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Design and Fabrication of Regenerative Braking System

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***Abstract*: Regenerative braking is an energy efficiency mechanism that slows an automobile or object by converting its Kinetic Energy (K.E) into a form that can be either used instantly or stored until needed. Using a regenerative braking system in automobiles enables us to recover the K.E. of the automobile to a few extents that are lost during the braking process. This energy is often reserved during a battery or bank of capacitors for later use. Energy also can be reserved with the subordinates of a rotating flywheel which is one among the foremost inexpensive and effective methods of storing and regenerating power. A brake-pad congregation arranged parallel with the hub of a ground-contact wheel is operated upon braking to provide frictional contact in the halfway of the hub and clutch mechanism, while putting in an operation decelerating torque to the wheel, to accumulate energy over respective braking events. Automobiles run by electric motors make use of the motor as a generator when operating regenerative braking and its output is supplied to an electrical load.**

***Keywords*: Generator, Regenerative braking, Flywheel, Brake pad, Energy recovery.**

1. Introduction

Commercial automobiles such as waste trucks and delivery automobiles lose a huge amount of kinetic energy during recurring braking and constant drive at low speeds on designated city routes, which results in higher fuel consumption and Green House Emission Gas (GHG) emission than other on-road automobiles. The technological combination of Exhaust Gas Recirculation (EGR) and Diesel Particulate Filter (DPF) after treatment is one of the effective ways to solve the automobile's emission, especially for NOx and soot.

Regenerative energy technology is one of the key features of electrified automobiles. It allows the vehicle to capture a tremendous amount of the kinetic energy lost during braking or decelerating for reuse. That means energy recapture technology can seriously bring down the energy.

Architecture; The latter in a parallel architecture. The regenerative braking system is supplied in the driven axle to recuperate the braking energy loss. The boost recuperation system is parallel-coupled with the mechanical propulsion system to recuperate kinetic energy during the deceleration process. The increased power the regenerative braking retrieves; the less fuel is absorbed.

2. Working Principle

Regenerative braking is a braking method that makes use of the mechanical energy from the motor by turning kinetic energy toward electrical energy and fed back towards the battery origin. Apparently, the regenerative braking system can transform a good fraction of its kinetic energy to charge up the battery, using the same theory as an alternator.

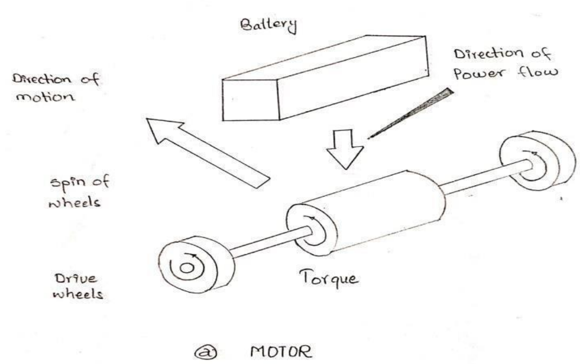

Fig. 1. Motor operation

In the regenerative braking system, it makes use of the motor to decrease the speed of the car when the driver applies power to the brake pedal then the electric motor works in inverse order thus slowing the car. While running backward, the motor acts as the generator and recharges the batteries as shown in fig. 1.

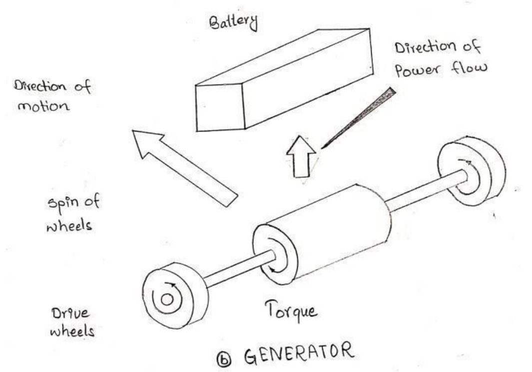

Fig. 2. Generator operation

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Meanwhile in fig. 2 displays the car in routine running condition whereas the motor turning forward and taken energy from the battery. By using regenerative braking, vastly decrease the reliance on fuel, amplifies fuel economy, and lesser emissions. These types of brakes work effectively in driving environments such as stop-and-go driving situations, especially in an urban city.

A. Types of Regenerative Braking System

There are various ways of energy conversion in the Regenerative Braking System along with spring, flywheel, electromagnetic and hydraulic. More often, an electromagnetic flywheel. Every type of Regenerative Braking System utilizes different energy conversion or storage techniques, giving varying productivity and applications for each type.

1) Electromagnetic

In the Electromagnetic system, the drive shaft of the automobile is joined to an electric generator, which utilizes magnetic fields to ban the rotation of the drive shaft, decreasing the automobiles and producing electricity. In the situation of electric and hybrid automobiles, the electricity produced is sent to the batteries, providing them a recharge.

2) Flywheel

In Flywheel Regenerative Braking System, it joins the kinetic energy of the automobile to spin a flywheel that is connected to the driveshaft from transmission and gearbox. The spinning flywheel can then give torque to the drive shaft, providing the automobile with a power boost.

3) Electromagnetic flywheel

Electro flywheel regenerative brake is a mixed product of electromagnetic and flywheel Regenerative Braking System. It provides the basic power generation techniques with the help of an electromagnetic system; that's why the energy is reserved in a flywheel rather than in batteries.

4) Spring

The spring-loaded regenerative braking system is usually used on human-powered vehicles, such as bicycles or wheelchairs. In the spring Regenerative Braking System, a coil or spring is circumfering a cone while braking to reserve energy in the form of elastic potential.

5) Hydraulic

The Hydraulic Regenerative Braking System slows the vehicle by producing electricity which is then used to compress a fluid. Nitrogen gas is frequently chosen as the working fluid. The compressed fluid does not dissipate energy over time. However, compressing gas with a pump is a steady process and severely limits the power of the hydraulic Regenerative Braking System.

Applications:

- Kinetic energy recovery method.
- Regenerative braking systems are utilized in electric elevators and crane lifting machines.
- Also applied in electric and hybrid cars, electric railway vehicles, electric bicycles, etc.

Advantages:

- Decreases pollution.
- Reduced wear and tear of Engines.
- Reduced Brake Wear.
- Reduced emissions.

Disadvantages:

- Expensive components, engineering, and installation.
- As studied to dynamic brakes, regenerative brakes are claimed to match the power generated by the input supply (D.C. and A.C. supplies).
- The excessive charge would cause the voltage of the battery to rise above a safe level.
- Added maintenance.

Future Scope:

Future growth, however, such as ultra-capacitors, flywheels, and hydraulic systems could have much extra power capacities, which could create the possibility to depend more effectively on the regenerative braking system, in fact for high speed, high stops, and the chance to decrease or even remove the friction-braking system.

3. Methodology

A. Design

The design is done by using Creo software.

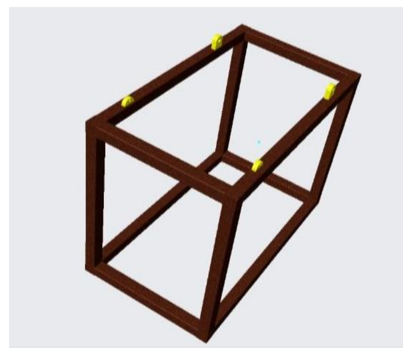

Fig. 3. Design of frame

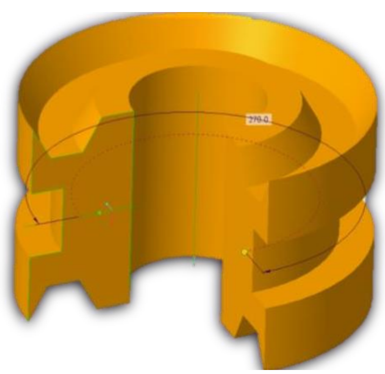

Fig. 4. Design of pulley

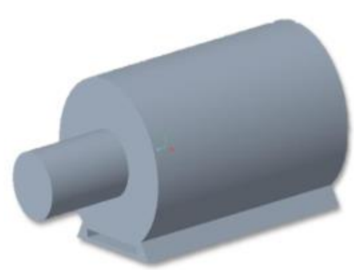

Fig. 5. Design of motor

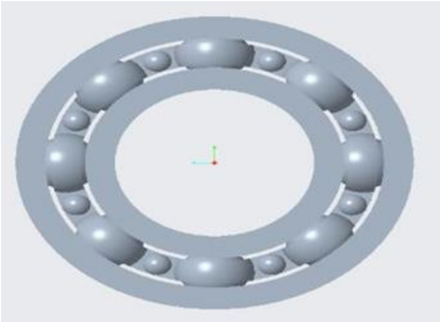

Fig. 6. Design of bearing

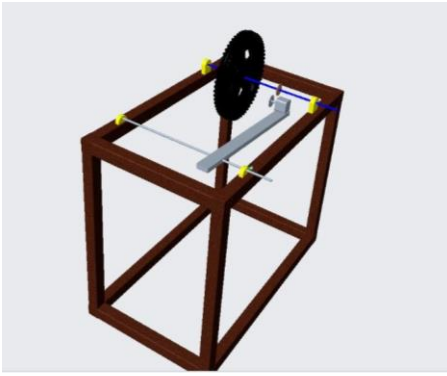

Fig. 7. Assembly of the component

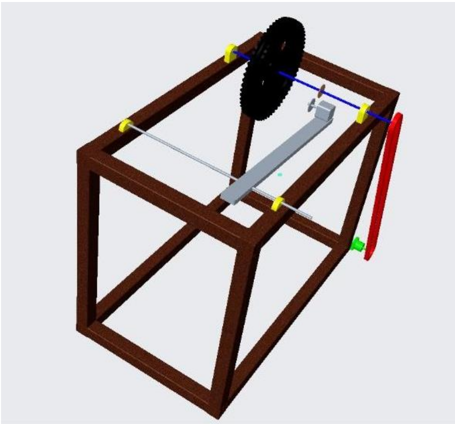

Fig. 8. Final assembly with belt drive mechanism

B. Fabrication

List of materials used in fabrication.

- Square bar
- Journal Bearing
- Brake Wheel
- Solid Shaft
- Bicycle Wheel
- Brake Spindle
- Sewing Machine Motor
- Pulley
- Pulley Rope
- LEDs
- Electric Wires
- D.C. Motor

C. Equipment

List of equipment used in fabrication.

- Drilling Machine
- Metal Cutting
- Hacksaw
- Angle Clip from square bar
- Arc Welding
- Basic Welding Circuit

4. Procedure

- First, the square bar is cut to an angle of 45 degrees and then welded together in order to form a square frame.
- The square bar is welded at both corners to form a table-like structure.
- The flat mild steel plate is drilled and welded in the square bar to grasp the solid shaft for the brake spindle.
- The Plummer block is equipped on top of the flat plate welded on the square frame.
- A solid shaft is placed in the Plummer block through the bicycle wheel and the brake wheel and pulley are arranged.
- Functioning the Frame, the motor is welded.
- The power of the motor is transmitted to the Bicycle wheel by joining the pulley and motor with a belt.
- The brake wheel is set at the tip of the Geared D.C motor which is set upon the brake spindle.

Precautions used while fabrication

- The Apron is should be at every process during Fabrication.
- Face shields and welding gloves are used throughout the welding process.
- Proper coolant is granted throughout the Drilling process.
- Gloves are used to calculate hands while the Grinding process.
- The materials were handled very carefully throughout the Fabrication.

Fig. 9. Final fabrication

5. Result

After the successful testing the model is operated and the results obtained in various loading condition are noted and tabulated below.

Table 1
Results obtained in various loading condition

S. No.	RPM before brake pedal pressed	RPM after brake pedal pressed	Voltage output
1	500	480	9.34
2	900	870	10.88
3	1300	1260	11.81
4	1700	1650	12.91
5	2100	2040	13.49
6	2300	2270	13.89
7	2500	2460	14.49

It is evident in the result tables that the efficiency of the regenerative braking systems using

D.C Motors increases as the angular velocity of the motor increases and hence the regenerative braking systems are more efficient as higher angular velocities and the recoverable energy increases with an increase in the motor speed.

6. Conclusion

Experimentally it is found that on increasing the speed of the wheel (rpm) the voltage generated will also be increasing and vice-versa. Like with others, researchers had used stepper or servo motors as regenerative motors, so in this project, it is replaced with a D.C motor. motor with gear. It has been found that the voltage generated by the D.C motor with gear is higher than that of voltage produced by those two motors.

Hence, if this system is installed in the actual automobile least 11% of battery energy can be recovered using the regenerative braking system which would otherwise be wasted to heat in friction brakes. So the gap traveled between two consecutive charging requirements can be expand to 10 to 15 % using this regenerative braking.

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