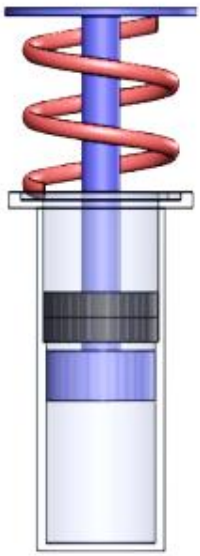


Figure 3.09: Suspension System

Capacitor

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge (+Q) to collect on one plate and negative charge (-Q) to collect on the other plate.

If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if an accelerating or alternating voltage is applied across the leads of the capacitor, a displacement current can flow.



Figure 3.10: Capacitor

An ideal capacitor is characterized by a single constant value for its capacitance. Capacitance is expressed as the ratio of the electric charge (Q) on each conductor to the potential difference (V). The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V).

Typical capacitance values range from about 1 pF (10−12 F) to about 1 mF (10−3 F).The capacitance is greater when there is a narrower separation between conductors and when the conductors have a larger surface area. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance. Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits, they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow.

LED

A light-emitting diode (LED) is a semiconductor device that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device. Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared (IR) light.

Infrared LEDs are used in remote-control circuits, such as those used with a wide variety of consumer electronics. The first visible-light LEDs were of low intensity and limited to red. Early LEDs were often used as indicator lamps, replacing small incandescent bulbs, and in seven-segment displays.



Figure 3.11: LED Light

DC Battery

Lithium batteries are primary batteries that have metallic lithium as an anode. These types of batteries are also referred to as lithium-metal batteries. They stand apart from other batteries in their high charge density and high cost per unit. Depending on the design and chemical compounds used, lithium cells can produce voltages from 1.5 V (comparable to a zinc-carbon or alkaline battery) to about 3.7 V.

Disposable primary lithium batteries must be distinguished from secondary lithium-ion or a lithium-polymer, which are rechargeable batteries. Lithium is especially useful because its ions can be arranged to move between the anode and the cathode, using an intercalated lithium compound as the cathode material but without using lithium metal as the anode material. Pure lithium will instantly react with water or even moisture in the air; the lithium in lithium-ion batteries is a less reactive compound.



Figure 3.12: 3.7V Battery

Lithium batteries are widely used in portable consumer electronic devices. The term "lithium battery" refers to a family of different lithium-metal chemistries, comprising many types of cathodes and electrolytes but all with metallic lithium as the anode.

The battery requires from 0.15 to 0.3 kg of lithium per kWh. As designed these primary systems use a charged cathode, that being an electro-active material with crystallographic vacancies that are filled gradually during discharge. Product Specification

- Voltage: 3.7 V
- Product Type: Lithium-Ion Battery
- Capacity: 2200mAh
- Weight: 45 g
- Model Number: ICR 18650

3.6 Project Prototype



Figure 3.13: Our Final Project Prototype

3.7 Working Principle

In this project, we are generating electrical power using non-conventional methods by simply suspension and speed breaker-based power generation. The non-conventional energy system is very essential at this time to our nation. Non-conventional energy using a speed breaker converts mechanical energy into electrical energy.

This project uses simple drive mechanisms such as rack and pinion assembly and chain drive mechanisms. that converts vehicle bump-generated linear motion & vibration, into electricity to be used in battery charging. General vehicle shock absorbers or other suspensions are used to simply absorb this energy converting it to electricity. So here we put forth a way to use this free energy and store it for further needs such as use area Road light, Road CC Camera, Auto Traffic signal Light, vehicle lights, cooling, indicator lights, etc.

3.8 Instrument Cost Analysis

Serial No	Components	Price
1	LED	20
2	Capacitor	100
3	Vero Board	90
4	Battery	90
5	Battery Case	30
6	Switch	05
7	Motor	820
8	Propeller	05
9	Wire	100
10	MS and Others	8000
	Total=	9260 Taka

Table 3.1: Cost analysis of instruments

3.9 Device Specification:

Device Name	Power Consumption
DC Motor	3-12 V Produce DC Voltage
LED	1.5 V consumptions
Propeller Motor	3 V consumption

Chapter 4

Method of Suspension system impact test

4.1 Impact Test Method of Suspension system

Impact testing is used to determine the ability of a material to withstand or absorb energy when experiencing a sudden high force or shock. The energy may be used to determine the toughness, fracture resistance, impact resistance, and impact strength of a material depending on the test performed. The impact test determines the amount of energy absorbed by a material during fracture.

This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition. It is to determine whether the material is brittle or ductile in nature. The standard test for measuring impact energy is the Charpy test. This indicates the characteristics of the material during fracture.

An arm is swung down in a pendulum motion to impact with the test material. The energy required to fracture the sample is recorded.

There are two types of impact tests: pendulum and drop weight. Izod, Charpy, and tensile impact are the most common of the pendulum-type tests.



Figure : 4.1 Working Time

Chapter 5

Data collection

To perform a nick break test, a specimen is prepared out of the weld metal. Stress concentrators are then machined into the specimen. The specimen is then broken and the fracture surface is observed after the nick break test.

5.1 Test Method of Suspension

The Nick Break Test or Fracture is used to determine the quality of a weld and involves breaking open the weld length-wise, and then visually inspecting the exposed weld interior for any internal imperfections such as lack of sidewall fusion, lack of inter-run fusion, and porosity.

It involves breaking open the weld length-wise and visually inspecting the exposed weld interior for internal imperfections such as lack of sidewall fusion, inter-run fusion, and porosity. The Fracture Test, also known as the Fillet Weld Break Test, is a destructive testing process for examining root penetration.

Nick break tests are used to determine the internal defects of the weld, such as gas pockets, poor fusion, slag inclusions, oxidation, or burnt metal.

5.2 Procedure of Testing



Figure 5.1: Testing Device

Test of Hardness

A hardness test is typically performed by pressing a specifically dimensioned and loaded object (indenter) into the surface of the material you are testing. The hardness is determined by measuring the depth of indenter penetration or by measuring the size of the impression left by an indenter.

There are several different types of hardness testers, including Vickers, Brinell, and Rockwell. All methods of hardness testing are based on the principle of applying a standard load through an indenter and measuring the penetration in terms of diameter/diagonal/depth of indentation.

5.3 Collection Of Data

Data collection Table: 01

Time	Dc voltage	change	Total
1 minute	3.00 v	20 mv	3.02 v
2 minute	3.02 v	20 mv	3.04 v
3 minute	3.04 v	20 mv	3.06 v
4 minute	3.06 v	20 mv	3.08 v
5 minute	3.08 v	20 mv	3.10 v

Data collection Table: 02

Time	Power (P=V×I)	Total
1 minute	(0.02*3/60)=0.001 J/min	0.001 J/min
2 minute	(0.02*3/120)=0.0005 J/min	0.0015 J/min
3 minute	(0.02*3/180)=0.00033 J/min	0.00183 J/min
4 minute	(0.02*3/240)=0.00025 J/min	0.00208 J/min
5 minute	(0.02*3/300)=0.0002 J/min	0.00228 J/min

Chapter 6

Conclusion

6.1 Conclusion

Energy is an important part of retaining the industrial production rate and also the progress of any Country. Conventional sources are reducing day by day and by the turn of the century, we have to depend upon non-conventional sources of energy. (Non-conventional sources such as solar energy, wind energy, biogas, etc.) We can also increase the growth of the country by installing Power Generation from speed breakers by using electromagnetic suspension in heavy traffic roads and toll plazas. We can generate electricity almost continuously by using the weight of the vehicles to produce mechanical power in the shafts by using the rack and pinion mechanism. As this method does not require any external power source and the traffic never reduces, these Power Generation from speed breakers by using electromagnetic suspension are more reliable and have a longer life span.

Our project has many application areas and actually,and we need to use them in many places to verify the exact person whohas the proper access. Some of the application areas of the project have been pointed out below:

- Street lights.
- Road signals.
- Sign boards on roads.
- Digital advertising boards on roads.
- Lighting of the check post on the highways

References:

[1] Olugboji, O. A., M. S. Abolarin, I. E. Ohiemi, and K. C. Ajani. "Modelling and design of an auto street light generation rack & pinion mechanism." *American Journal of mechanical engineering* 3, no. 3 (2015): 84-92.

[2] Bhagdikar, Piyush, Shubham Gupta, Navneet Rana, and R. Jegadeeshwaran. "Generation of electricity with the use of rack & pinion mechanism." *International Journal of Advances in Engineering & Technology* 7, no. 2 (2014): 589.

[3] Manbachi, Amir, and Richard SC Cobbold. "Development and application of piezoelectric materials for ultrasound generation and detection." *Ultrasound* 19, no. 4 (2011): 187-196.

[4] Ramadan, Mohamad, Mahmoud Khaled, and Hicham El Hage. "Using speed bump for power generation–Experimental study." *Energy Procedia* 75 (2015): 867-872.

[5] Hossain ME, Hasan MR, Ahmed KT, Shawon MN. Design and performance of power generation using speed breaker with the help of Rack and Pinion mechanism. In2017 4th International Conference on Advances in Electrical Engineering (ICAEE) 2017 Sep 28 (pp. 7-11). IEEE.

[6] Raj, Nikhil, Ankit Dasgotra, Surajit Mondal, Suresh Kumar, and Ravi Kumar Patel. "Deflection-Based Energy Harvesting Speed Breaker and It's Mechatronic Application." *International Journal of Sustainable Engineering* 14, no. 5 (2021): 1033-1042.

[7] Sebastiraj B, Arivazhagan A. Design and Development of Power Generation using Vehicle Suspension. International Journal of Vehicle Structures & Systems (IJVSS). 2023 Sep 1;15(5).

[8] Ahmad M, Bhatti AH, Ashraf MM. Energy Recovery Using Regenerative Suspension System. In2024 7th International Conference on Energy Conservation and Efficiency (ICECE) 2024 Mar 6 (pp. 1-6). IEEE.

[9] Gupta, Rajat, Suyash Sharma, and Saurabh Gaykawad. "A revolutionary technique of power generation through speed breaker power generators." *International Journal of Engineering Research & Technology (IJERT)* 2, no. 8 (2013): 2278-0181.

[10] Bhoite R, Jadhav S, Jape A, Phadatare V, Jadhav A. Energy Generation by Suspension System. IJISET-International Journal of Innovative Science, Engineering & Technology. 2015 May;2(5).

[11] Gupta, Abhishek, Nikita Mittal, Pushpendra Pal Singh, Ram Arora, RamkishanDhakar, Purab Chand, and Piyush Mangal. "Electricity Generation from rack&pinion." *International Journal of Electrical and Electronics Research* 4 (2016).

[12] Kharche L, Jadhav K, Gawas P, Gharat C. suspension power generation. International research journal of engineering and technology. 2019 Apr;6(2):2973-9.