DESIGN OF RETROFITTING SMART SHOCK ABSORBER

A PROJECT REPORT

Submitted by

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to

the APJ Abdul Kalam Technological University

in partial fulfillment of the requirements for the award of the Degree

of

Bachelor of Technology

in

Mechanical Engineering

Department of Mechanical Engineering

Government Engineering College

Thrissur, Kerala

JULY 2020

DECLARATION

We undersigned hereby declare that the project report **"DESIGN OF RETROFITTING SMART SHOCK ABSORBER "**,submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by us under supervision of **Dr. A R Soman** , Associate Professor, Government Engineering College, Thrissur. This submission represents our ideas in our own words and where ideas or words of others have been included; we have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not previously formed the basis for the award of any degree, diploma or similar title of any other University.

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CERTIFICATE

This is to certify that the project proposal report entitled **"DESIGN OF RETROFITTING SMART SHOCK ABSORBER"** submitted by **Jishnu P (TCR16ME052) , Jojin Johnson (TCR16ME055) , Muhammed Rufaid P (TCR16ME067) and Rahul P (TCR16ME078)** in partial fulfillment of the requirements for the award of degree of Bachelor of Technology in Mechanical Engineering is a bonafide record of the project work carried out under our guidance and supervision at Government Engineering College, Thrissur, Kerala , India.This report in any form has not been submitted to any other University or Institute for any purpose.

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ACKNOWLEDGEMENT

This project proposal report has been possible only due to support and help from various people. This report would not be complete unless their contributions are acknowledged.

First of all, we would like to thank **Dr.Sheeba V S**, Principal, Government Engineering College, Thrissur for giving us an opportunity to do this work.

We would like to express our sincere thanks to **Dr.Mohandas V P**, Head of the Department, Department of Mechanical Engineering, Government Engineering College, Thrissur for giving us permission to do this work and timely support he gave whenever required.

We take this opportunity to express our sincere gratitude to our guide, **Dr.A R Soman**, Associate Professor, Department of Mechanical Engineering, Government Engineering College, Thrissur for his constant encouragement and guidance throughout the work.

We wish to express our sincere gratitude to our project coordinator, **Dr. Sunil A S**, Associate Professor project evaluation committee members and all teaching and non teaching staff of Government Engineering College, Thrissur for their guidance and timely help rendered.

We would like to express our gratitude to our families and friends, for their unending support, love and encouragement. Finally we express our gratitude to all of those who are remotely involved in this work.

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ABSTRACT

Automotive play a vital role among humans since its invention. The development in the field of automotive is drastic till today. Several researches and studies are going on to improve the efficiency of automobile and make it more energy efficient. There are several ways of harnessing energy to meet the energy requirements, one such technology is regenerative energy harnessing. There are many ways by which energy can be regenerated like regenerative breaking, regenerative compression (in the case of compressed air hybrid vehicle), regenerative shock absorber etc. This project aims at design of retrofitting smart shock absorber for automobiles.The new setup enhances the battery life without much loss in comfort.

CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

Eg	Generated voltage
K	Fixed constant
F	Magnetic field strength
%	Percentage
N	Speed in RPM
A	Ampere
kg	Kilogram
σB	Bending stress
σu	Ultimate stress
V_m	Velocity
y	Lewis form factor
F_d	Dynamic force
F_t	Tangential force
V	Volts
W	Watts
C_v	Velocity factor
m	Module
d	Diameter
b	Face width
^{o}	degree
Hr	Hour

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

It is known that automobiles are inefficient, wasting over 80% of the energy stored in the fuel as heat. Thus, eight of every ten gallons in the vehicle's tank don't help propel the vehicle; they are burned to overcome losses in the system. Automobile manufacturers have made costly strides to improve fuel economy. For example, regenerative braking is standard on many hybrid automobiles. Car manufacturers also spend a great deal of effort to reduce wing drag so as ,improve fuel economy through streamlined, low drag automobile body designs. Manufacturers also use lighter, yet more expensive, materials to reduce vehicle weight to reduce fuel consumption. This investigation looks into the most efficacious rack and pinion-based mechanism of harvesting energy from a vehicle suspension system.

Suspension system in two wheelers is equipped with large hydraulic shock absorbers with internal coil springs. The main work of the absorber is to allow the front wheel to react to imperfections in the road while isolating the rest of the vehicle from that motion thus huge amount of energy is wasted through suspension system and the aim is to harness a portion of this energy

Custom apparatuses were designed for the purpose of this investigation.

1.1 BACKGROUND & MOTIVATION

The function of vehicle suspension system is to support the weight of vehicle body, to isolate the vehicle chassis from road disturbances, and to enable the wheels to hold the road surface. Two chief elements in suspension are spring and damper. Conventionally, damper is designed to dissipate vibration energy into heat to attenuate the vibration which is transmitted from road excitation. However, the dissipated heat is from fuel or electrical power. It is a pity that so much energy is wasted. Green manufacturing, also called environmentally conscious manufacturing, is one of the most popular topics nowadays. The future of green manufacturing technology is foreseeable, especially on vehicle industry. Since the suspension is an important source of energy dissipation, it is feasible to harvest its vibration energy and convert into regenerative energy to improve the vehicle fuel efficiency. Therefore, so called smart shock absorbers arise as the times require. Regeneration of waste energy is one of the important elements in mechanical engineering fields. The mechanical element is always playing an important role on designing a new system in engineering field. A suspension system on land vehicle is one of them which dissipate energy to facilitate passenger isolation by using viscous dampers. The energy regenerative suspension system is already been researched by several automotive industries since the 1990s and several papers have been presented and proposed. The researches on the regenerative suspension system and improvement done to the proposed model but until now the development is still far away from the demands on the commercial applications. There are only some researchers that discovered and made a concrete achievement in specific test. The energy regenerative suspension system is introduced to reduce the energy consumption without losing damping efficiency and electric energy is generated during a high-speed motion of the suspension system. The suspension system has high dissipation energy that is suitable for harvested for the regeneration system Instead of dissipating the vibration energy into heat wastes, the damper in regenerative suspension will transform the kinetic energy into electricity or other potential energy and store it for late use.

1.1.1 Retrofitting smart shock absorber

A retrofitting smart shock absorber consists of rack and pinion arrangement to convert irregular vibrations into useful electric energy. It is actually a kind of regenerative shock absorber which make use of vehicles suspension’s dissipative energy and convert into useful electrical energy. The working principle of the retrofitting smart shock absorber is shown in the fig.1.1. Shock absorbers are installed between chassis and wheels to suppress the vibration, mainly induced by road roughness, to ensure ride comfort and road handling. Retrofitting smart shock absorbers translate the suspension oscillatory vibration into bidirectional rotation, using a mechanism like rack and pinion gear. This bidirectional rotational motion is used for generating electricity.

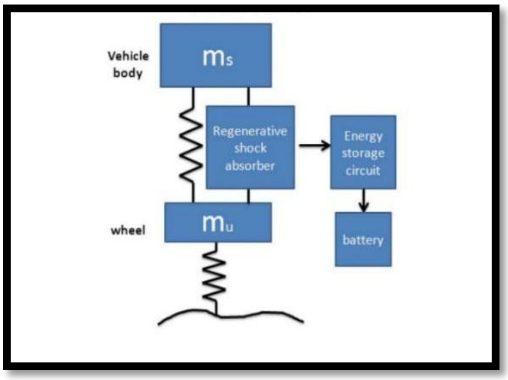

Fig.1.1 Working of retrofitting smart shock absorber [2]

1.1.2 Advantages

- Power generation in every second of motion of vehicle
- Simple in construction
- No need of fuel
- This is a Non-conventional system
- Battery is used to store the generated power
- Enhances fuel efficiency
- Improves suspension damping efficiency
- Can be fitted in any motor bikes and hence flexible.

1.1.3 Limitations

Though they have many advantages, there are some limitations also.

- Mechanical moving parts is high
- Initial cost of this arrangement is high.
- Care should be taken for batteries

1.2 OBJECTIVE

There have been several types of smart shock absorber being developed across the world like electromagnetic smart shock absorber, hydraulic regenerative shock absorber etc. The main objective of proposed work is to design a smart shock absorber which can be externally fitted to a motorbike and to calculate power output of the same under various road conditions.

1.3 ORGANIZATION OF THE REPORT

In the first chapter a brief description on retrofitting smart shock absorber is described. Review of literature on performance studies on regenerative shock absorbers and conclusions from literature review are presented in chapter 2. In chapter 3, detailed description of retrofitting smart shock absorber is given along with its design .Also, the design of test rig is also described in chapter 3. Chapter 4 gives the manufacturing process involved in the fabrication of the model. Finally, conclusions of the work carried out and scope for the future work are presented in chapter 5.

CHAPTER 2

LITERATURE SURVEY

Luhrs et al.[1] proposed an innovative motion rectifier system, which can convert the up and down movement of the shock absorber into unidirectional rotation of the generator. The rack and pinion mechanism help to convert and amplify the excitation displacement. The bidirectional linear motion to unidirectional rotation rectification is accomplished with the bevel gear and clutch. The experiments and simulations were carried out by the researchers and it showed that the prototype achieved over a high efficiency of 60% and 15 W power output was obtained when the vehicle is driven at a speed of 15 mph. Further investigation was conducted by Li and Zuo to evaluate the performance of the prototype. A quarter car suspension model was constructed to simulate the situation where vehicle was driven on the ISO Class C road. It was found that the motion rectifier can achieve the road comfort and the road handling on a conventional vehicle. 60–84 W can be harvested from a quarter car regenerative suspension with the motion rectifier when travelling at 67.5 mph, which is more than that from the quarter car regenerative suspension without the motion rectifier.

There are a variety of diff erent methods to achieve the conversion of energy. Zhang jin-qiu et al.[2] compares diff erent electromagnetic regenerative suspensions. An example of a suspension system that utilizes a linear electromagnetic generator is the direct-drive electromagnetic suspension which turns linear motion caused by vibrations into electrical energy needing no transmission. Ball-screw and rack-pinion electromagnetic suspensions, on the other hand, converts the linear motion into rotational, using a mechanical transmission. It is this rotational energy that then is converted into electrical energy using a rotary electromagnetic generation.

Abdullah et al.[3] stated that the purpose of the energy regenerative suspension system is to convert the dissipating energy on the vehicle suspension system to a useful electrical energy for the vehicle usage. 10% to 20% of vehicle component uses fuel energy other than the internal combustion engine. There are about 200 W power that produced by the vehicle suspension dissipation energy that can be used as alternate resource of energy for electrical component of the vehicle. This is proved that the vertical energy can be harvested that is useful for hybrid and electric vehicle.

One of the major applications of the wheel suspension system is to prevent the vibrations of the wheel, caused by road roughness, to be transferred to the vehicle body. This is done by having a damper that absorbs the energy from these vibrations. According to simulations carried out by Segel et al.[4] a passenger car traveling on a poor roadway at 13.4 m/s dissipates approximately 200 W worth of energy only from the dampers on the car. If the mechanical energy, on the other hand, could be converted to electrical energy and redirected into diﬀ erent features of the vehicle it would provide less dissipation of energy. This conversion can be done with the help of, for example, an electromagnetic generator. Depending on the construction of the suspension system this electromagnetic generator can either be rotary or linear.

Zhang et al.[5] modelled road roughness and vehicle dynamics, concluding 100–400-W energy potential from the shock absorbers of a typical vehicle at 96km/h (60mi/h).It is also noted that typical vehicles use about 300 W of electricity when the optional electric accessories are turned off, which demands five to six times more fuel power, considering 25%–45% engine efficiency and 50%–65% alternator efficiency. To improve the fuel efficiency of vehicles, regenerative shock absorbers are designed to harvest energy from the vibration.

Zuo et al.[6] suggested the use of an electromagnetic energy harvesting shock absorber with a rack pinion mechanism. The principle design of the shock absorber utilizes a rack and pinion to transform linear motion into rotational. With the use of a bevel gear the transmission is changed 90◦ and the rotation can be
transferred to the motor via a planetary gear. If the transmission ratio is chosen to be high the system can achieve a high damping coeﬃcient but this is limited by the fact that a large

transmission ratio leads to a low transmission efficiency. The choice of gears is very important because they are often the cause for failure not only because of fatigue but also because roughness on the cog teeth can interfere with the regeneration performance. There is also friction and backlash impacts in the system. In order to reduce this the article, suggest a roller that guides the rack. Teflon rings were also used between the inner and outer cylinders to further reduce friction. The article used a permanent magnetic DC motor as a generator.

Zuo et al.[7] previously built a rack–pinion-based shock absorber prototype, but the size of the shock absorber prototype is not retrofittable for common vehicles (101.6 mm of overall diameter, in comparison with the 72-mm outside diameter in this prototype). Moreover, there are large backlash and friction in the transmission. To reduce friction forces and backlash impacts, in this design, a roller is used to guide the rack and preload of rack on the opposite side of the pinion gears.

Drapalyuk et al.[8] gives the research results of the units designed for electrical energy regeneration in the suspension of an off-road car travelling along different road surfaces. The minimal value of regenerative energy is 0.3 kWh, while with speed and load weight increasing, it tends to grow.

Scizek et al.[9] presents the theoretical performance calculation of energy regeneration in the electromagnetic shock absorber under different speeds and road surfaces, based on the road micro profile analysis. According to the calculation results, the peak recuperative power is 140.

2.1 Summary of literature survey

The idea of regenerating dissipated energy into useful electrical energy has been around for a while and often it is vibrations that dissipate in the form of heat energy. The idea is to make use of kinetic energy in the ambient vibrations and regenerate it as electrical energy. Three of the most established methods of achieving this are electrostatic, piezoelectric and electromagnetic. Electrostatic transducers operate by having the overlapping distance between two electrodes of a polarized capacitor change when the system is exposed to vibration. The introduced movement causes the voltage inside the capacitor to change and thus gives rise to a current flow, which, with an external circuit, can be extracted. The piezoelectric transducers utilize external vibrations to deform a piezoelectric ceramic, causing a voltage in the capacitor to arise and thereby generating electric power. Finally, the electromagnetic transducers use the relative motion between a magnet and a coil to change the magnetic flux in the system. This generates an alternating current and voltage across the coil.

Although the piezoelectric method of converting mechanical energy into electrical is shown to be very effective, the application for vehicle suspension systems is yet to be thoroughly tested. The biggest advances for the scientific field of piezoelectricity seem to be in microscopic applications, such as the development of MEMS. The same is for the electrostatic generator; they too are best suited for MEMS-applications.

Compared to piezoelectric and electrostatic methods of use, there is a lot of literature reviewing the use of electromagnetic transducers applied to vehicle suspension systems. Systems such as the ball-screw and rack-pinion suspension system, hydraulic transmission electromagnetic system, linear electromagnetic system and regenerative magnetorheological (MR) damper systems are some that has been acknowledged.

CHAPTER 3

RETROFITTING SMART SHOCK ABSORBER

An innovative design of regenerative shock absorbers is fabricated, with the advantage of significantly improving the energy harvesting efficiency and reducing the impact forces caused by the suspension's to and fro motion. The key component is a rack and pinion mechanism attached to a PMDC generator, to convert the vibrations developed from suspension system to electrical energy. The PMDC generator contains commutator and rectifier circuit, which produces current from bidirectional rotation of the pinion.

The retrofitting smart shock absorber is capable to regenerate the mechanical vibration energy of the sprung mass into the electrical energy. The rack and pinion being a part of the retrofitting smart shock absorber is fixed immovably along with the shock absorber. The pinion is fixed and is coupled with the PMDC generator and the rack carries up and down movement along with the shock absorber. During the shock absorber compression and rebound motion, the alternating motion of the rack is converted to the rotational motion of the pinion coupled with the PMDC generator. The size of the pinion is chosen to be as small as possible to improve the sensitivity of the model; that is smaller vibration created by the vehicle suspension system can be converted to rotary motion of the pinion. The rotation of the permanent magnets, fixed at the rotor, induces EMF at the generator stator windings. Thus, the mechanical energy from the shock absorber's alternating motion is converted into electrical energy which can be used for charging vehicle battery.

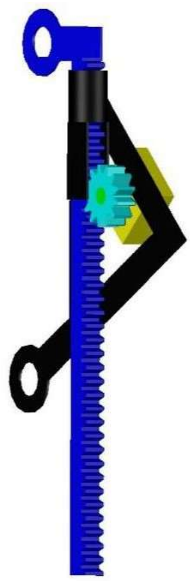

Fig 3.1 3D model of retrofitting smart shock absorber

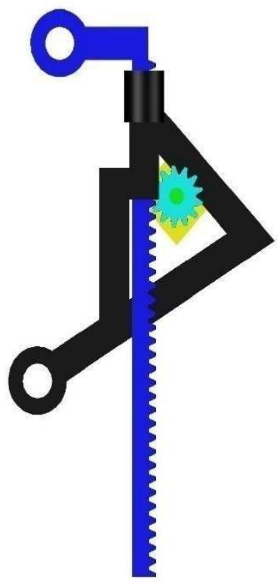

Fig 3.2 Front view of the designed model

3.1 Design of retrofitting smart shock absorber

There are several constraints for designing the retrofit model. The various considerations given during the design process are weight of the model, comfort level of the occupant, and design simplicity.

3.1.1 Components of retrofitting smart shock absorber

1. Rack and pinion

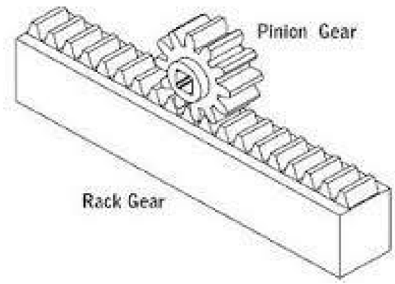

Fig3.3. Rack and pinion [6]

A rack and pinion are a type of rotational actuator that comprises a pair of gears which convert linear motion into rotational motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; linear motion applied to the rack causes the pinion to rotate, thereby translating the linear motion of the rack into rotary motion.

Spur gears(pinion) or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with teeth projecting radially. Though the teeth are not straight-sided, the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears mesh together correctly only if fitted to parallel shafts. Gear rack has straight teeth cut into one surface of a square or round section of a rod and operates with a pinion.

Rack: -

Material : cast iron

Length : 28 cm

Pitch : 6 cm

Pinion: -

Diameter : 3 cm

Material : cast iron

Module : 0.17 cm

2. DC Generator

In DC Circuits, there are three conditions necessary to induce a voltage into a conductor.

a. A magnetic field

b. A conductor

c. Relative motion between the two.

A DC generator provides these three conditions to produce a DC voltage output.

Theory of Operation :-

A basic DC generator has four basic parts:

(a) A magnetic field;

(b) A single conductor, or loop;

(c) A commutator; and

(d) Brushes

The magnetic field may be supplied by either a permanent magnet or an electromagnet. For now, we will use a permanent magnet to describe a basic DC generator. A single conductor, shaped in the form of a loop, is positioned between the magnetic poles. As long as the loop is stationary, the magnetic field has no effect (no relative motion). If we rotate the loop, the loop cuts through the magnetic field, and an EMF (voltage) is induced into the loop. When we have relative motion between a magnetic field and a conductor in that magnetic field, and the direction of rotation is such that the conductor cuts the lines of flux, an EMF is induced into the conductor. The magnitude of the induced EMF depends on the field strength and the rate at which the flux lines are cut. The stronger the field or the more flux lines cut for a given period of time, the larger the induced EMF.

$E_g = KFN$

Where E_g = generated voltage

K = fixed constant

F= magnetic flux strength

N = speed in RPM

Specifications: -

Type : PMDC

Volt :12V

Speed :100rpm

3.1.2 Design of rack and pinion

The motorcycle weight of 143kg along with average occupant weight of 150kg was considered during the design procedure. Out of the total load 40% was distributed to the front wheel.

Weight of motorcycle = 143 kg

Weight of occupant = 150 kg

Load acting on front wheel through 2 suspension = $293\ \text{kg} \times 0.4 = 117.2\ \text{kg}$

Load acting on single suspension = 117.2/2 = 58.6 kg

Selection of material for pinion

(From PSG DB Pg.8.5)

Cast iron σ_B = 800kgf /cm^2

$\sigma_u \geq$ 35kgf/cm^2

Let N = 100 rpm and Z= 17

V_m= πDN/60 = (π×m× 17 × 100)/(60 × 100) = 0.889m m/s

(From PSG DB Pg.8.50

Let pinion be 20^0 involute

y = 0.154 − 0.912/17 = 0.1003

Tangential force = F_t = load acting on single suspension = 58.6 kgf

The dynamic load,

$F_d = F_t \times C_v$

(From PSG DB Pg.8.51)

For the speed range < 10m/s commercially cut wheels are recommended. The velocity factor for commercially cut wheels,

$C_v = \frac{3+Vm}{3}$

C_v = 1 + 0.29 m

The dynamic load,

F_d = 586(1+0.29m) = 586+16.994m

(From PSG DB Pg.8.50)

Lewis equation for strength, $F_s = [\sigma_B] \times b \times y \times P_c$

Take b = 10m

$F_s = 800 \times 10m \times 0.1003 \times \pi \times m = 2519.53m^2$

The strength should be greater than dynamic load, so that

$F_s \geq F_d$

$2519.53m^2 - 16.994m - 586 = 0$

m=0.16cm

$m = \frac{d}{z}$

d= .16 × 18 = 2.88cm ≈ 3cm

Buckingham's dynamic loading

$$F_d = F_t + \frac{0.164\ Vm(C_b + F_t)}{0.164Vm \quad .485\sqrt{C_b + F_t}}$$

(From PSG DB PG. 8.53)

The factor c = 5930e for 20^0 involute and e = 0.05

c = 5930e

e=0.05

c= 296.5

$V_m = 0.889\ X0.16 = 0.14$ m/s

Buckingham's dynamic load

$$F_d = 58.6 + \frac{0.164 \times 0.14(296.5 + 58.6)}{0.164 \times 0.14 + 1.485\sqrt{(296.5 \times 1.6 + 1.586)}}$$

$F_d = 58.88$kgf

$F_s \geq F_d$

The design is okay.

3.2 Design of test rig

The test rig is designed to simulate the various road condition for the model to obtain the power output. The test rig is designed in such a way that it generates different amplitudes of vibrations that replicate the road conditions. The model for testing is supported within a frame which resembles the ordinary suspension system in motor bikes.

3.2.1 Components of test rig

1. Cam

A cam is a rotating or sliding piece in a mechanical linkage used especially in transforming rotary motion into linear motion. It is often a part of a rotating wheel (e.g. an eccentric wheel) or shaft (e.g. a cylinder with an irregular shape) that strikes a lever at one or more points on its circular path. The cam can be a simple tooth, as is used to deliver pulses of power to a steam hammer, for example, or an eccentric disc or other shape that produces a smooth reciprocating (back and forth) motion in the follower, which is a lever making contact with the cam.

Cam used in the test rig is a plate cam also known as disc cam which is cut out of a piece of flat metal or plate. The cam profile is first drawn on a paper and is the used for cutting the cam profile out of Mild steel plate of 5mm thickness. With the help of this cam and a starter motor road conditions are simulated on the retrofitting smart shock absorber.

1. Starter motor (motor bike)

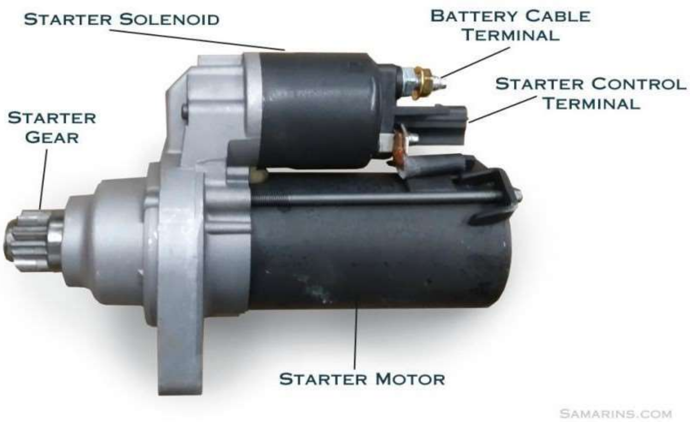

Fig.3.4 Starter motor

A starter (also self-starter, cranking motor, or starter motor) is a device used to rotate (crank) an internal combustion engine so as to initiate the engine's operation under its own power. Starters can be electric, pneumatic or hydraulic.

Starter motor is either a permanent-magnet or a series-parallel wound direct current electric motor with a starter solenoid (similar to a relay) mounted on it. When DC power from the starting battery is applied to the solenoid, usually through a key-operated switch (the "ignition switch"), the solenoid engages a lever that pushes out the drive pinion on the starter driveshaft and meshes the pinion with the starter ring gear on the flywheel of the engine.

Since starter motors are motor having high RPM and high power, and is hence used in the test rig to drive the cam for generating oscillatory or vibratory motion.

2. Battery 12V

Fig.3.5 Battery

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A. One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery. The lead acid cell type is a secondary cell or storage cell, which can be recharged. The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents shortens the useful life to about 3 to 5 years for an automobile battery. Of the different types of secondary cells, the lead-acid type has the highest output voltage, which allows fewer cells for a specified battery voltage.

3. Suspension springs

Fig.3.6 Suspension spring

A coil spring, also known as a helical spring, is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded. The suspension spring used in the test rig resembles a shock absorber of two-wheeler.

4. Frame (mild steel)

This is made of mild steel material. The whole parts are mounted on this frame structure with the suitable arrangement.

3.2.2 Design of cam

The cam is designed to simulate the road vibrations. Thus, the cam is used to get different amplitudes of vibrations. The rise of the cam is supposed to move the suspension to a maximum of 5 cm, similar to the motion of the suspension systems in bikes moving over a hump. The cam is designed for uniform acceleration and deceleration.

Specifications: -

Inner radius of the cam = 25mm

Length of stroke = 50mm

Rise = 120° cam angle

Dwell = 30° cam angle

Fall = 120° cam angle.

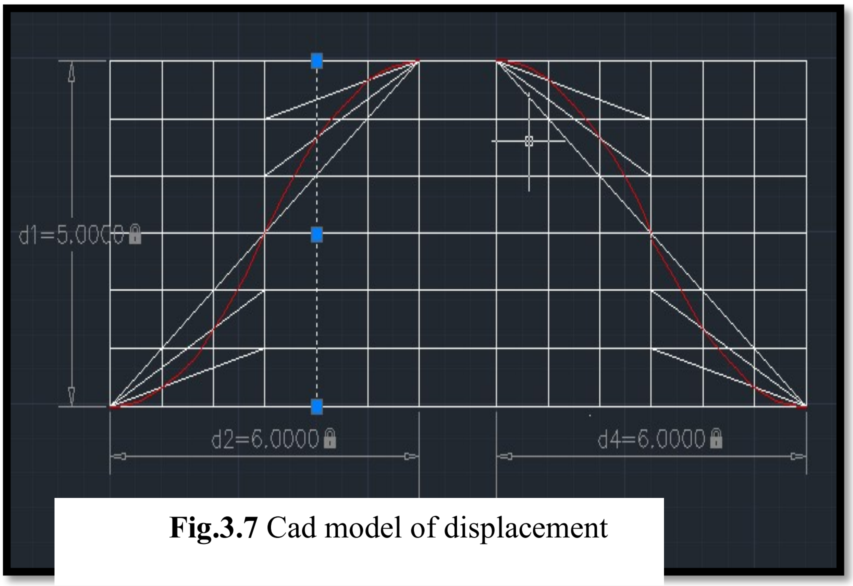

Fig.3.7 Cad model of displacement

Scale X axis
1 cm=20°

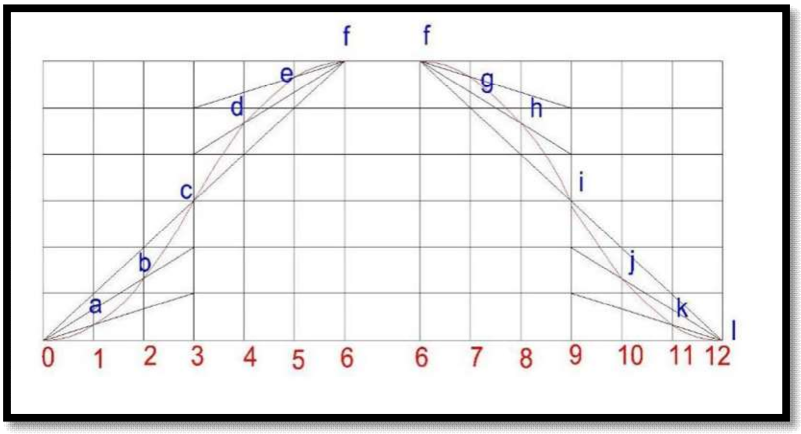

Fig 3.8 Displacement diagram for uniform acceleration and deceleration

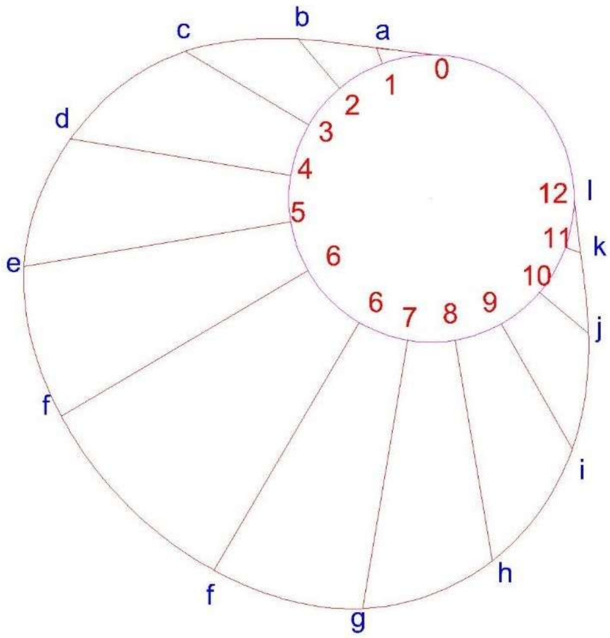

Fig.3.9 Cad model of Designed cam

3.2.3 Operation of test rig

The major component of the rig is cam. Cam is a mechanical device used to transmit motion to a follower by direct contact. Cams are used to convert rotary motion into oscillatory motion. Cam is driven by a starter motor.

Starter motor is a device used to rotate (crank) an internal combustion engine under its own power. Therefore, starter motors are motor having high RPM and high power, and is hence used in the test rig to drive the cam for generating oscillatory or vibratory motion. Thus, with the help of cam and a starter motor road conditions are simulated on the retrofitting smart shock absorber (supported within a frame).

Cam coupled along with the starter motor can slide through slot provided on the supporting frame of the same. The starter motor can be fixed with the help of custom-made U-Bolts at any point on the slot depending upon the amplitude of vibration needed. The whole arrangement consisting of cam, starter motor, and frame with a slot is fixed on a bench with help of a C-clamp. The frame supporting retrofitting smart shock absorber is placed below the cam such that when cam rotates, it touches the shock absorber and generates vibratory motion.

The test rig is mainly designed for obtaining power output for three different amplitude of vibration. When the starter motor is fixed at the bottom most position of the frame it produces maximum displacement of 5cm (upward stroke of the cam is designed to be 5cm). By changing the position of the starter motor through the slot, shock absorber can be tested for other amplitudes of vibration.

CHAPTER 4

MANUFACTURING PROCESS

Manufacturing involves turning raw material to finished products, to be used for various purposes. The manufacturing process begins with product design and material specifications from which the product is made. There are a large number of processes available. The following manufacturing processes are used for the project model.

1 Joining processes

2 Forming processes

3 Machining processes

4 Fabrication processes

1. Metal joining process: - Metal joining is defined as joining of two metal parts either temporarily or permanently with or without the application of heat or pressure. There are several joining process among which the most important one is welding.

Welding is the process of joining metals by using high heat to melt the parts together and allowing them to cool causing fusion. The welding process used for the model here is Arc welding.

Arc welding joins metals using electricity to create enough heat to melt metal, and the melted metals when cool result in binding of the metals. Arc welding is differentiated based on the types of electrodes used which are consumable and non-consumable. Here, the process used is Arc welding using consumable electrodes. An electric current is used to strike an arc between the base material and a consumable electrode rod or stick. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives of vapours that serves as shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination.

2. Forming process: - Forming process are particular manufacturing process which make use of suitable stresses like tension, compression, shear or combined stresses which causes plastic deformation of the materials to produce required shapes. During forming processes no material is removed; they are deformed and displaced.

Bending is a type of forming process which involves bending load as the primary means of plastic deformation.

3. Machining process: - Material removal process is a manufacturing process in which the final product is obtained by removing excess metal from the stock. This is one of the most expensive manufacturing processes. Machining process includes cutting, grinding, drilling etc.

Cutting process uses physical force to cut an object.

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. Grinding is usually followed after all metal cutting operations are done for a smoother finish to the components.

Drilling is a cutting process that make use of drill bit to cut a hole of circular cross section in solid materials. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute.

4. Fabrication process: -Metal fabrication is the creation of metal structure by cutting, bending and assembling process. It is a value-added process involving the creation of machine, parts, and structures from various raw materials.

Along with manufacturing processes painting and lubrications are carried out.

CHAPTER 5

CONCLUSIONS AND SCOPE FOR FUTURE WORK

5.1 Conclusions

This work investigated the application of regenerative suspension systems in motor bikes. The potential in converting vibration energy into electrical energy through the shock absorber is promising and rewarding and can make the vehicle more sustainable by consuming less amount of fuel. The principle design of the shock absorber utilizes a rack and pinion to transform linear motion into rotational. The model has a great advantage that it can be fitted easily in any two wheelers which makes them more flexible.

The voltage increases as amplitude of vibration increases. Thus, the model is more advantageous for vehicles running over rough road conditions.

The power output can be further increased by changing the model specifications. If the transmission ratio is chosen to be high the system can achieve a high damping coefficient but this is limited by the fact that a large transmission ratio leads to a low transmission efficiency. Here we focus on a simple design without much compromise in comfort level.

5.2 Scope for Future Work

The environmental performance of a product can be divided into three categories; low global impact, low regional or local impact and resource efficiency. Low global impact refers to the product's net contribution of carbon dioxide, low regional or local impact refers to leakage, pass-by noise and exhaust emission, and resource efficiency refers to choice of material, choice of fuel and its end of life treatment. Being one of the largest environmental hazards the vehicle industry is in need of increasing the efficiency of energy use which leads to the question of whether or not the regenerative shock absorber is environmentally friendly.

The retrofitting smart shock absorber is able to make use of energy that otherwise would be wasted which would increase the environmental performance of vehicles when regarding low global impact. Having such a system implemented in the vehicles we use today can effectively contribute to making the cars and two wheelers more environmental friendly and thereby lessen their carbon footprint. The energy that can be harvested from the retrofit smart shock absorber could be used to make the suspension system self-powered. The harvested energy could also be used as stored electrical energy in the battery which can be at the disposal for other systems. This means that the engine would not be needed to charge the battery on its own and could therefore use this extra energy to drive the vehicle. Having a retrofit smart shock absorber system would therefore be beneficial for the decreasing of fuel consumption in vehicles and thus also in decreasing the global impact.

The rapid developments of the new technologies have improved the feasibility of the regenerative shock absorber. In order to be implemented onto the vehicle, a regenerative shock absorber needs to meet the requirements for the power output, energy harvesting efficiency and vehicle dynamic control. The main limitation of the indirect-drive regenerative shock absorber is that the complexity of the motion conversion mechanism can affect the vehicle dynamics, resulting in poor handling or discomfort. Therefore, it is suggested that the future design of the regenerative shock absorber should incorporate more efficient generator, to get maximum energy recovery. It is also expected that the mechanism needs to be less complicated to reduce the friction energy loss. Many researches have been done focusing on improving the performance of the regenerative shock absorbers, however, the integration with the vehicle has not been addressed enough yet.

REFERENCES

[1] Zhongie Li, Lei Zuo, Jian Kuang, and George Luhrs, A motion rectifier based energy harvesting shock absorbers, In Proceedings of the 2012 ASME Design Engineering Conference, Chicago, IL, USA, 12–15 August 2012.

[2] Zhang Jin-qiu, Peng Zhi-zhao, Zhang Lei, and Zhang Yu, A review on energy-regenerative suspension systems for vehicles, In Proceedings of the World Congress on Engineering, Vol. 3, 2013, pp. 3–5.

[3] Abdullah, M.A., Jamil J.F., and Muhammad, Fabrication and Testing of Energy Regenerative Suspension, Proceedings of Mechanical Engineering Research Day 2015 MERD’15, 2015, pp.19-20.

[4] L Segel and Xiao Lu, Vehicular resistance to motion as influenced by road roughness and highway alignment, In Australian Road Research 12.4, 1982, pp. 211–222.

[5] L. Zuo and P. Zhang, Energy harvesting ride comfort and road handling of regenerative vehicle suspensions, In Proc. DSCC, 2012, pp. 295–302.

[6] Zhongjie Li, Lei Zuo, and George Luhrs, Electromagnetic energy-harvesting shock absorbers: design, modelling, and road tests, In Vehicular Technology, IEEE Transactions on 62.3 (2013), pp. 1065–1074.

[7] Z. Li, Z. Brindak, and L. Zuo, Modelling of an electromagnetic vibration energy harvester with motion magnification, In Proc. ASME Int. Mech. Eng. Cong, Denver, CO, 2011, pp. 285–29.

[8] Posmetyev V.I., M.V. Drapalyuk, and V.A. Zelikov, Estimation of efficiency of application of system recovery of energy in car suspender, Proceedings of the Kuban State Agrarian University,2011, No. 76(02).

[9] Siczek and K M. Kuchar, Researches on the amount of recuperated energy by electromagnetic shock absorber in small car, Journal of KONES Powertrain and Transport, 2011, Vol. 20, No. 3, pp. 367-374.