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Experimental Analysis on Generation of Electricity Through Braking System (Regenerative Braking System)

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ABSTRACT

In conventional braking system the motion is retarded or stopped by absorbing kinetic energy by friction, by making the contact of the moving body with frictional rubber pad (called brake liner) which causes the absorption of kinetic energy, and this is wasted in form of heat in surroundings. Each time we brake, the momentum of vehicle is absorbed that it has gained by it and to re-accelerate the vehicle. As the basic law of Physics says 'energy can neither be created nor be destroyed it can only be converted from one form to another. That is the basic concept of regenerative ("regent") brakes, which provide braking for the system when needed by converting the available energy to some usable form.

Keywords: brakes, conventional braking system, electricity, engine

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INTRODUCTION

Regenerative braking is an important technology of the hybrid vehicles that appeals to very strong research interests all over the world. Research on control strategy is one of most important topics of regenerative braking and can be roughly categorized into two types according to the purpose of research. One is to enhance the braking performance and driving comfort. The other is to improve the regenerative efficiency and to save resources. Almost the present research concentrates on regenerative braking in many of electric vehicles (EV), hybrid electric vehicles (HEV), and plug-in hybrid electric vehicles. any moving body. Thus, in Brakes are employed to stop or retard the motion of automobiles the brakes are having the most important function to perform. In conventional braking system the motion is retarded or stopped by absorbing kinetic energy by friction, by making the contact of the moving body with frictional rubber pad (called brake liner) which causes the absorption of kinetic energy, and this is wasted in form of heat in surroundings. Each time we brake, the momentum of vehicle is absorbed that it has gained by it and to re-accelerate the vehicle we have to start from the scratch to redevelop that momentum by using the more power from an engine. Thus, it will ultimately result in huge waste of energy. As the basic law of Physics says "energy can neither be created nor be destroyed it can only be converted from one form to another." It will be good if we could store this energy somehow which is otherwise getting wasted out and reuse it next time we started to accelerate. That is the basic concept of regenerative ("regent") brakes, which provide braking for the system when needed by converting the available energy to some usable form. Regenerative brake is an energy recovery mechanism which slows a vehicle by converting its kinetic energy into another form, which can be either used immediately or stored until needed. Energy may also be stored by compressing air or in a rotating

flywheel. This was a completely battery powered urban concept car whose batteries were recharged by regenerative braking, thus increasing the range of the automobile. Examples include the Toyota Prius, Honda Insight, the Vectrix electric maxi-scooter, and the Chevrolet Volt [1-2].

Description

Regenerative Braking System is the way of slowing vehicle by using the motors as brakes. These are widely used in electric trains and the latest electric cars. Thus, the generated electricity during the braking is fed back into the supply system (in case of electric trains), whereas in battery electric and hybrid electric vehicles. The regenerative braking system delivers a number of significant advantages over a car that only has friction brakes. In low-speed, stop- and-go traffic where little deceleration is required; the regenerative braking system can provide the majority of the total braking force. This vastly improves fuel economy with a vehicle, and further enhances the attractiveness of vehicles using regenerative braking for city driving. During "Regent," the motor becomes a generator and sends energy back to the batteries. In this experiment the motor is used rotate the tyre which is powered by the power supply. With the rotation of motor electricity is generated which can be stored in a battery, is indicating by the LEDs connected to the motor [3].

Brake

Vehicle brakes are used to absorb kinetic energy whereas in hoists or elevators brakes are also used to absorb potential energy (Figure 1).

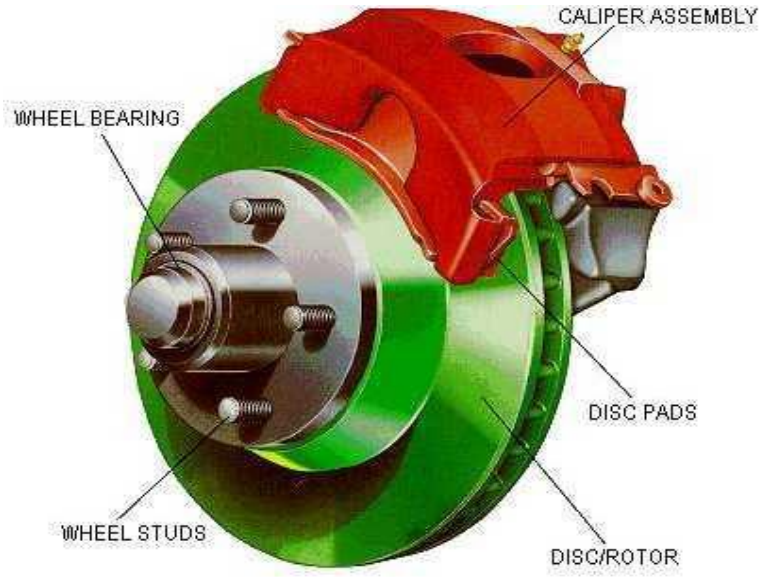


Fig. 1. *Elements of a brake.*

Conventional Braking System

- Conventional braking systems use friction to counteract the forward momentum of a moving car (Figure 2).
- As the brake pads rub against the wheels, excessive heat energy is created.
- This heat energy dissipates into the air, wasting up to 30% of the car's generated power.

Regenerative Braking System

- Regenerative Braking System is the way of slowing vehicle by using the motors as brakes. Instead of the surplus energy of the vehicle being wasted as unwanted heat, the motors act as generators and return some of it to the overhead wires as electricity [4].
- The vehicle is primarily powered from the electrical energy generated from the

generator, which burns gasoline. This energy is stored in a large battery and used by an electric motor that provides motive force to the wheels [5].

The regenerative braking taking place on the vehicle is a way to obtain more efficiency; instead of converting kinetic energy to thermal energy through frictional braking, the vehicle can convert a good fraction of its kinetic energy back into charge in the battery, using the same principle as an alternator (Figure 3).

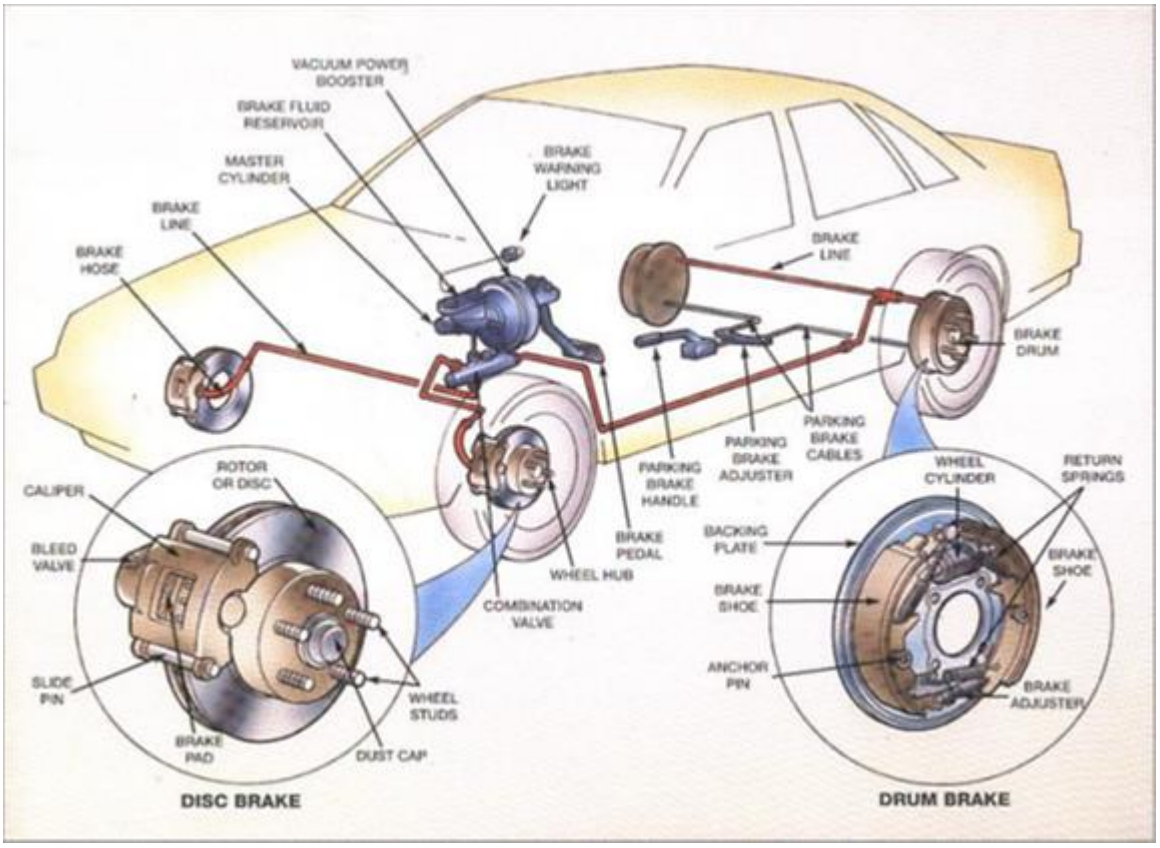


Fig. 2. *Conventional braking system.*

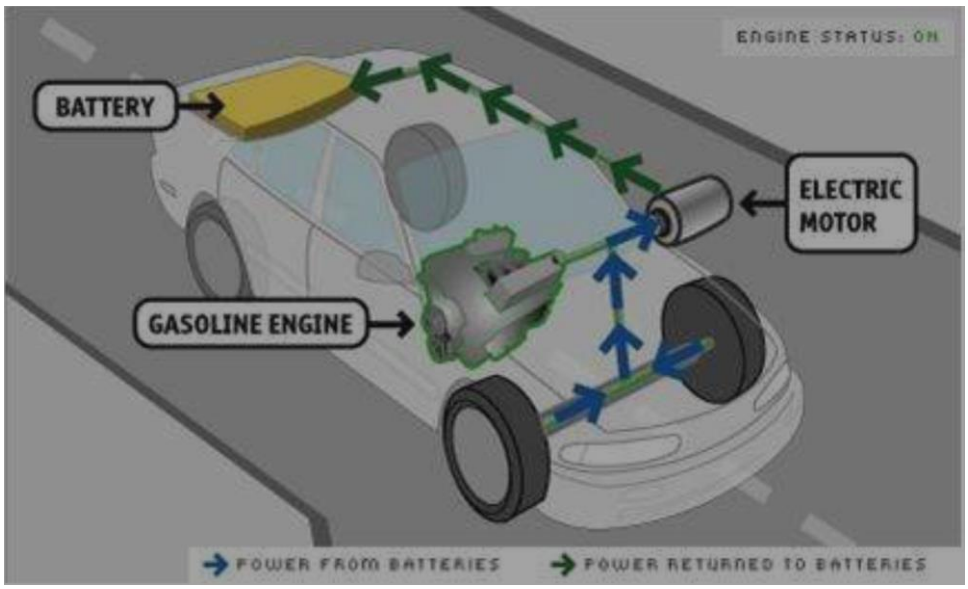


Fig. 3. *A basic regenerative braking system.*

Definition

Braking method in which the mechanical energy from the load is converted into electric energy and regenerated back into the line is known as Regenerative Braking. The Motor operates as generator [6].

Basic Idea of Regenerative Brakes

If our bicycle has a dynamo (a small electricity generator) on it for powering the lights, we'll know it is harder to peddle when the dynamo is engaged than when it's switched off. That's because some of our peddling energy is being "stolen" by the dynamo and turned into electrical energy in the lights. If we're moving along at speed and we suddenly break peddling and turn on the dynamo, it'll bring us to a stop more quickly than we would normally, for the same reason. Bicycle with a dynamo that is 100 times bigger and more powerful. In theory, it could bring our bike to a break relatively quickly by converting our kinetic energy into electricity, which we could accumulate in a battery and use again later. And that's the basic idea behind regenerative brakes electric trains, cars, and other electric vehicles are powered by electric motors connected to batteries (Figure 4).

When we stop and hit the brakes, the whole process goes into reverse: electronic circuits cut the power to the motors. Now, our kinetic energy and momentum cause the wheels to rotate the motors, so the motors behave like generators and jump to producing electricity rather wasting it. Power flows back from these motor-generators to the batteries, charging them up. So, a maximum proportion of the energy we lose by braking is back to the batteries and can be reused when we start off again. In practice, regenerative brakes take time to slow things down, so most vehicles that use them also have ordinary (friction) brakes working alongside (that is also a good idea in case the regenerative brakes fail). That's one reason why regenerative brakes do not save 100 percent of our braking energy.

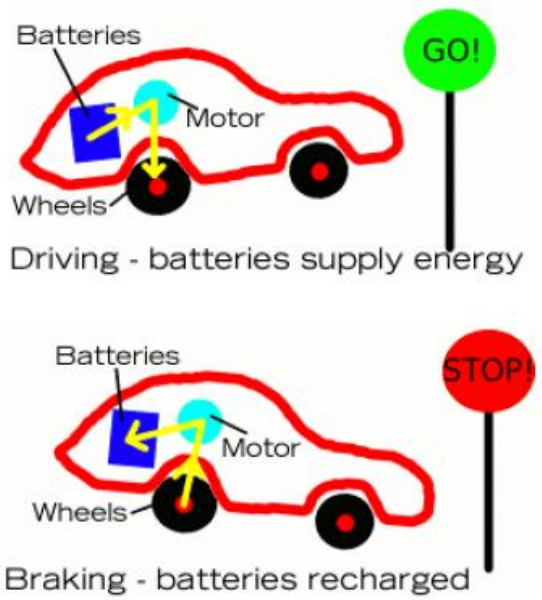


Fig. 4. *Basic idea of regenerative brakes.*

Regenerative Braking for Vehicles

In most electric and hybrid electric vehicles on the road today, this is accomplished by operating the traction motor as a generator, providing braking torque to the wheels and recharging the traction batteries. The energy provided by regenerative braking can then be used for propulsion or to power vehicle accessories (Figure 5).

- During acceleration, the motor/generator unit acts as an electric motor drawing electrical energy from batteries to provide extra driving force to move the vehicle.
- During braking electric supply from the battery is cut off by the electronic system.

Working of Regenerative Braking System

Regenerative (or dynamic braking) arises when the vehicle is in motion, like coasting, traveling downhill or braking. And the accelerator pedal is not being depressed. During "Regent," the motor becomes a generator and sends energy back to the batteries [7].

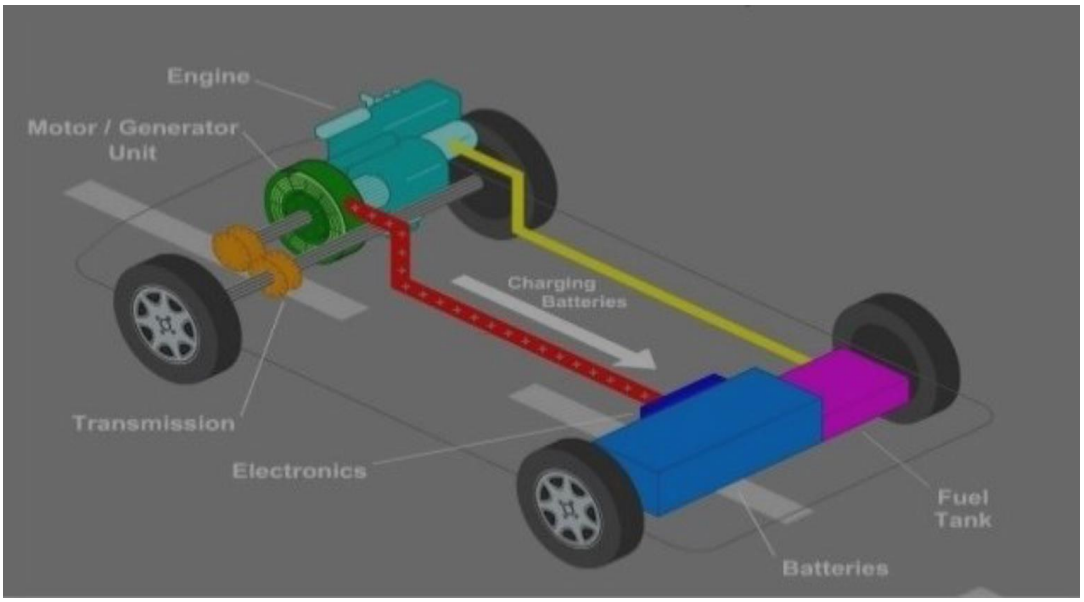


Fig. 5. *Charging of battery during braking.*

It is elucidated as follows, since the wheels of a decelerating vehicle are still moving forward, they can be made to turn the electric motor, which then feeds energy to the batteries for storage. The system becomes, in effect, a generator, which provides braking force while it converts the vehicle's kinetic energy into in usable form electrical energy.

When the accelerator pedal is free, the absence of pressure triggers a response from the Energy Storage Unit (ESU). Regenerative braking begins, and the batteries are re-charged by the motor, which is turned by the wheels. In this case, the friction brakes are not engaged. However, to maximize energy efficiency, it is advantageous to apply the regenerative as such as possible – it therefore tends to do more of its total work in the first part of the braking motion (Figure 6).

There are two deceleration modes:

(1) Foot off throttle but not on brake pedal In this mode, the charge/assist gauge will show partial charge, and the vehicle will slow down gradually.

(2) Foot on brake pedal more rapidly. During light brake pedal application, only the IMA motor/generator is slowing the car. With heavier brake pedal application, the conventional friction brakes also come into play. When decelerating, regeneration will continue until engine speed falls to about 1000 rpm. At this point, the driver will typically shift into neutral.

Necessity of the System

This vastly improves fuel economy with the vehicle and further enhances the attractiveness of vehicles using regenerative braking for city driving.

At higher speeds, the regenerative braking has been shown to contribute to improve fuel economy by as much as 20%.

Energy Conservation

The flywheel engages with energy when braking via a clutch system slowing of car down and speeding up the wheel. To accelerate, another clutch system connects the flywheel to the drive train, speeding up the car and slowing down the flywheel. Energy is therefore reserved rather than lost as heat and light which is what normally happens in the contemporary shoe/disc system.

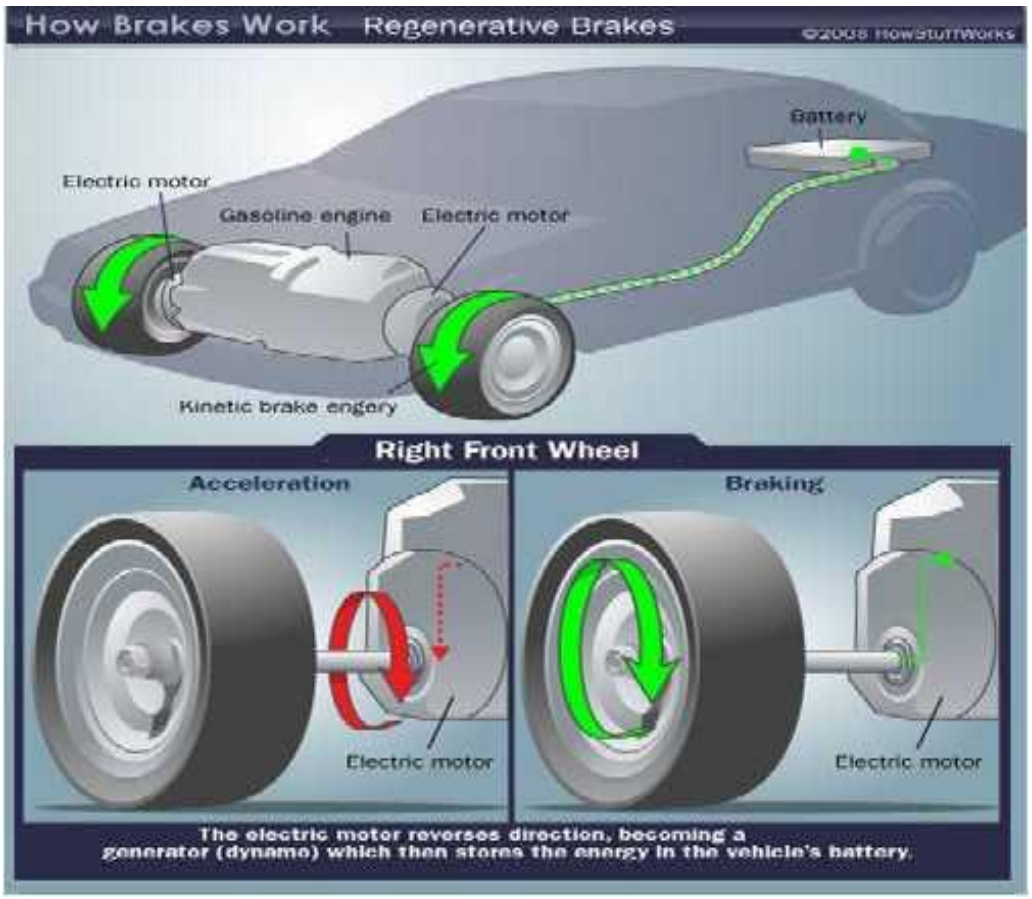


Fig. 6. *Working of regenerative brakes.*

Wear Reduction

An electric drive train also allows for regenerative braking which increases efficiency and reduces wear on the vehicle brakes. In regenerative braking, when the motor is not receiving power from the battery pack, it controls the turning of the wheels, catching some of the energy of motion as if it were a generator and returning that energy to the battery pack. In mechanical brakes; lessening wear and extending brake life is not possible. This reduces the use of the brake.

Fuel Consumption

The fuel consumption of the conventional vehicles and regenerative braking system vehicles was evaluated over a course of various fixed urban driving schedules. The results are compared as shown in figure. Representing the significant cost saying to its owner, it has been proved the regenerative braking is very fuel-efficient.

Braking Is Not Total Loss

Conventional brakes apply friction to convert a vehicles kinetic energy into heat. In energy terms, therefore braking is a total loss.

Elements of Regenerative Braking System Model

There are four elements required which are necessary for the working of regenerative braking system, these are:

Energy Storage Unit (ESU)

The ESU performs two primary functions:

(1) To recover and store braking energy

(2) To absorb excess engine energy during light load operation

The energy restored by regenerative braking in one of three devices:

- An electrochemical battery
- A flywheel
- Compressed air

Motor

Three phase AC induction motors rated 1 Hp (746 W) and 25 W with small motors from CD player, toy and CD/DVD drive reader head traverse Disassembled 250W motor from a washing machine. The 12 stator windings are in the housing on the left. Next to it is the "squirrel cage" rotor on its shaft. Where a polyphase electrical supply is available, the three-phase (or polyphase) AC induction motor is commonly used, especially for higher-powered motors. The phase differences between the three phases of the polyphase electrical supply create a rotating electromagnetic field in the motor.

Induction motors are the workhorses of industry and motors up to about 500 kW (670 horsepower) in output are produced in highly standardized frame sizes, making them nearly completely interchangeable between manufacturers (although European and North American standard dimensions are different). Very large induction motors are capable of tens of thousands of kW in output, for pipeline compressors, wind-tunnel drives and overland conveyor systems.

Belt

Belts may be used as a source of motion, to transmit power efficiently or to track relative movement.

LEDs

LEDs are basically the single light display that include incandescent and are treated as single binary points to be switched on and off by programmer instructions. The individual light display is easy to use. A port presents a bit or a character and then strobe the device.

When the diode is forward biased, then the electrons & holes are moving fast across the junction and they are combining constantly, removing one another out. Soon after the electrons are moving from the n-type to the p-type silicon, it combines with the holes, then it disappears. Hence, it makes the complete atom and more stable and it gives the little burst of energy in the form of a tiny packet or photon of light.

Colors

LEDs have traditionally been red, orange, yellow, or green, but advances in LED technology mean that blue and white LEDs are now available, though at a much higher price. These LEDs are considerably brighter than standard LEDs so they could be used for lighting, but you will find the ones described as "white" still have a blue tinge.

A taut cable or belt, or transfer of power between the shaft and cable or belt. In the case of a pulley supported by a frame or shell that does not transfer power to a shaft, but is used to guide the cable or exert a force, the supporting shell is called a block, and the pulley may be called a sheave. A pulley may have a groove or grooves between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt, or chain.

Continuously Variable Transmission (CVT)

The energy storage unit requires a transmission that can handle torque and speed demands in a steeples manner and smoothly control energy flow to and from the vehicle wheels.

An electronic speed control follows a speed reference signal (derived from a throttle lever, joystick, or other manual input) and varies the switching rate of a network of field effect transistors (FETs). By adjusting the duty cycle or switching frequency of the transistors, the speed of the motor is changed. The rapid switching of the transistors is what causes the motor itself to emit its characteristic high-pitched whine, especially noticeable at lower speeds.

Different types of speed controls are required for brushed DC motors and brushless DC motors. A brushed motor can have its speed controlled by varying the voltage on its armature. (Industrially, motors with electromagnet field windings instead of permanent magnets can also have their speed controlled by adjusting the strength of the motor field current.) A brushless motor requires a different operating principle. The speed of the motor is varied by adjusting the timing of pulses of current delivered to the several windings of the motor (Figure 7).

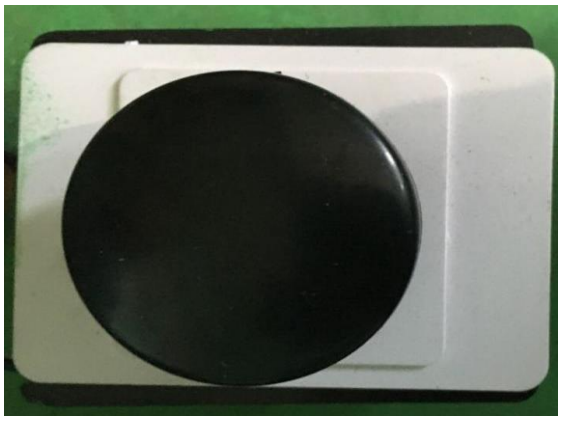


Fig. 7. *Continuously variable transmission.*

Dynamo

A dynamo is an electrical generator that produces direct current with the use of a commutator. Also, converting alternating to direct current using power rectification devices (vacuum tube or more recently solid state) is effective and usually economical. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. On small machines the constant magnetic field may be provided by one or more permanent magnets; larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils.

Regenerative Brake Controllers

During the braking operation, the brake controller directs the electricity produced by the motor into the batteries or capacitors. The most important function of the brake controller, however, may be deciding whether the motor is currently capable of handling the force necessary for stopping the car. Figure 8 as much as any other piece of electronics on board a hybrid or electric car, the brake controller makes the entire regenerative braking process possible.

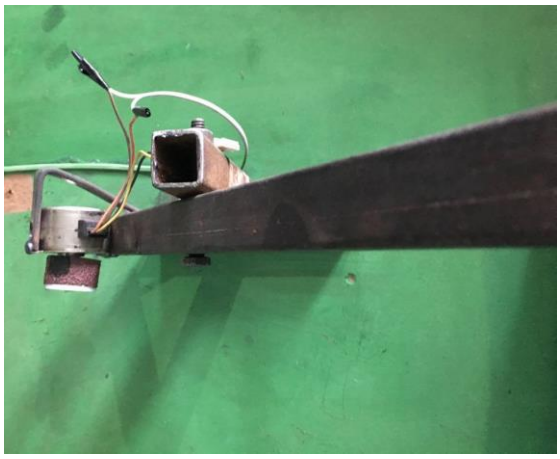


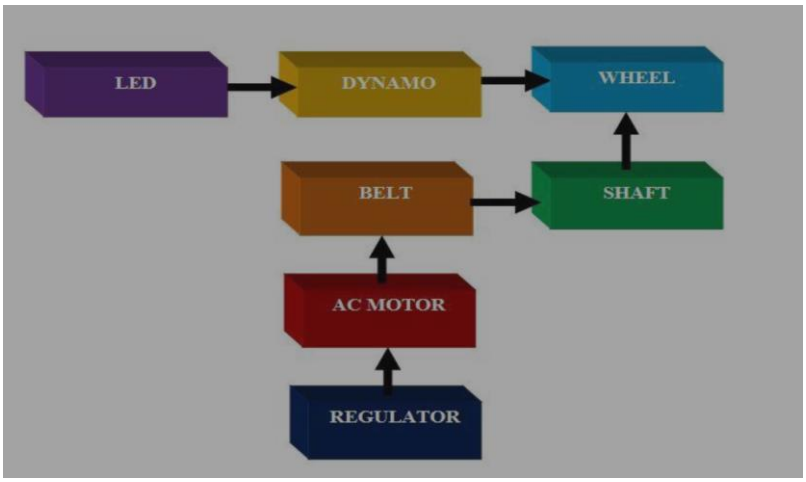
Fig. 8. *Regenerative brake controllers.*

Wheel

Wheel is placed on the shaft when the power is provided through the motor the wheel tends to rotate. The brake lever having dynamo attached with it gets in contact with the wheel and electricity is produced.

Working of Model

In this model of Regenerative braking system first all the components will be assembled on the wooden board. A ON/OFF switch is provided when the power is supplied to the motor, the shaft is connected through the belt with the motor. On the shaft wheels are attached the wheels will move with the movement of motor. A dynamo is attached with the brake lever. when the brake lever is pushed upwards the wheels get in contact with the dynamo and that energy gets converted into electricity with the help of dynamo and L.E.D lights placed on the board will blink. To design and implement a model for regenerative braking system.



Block diagram of model.

Objective

- To develop and verify a prototype (model) of a regenerative-breaking system.
- For improvement in the efficiency of electric vehicles (EV), hybrid vehicles (HV).

Need for Regenerative Brakes

The regenerative braking system delivers a number of significant advantages over a car that only has friction brakes. In low-speed, stop- and-go traffic where little deceleration is required; the regenerative braking system can provide the majority of the total braking force. This vastly improves fuel economy with a vehicle, and further enhances the attractiveness of vehicles using regenerative braking for city driving. It is operated near maximum engine efficiency. The 80% of the energy produced is utilized to overcome the rolling and aerodynamic road forces. The energy wasted in applying brake is about 2%. Also, its brake specific fuel consumption is 5%. Now consider a vehicle, which is operated in the main city where traffic is a major problem here one has to apply brake frequently (Figure 9).

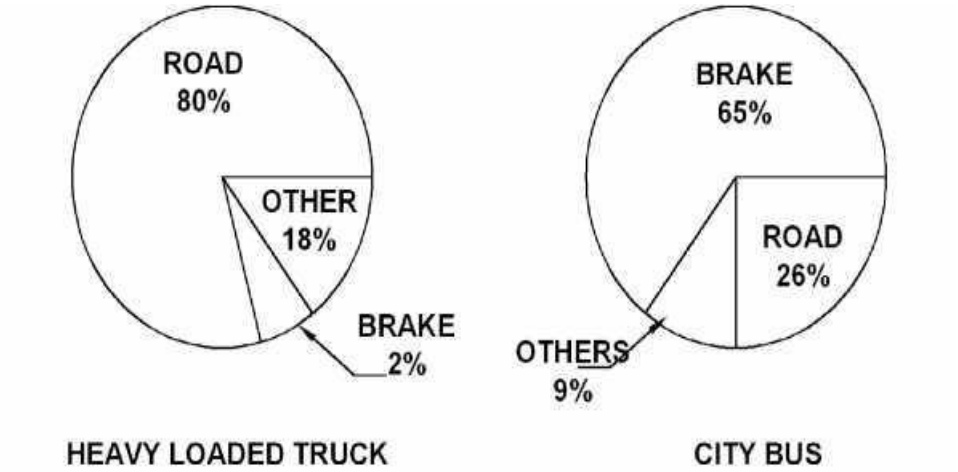


Fig. 9. *Graphical representation of energy usage of two vehicles.*

Energy Conservation

The flywheel absorbs energy when braking via a clutch system slowing the car down and speeding up the wheel. Energy is therefore conserved rather than wasted as heat and light which is what normally happens in the contemporary shoe/disc system [8].

Wear Reduction

An electric drive train also allows for regenerative braking which increases efficiency and reduces wear on the vehicle brakes. In regenerative braking, when the motor is not receiving power from the battery pack, it resists the turning of the wheels, capturing some of the energy of motion as if it were a generator and returning that energy to the battery pack. In mechanical brakes; lessening wear and extending brake life is not possible. This reduces the use of the brake.

Fuel Consumption

The fuel consumption of the conventional vehicles and regenerative braking system vehicles was evaluated over a course of various fixed urban driving schedules.

Braking Is Not Total Loss

Conventional brakes apply friction to convert a vehicles kinetic energy into heat. In energy terms, therefore braking is a total loss. Once heat is generated, it is very difficult to reuse.

Experimentation and Methodology

It comprises the theoretical analysis of the body of the methods applied with a branch of knowledge. Typically, it encompasses concepts such as theoretical models, phases and quantitative or qualitative techniques.

It has been defined as follows:

- "The analysis of the principles of methods, rules, and postulates employed by a discipline."
- "The systematic study of methods that are, can be, or have been applied with in a discipline."
- "The study or description of methods."

SUMMARY

This is an extensive review of the elements which is to be carried out on various aspects for the designing of a regenerative-breaking system model. The elements are selected on the basis of required criteria and on the basis of gaps in the past work purposed details and objective of work have been done (Figure 10).

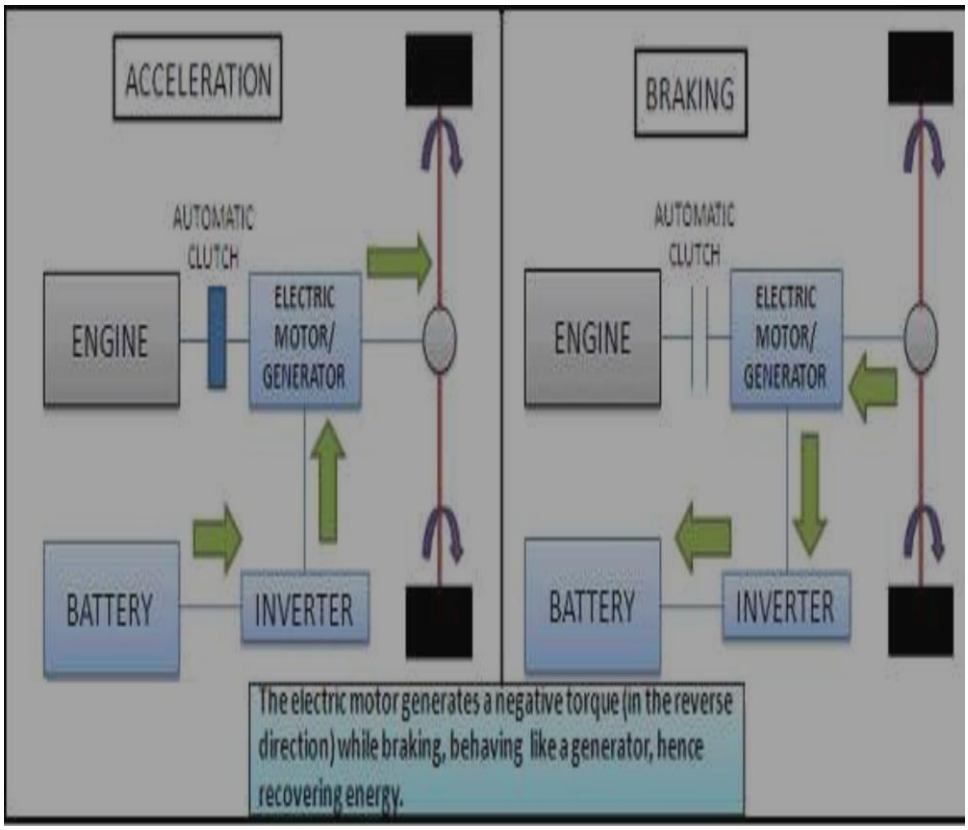


Fig. 10. *Block dig. of acceleration and braking in system.*

Plan of experimentation is shown in Figure 11.

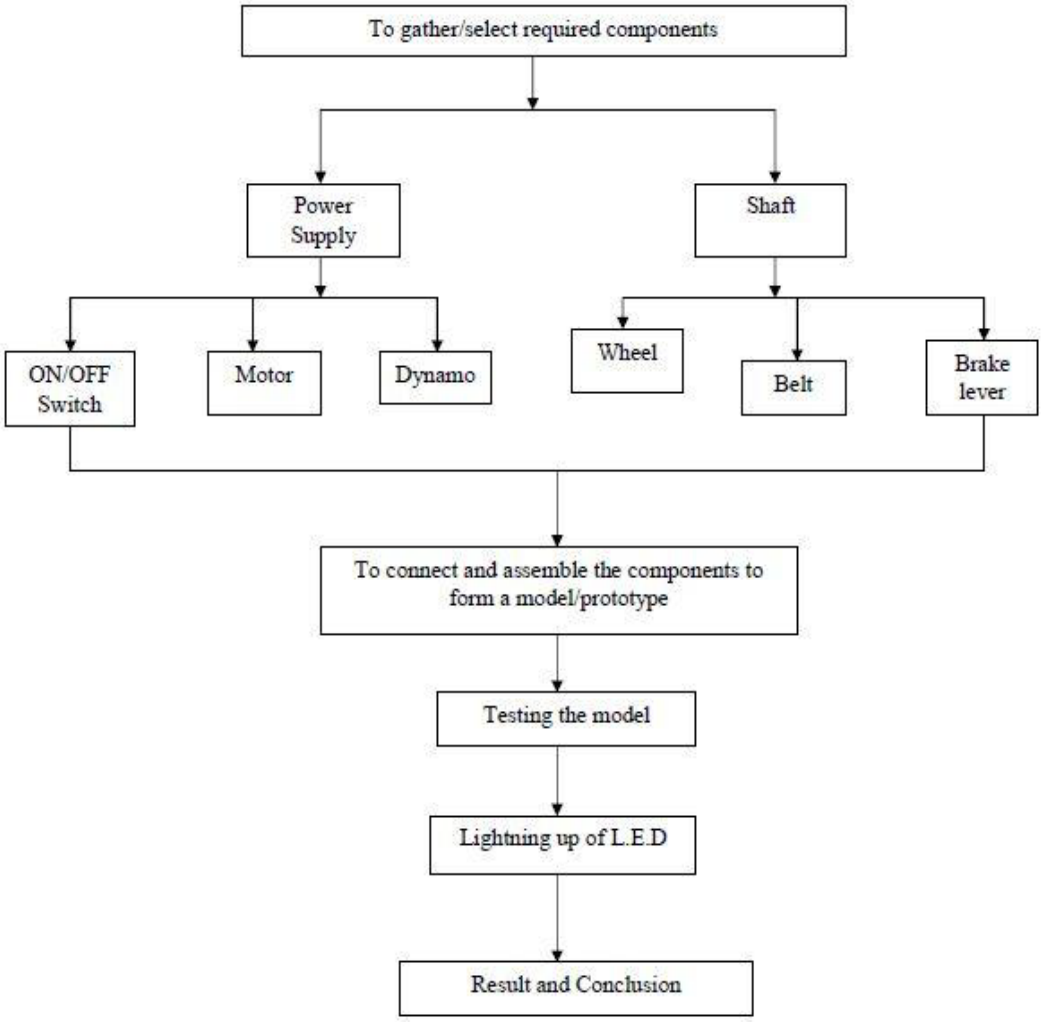


Fig. 11. *Flow chart of experimentation.*

Design of Model

Specifications of equipments used.

Motor

Three phase AC induction motors rated 1 Hp (746 W) and 25 W with short motors from CD player, toy and CD/DVD drive reader head traverse Stripped 250W motor from a washing machine. The 12 stator windings are in the housing on the left. Next to it is the "squirrel cage" rotor on its shaft. Where a polyphase electrical supply is present, the three-phase (or polyphase) AC induction motor is commonly used, especially for higher powered (Figure 12 & table 1)

Fig. 12. *Diagram of motor.*

Table 1. *Specification of motor.*

S.No.	Type of Motor	Speed (in RPM)	H.P	AMPS	Frequency (in Hz)	Volts
1	D.C Motor	9500	1/12	0.5	50	220/230

Dynamo

Dynamos were the first electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator, and the rotary converter. Today the simpler alternator dominates large scale power generation, for efficiency, reliability and cost reasons (Figure 13 & Table 2)

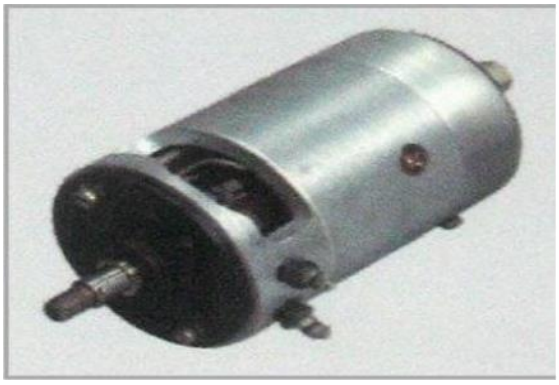


Fig. 13. *Diagram of dynamo.*

Table 2. *Specification of dynamo.*

S.No.	Voltage	Speed (in RPM)
1	12	300

Belt

A belt is a loop of flexible material used to link two or more rotating shafts mechanically, most often parallel. Belts may be used as a source of motion, to transmit power efficiently or to track relative movement. Belts are looped over pulleys and may have a twist between the pulleys, and the shafts need not be parallel (Figure 14 & Table 3).

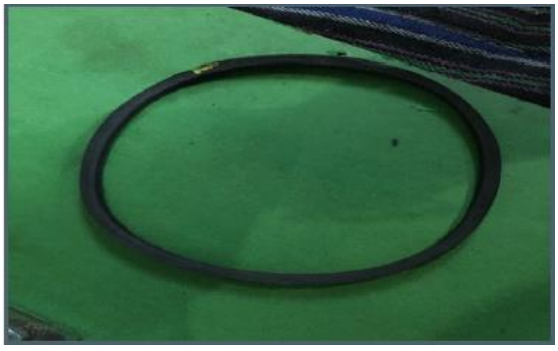


Fig. 14. *Diagram of belt.*

Table 3. *Specification of belt.*

S.NO.	thikness (In mm)	width (in mm)	Type of belt	Material Used	Mass Density (in Kg/m3)
1	6	5	V -type	Leather	1000

Pulley

A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or conversion of power between the shaft and cable or belt. In the case of a pulley maintained by a frame or shell that does not move power to a shaft but is used to guide

the cable or apply a force, the supporting shell is called a block, and the pulley may be called a sheave. A pulley may have a groove or grooves between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt, or chain (Figures 15-16 & Table 4).

Fig. 15. *Diagram of pulley.*

Table 4. *Specification of pulley.*

S.No	Material Used	Outer diameter (In mm)	Inner Diameter (in mm)
1	Plastic	60	50

Complete Assembly of Model

Fig. 16. *Complete assembly of model.*

Steps used in preparation of model:

- In this model of regenerative braking system first all the required components and gathered and assembled on the wooden block.
- Power supplied is provided to the set up. is control by controlled variable transmission switch which is connected to motor through wires.
- Motor provides power to shaft through the belt.
- Wheels are mounted on the shaft and supports are provided on both the ends of shaft.
- Dynamo is attached to the one end of brake lever.
- LED bulbs are connected through wires passing through dynamo.
- When the power comes into the motor and its gives power to shafts. On the shaft wheels are attached the wheels will move with the movement of motor. When the brake liver is pushed downwards the wheels tends to slower their motion a dynamo placed on the end of brake lever gets in contacts with wheels and the kinetic energy of the wheels gets converted into electrical energy and as result the LED bulbs will blink.
- This is the whole method involved in working of this model.

CONCLUSION

The regenerative-breaking system used in the vehicles satisfies the purpose of saving a part of the energy lost during braking. Also, it can be operated at high temperature range and are efficient as compared to conventional braking system. Regenerative braking system has a wide scope for further development and the energy savings. The use of more efficient systems could lead to huge savings in the economy of any country.

ACKNOWLEDGEMENT

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