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RESEARCH ARTICLE

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DESIGN AND FABRICATION OF REGENERATIVE BRAKING SYSTEM

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ABSTRACT
As in today's world, where there are energy crises and therefore the resources are depleting at a better rate, there's a requirement of specific technology that recovers the energy, which gets usually wasted. So, just in case of automobiles one among these useful technologies is that the regenerative braking system.
Regenerative braking system is an energy recovery mechanism that reduces the speed of a vehicle by converting its Kinetic Energy. Into a form which will be either used for energy generation. By the help of Regenerative braking system in automobiles, we can recover the Kinetic Energy of the vehicle to some extent that's lost during the braking process.
The converted Kinetic Energy is stored for future use or is fed back to the facility system of the vehicle. This energy is often stored during a battery or bank of capacitors for later use. Energy also can be stored with the assistance of a rotating flywheel which is one among the foremost inexpensive and effective method of storing and regenerating power. This invention provides energy-storing regenerative braking system by transmitting the flywheel force as a torque tending to oppose the forward rotation of a wheel on applying the brakes.
Keywords— Regenerative Braking, Generator, Energy Crises, Energy Recovery, Capacitors, Flywheel.

1. Introduction

In recent years, there is the Shortage of reliable alternative energy sources, increasing efficiency and reducing exhaust gas emissions has become the main target of the modern automotive research. Commercial vehicles like refuse trucks and delivery vehicles lose a great amount of kinetic energy (K.E) during frequent 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 vehicles. Numerous attempts are made to enhance sort of vehicles. The technological combination of Exhaust Gas Recirculation (EGR) and Diesel Particulate Filter (DPF) after treatment are the effective ways to solve the vehicle emission, especially for NOx and soot. However, this method is not continually able to reduce the GHG emission during the lower temperature combustion of this technology leads to increasing the fuel penalty.

Regenerative energy technology the key features of electrified vehicles. It allows the vehicle to capture a great amount of the K.E lost during braking or decelerating for reusing in any ways in Future. So that, energy recovery technology can significantly bring down the energy consumption of electrified vehicle, particularly in city operated route. The regenerative braking system is placed within the driven axle to recuperate the braking energy loss. The boost recuperation system is

parallelly attached with the mechanical system to recover K.E during the slowing process. This technology allows commercial vehicles to have an important improvement of reducing fuel consumption and also emissions. The more energy the regenerative braking recovers, the less fuel is consumed.

2. Working Principle

Regenerative braking is a method that utilizes the energy from the motor by converting K.E into electrical energy and fed back to the battery source. Hypothetically, regenerative braking system can convert a good amount of its K.E to charge up the battery, using the principle as an alternator.

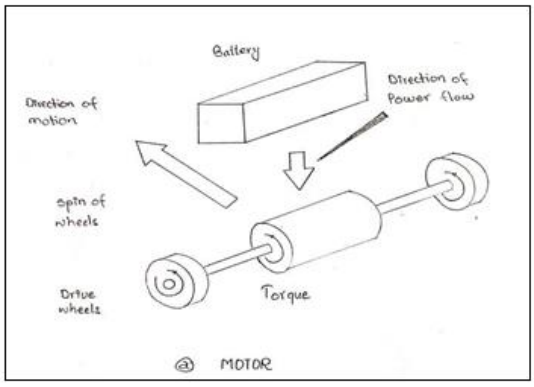

Fig 1.2.1: Normal forward driving condition

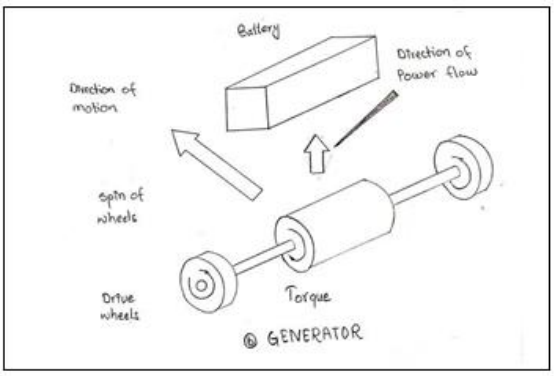

Fig 1.2.2: Regenerative action during braking

In regenerative braking mode, the motor is used to slow down the vehicle when the driver presses the brake pedal then the electric motor works in reverse direction and the vehicle slows down. While running anti-clockwise direction, the motor acts as the generator and recharge the batteries as shown in figure (1.2.2). Meanwhile in figure (1.2.1) shows the vehicle in normal running condition whereas the motor turning forward and taken energy from the battery. These brakes work effectively in driving environment such as stop-and-go driving situations especially in town and city.

3. LITERATURE REVIEW

Sayed Nashi [1] a test bench for testing of regenerative braking capability of a Brushless DC Motor is design and then fabricated according to the model. This project creates awareness to engineers and the ideal drivers towards energy efficiency and energy conservation. It concludes that the regenerative braking systems are more effective and efficient at higher speed and it cannot be used as the only brakes in a vehicle as alone this system cannot stop the vehicle at sudden braking, so along with this system Anti-lock braking system (ABS) can be used. The definite use of this technology described as in the project in the future automobiles can help us to a certain level to sustainable and positive future of energy efficient world as a part of power that is lost can be recovered by using this system.

Khushboo Rahim and Mohd. Tanveer [2] the advantages of regenerative braking system over conventional braking system are mentioned. Regenerative braking systems can effectively work at the high temperature ranges and are highly efficient when compared to the traditional brakes. They are also more effective at higher speed. The more often a vehicle stops, the more it can get benefit from this braking system. Large and heavy vehicles that runs at higher speeds develops lots of K.E, so they conserve energy more efficiently. It has broad scope for further improvements and the energy conservation.

Tushar L. Patil, Rohit S. Yadav, Abhishek D., Mahesh Saggam, Ankul Pratap [3] the procedures to increase the efficiency of the regenerative braking system is mentioned. The procedure mentioned was to decrease the weight of the automobile which increase performance. Also, the usage of super capacitor improves the conversion rate of energy in regenerative braking system, making the automobile compact and have a tendency to increase the efficiency of the system.

C. Jagadeesh Vikram, D. Mohan Kumar, Dr. P. Naveen Chandra [4] Fabrication process on the

Regenerative Braking System had been executed as per the prescribed measures has been taken and the future enhancements should be processed on basis of the need of the study. The application of the regenerative braking system is quite crucial in automotive transportation with maximized performance in braking.

A. Eswaran, S Ajith, V Karthikeyan, P Kavin, S Loganandh [5], the regenerative braking system used in the vehicles fulfill the purpose of saving a part of the energy lost during braking. Also, it can function in the high-temperature range and are effective as compared to a conventional braking system. Regenerative braking systems need further research to develop an improved system that seizures more energy and stops faster. All vehicles in motion can get benefit from the system by obtaining energy that would have been lost during the braking process. The use of more efficient systems results in huge savings in the economy of any country.

Ketan Warake, Dr. S. R. Bhahulikar, Dr. N. V. Satpute [6], the regenerative braking system used in the vehicles fulfill the purpose of saving a part of the energy lost during braking. The regenerative braking system is planned to partially recover the battery charge lost in braking of the vehicle. The energy is transformed into heat by friction brake which is released to the environment. This Energy is applied to rotate the rotor of the generator converting mechanical energy of wheels into the useful charge of the battery. The regenerative braking system cannot be used as a main braking system of the vehicle. Research shows that a minimum of 11% battery energy can be recovered using the regenerative braking system which would else be wasted to heat in friction brakes. Hence the distance traveled between two consecutive charging requirements can be boosted to 10 to 15 % using this regenerative braking, when applied in actual vehicles.

Siddharth K Sheladia, Karan K Patel, Vraj D Savalia, Rutvik G Savaliya,[7] it is mentioned that Regenerative braking can conserve up to 5% to 8% of waste energy. The systems have been improved with advanced power electronic mechanisms such as ultra-capacitors, DC-DC converters and flywheels. Ultra-capacitors, which help improve the transient state of the car during startup, provide a smoother charging characteristic of the battery and improve the overall performance of the electric vehicle system. Ultra-capacitors converters help to maintain power management in regenerative braking systems. Finally, flywheels are used to improve the power recovery process through automotive wheels.

The main Objectives of the work are

- To control the speed of the vehicle and stop it quickly and efficiently without sticking.
- To reduce the reaction time of braking by using regenerative braking and generating power by converting kinetic energy into electrical energy and storing in the batteries for any future work.

4 Materials and Methodology

Regenerative braking system may not suit the basic requirement of braking system alone. This is because of limitation of energy dissipation at very high power. The storage and generation systems may not be capable to operate at those levels due to design limitations. Due to critical level of safety involved with the system, reliability becomes doubtful and it requires a frictional braking system to co-exist with electrical regenerative braking system. [8] This forms a hybrid braking system [9], which means:

1. Just like hybrid propulsion systems, there can be many design configurations and control strategies.
2. Design and control of system should be such that they ensure vehicle's desired braking performance while at the same time capturing as much energy as possible.

During developing strategies, a careful consideration of braking behavior and its characteristics with respect to speed, braking power, deceleration rate etc. must be made.

The following materials was used for fabrication are first understood and then bought from the market. The tabular below shows the materials required with the quantities.

Table 1. List of materials

Sr. No	Name of Parts Used	Description	Quantity
1	Square bar	40*40 Hollow Bar (M.S)	8 m
2	Journal Bearing	Internal Dia.12mm	2 pieces
3	Brake Wheel	Outer Dia.8cm	1 piece
4	Solid Shaft	Outer Dia.12mm	1.5m
5	Bicycle Wheel	Inner Dia. 12 mm	1 piece
6	Brake Spindle	40*40 Hollow Bar (M.S)	0.6m
7	Sewing Machine Motor	9500 rpm	1 piece
8	Pulley	Internal Dia.12mm	2 pieces
9	Pulley Rope	V-belt	0.5m
10	LEDs	12v	6 pieces
11	Electric Wires	Copper wire	6 m
12	D.C Motor	Brushed D.C 12v	1 piece

4.1 Procedure

- First the square bar is cut into an angle of 45 degree and then welded together in order to form a square frame.
- The square bar is welded at each corner to form a table like structure.
- The flat mild steel plate is drilled and welded in the square bar to hold the solid shaft for brake spindle.
- The Plummer block is fitted over the flat plate welded on the square frame.
- Solid shaft is inserted in the Plummer block upon which the bicycle wheel and brake wheel and pulley are fitted.
- On the Frame the motor is welded.
- The power of the motor is transmitted to the Bicycle wheel by the joining the pulley and motor with a belt.
- The brake wheel is fixed at the tip of the Geared D.C motor which is fixed upon the brake spindle.
- The L.E.Ds is fixed on the square frame.
- The output of the Geared D.C motor is connected to L.E.Ds through copper wire.
- The small wheels are placed on the legs to give movements to the Assembly.
- The Entire Assembly is colored with Red and black Paint to protect form Rust.

4.2 Fabrication

Fig: Fabrication of the project.

4.3 Testing

The final design after the fabrication is tested to know that the design is made as per the requirement and the model should fulfill some Mechanical properties. Mechanical testing employs

a variety of strength tests that can determine the suitability of component for the intended application.

4.4 Result

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

Table 2. Result Table

S. N	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 can be seen from the result tables that the efficiency of the regenerative braking systems using Geared D.C Motor increases as the angular velocity of the motor increases .So we can say that, the regenerative braking systems are more efficient as higher angular velocities and the recoverable energy increases with increase in the motor speed. The losses are higher at lower speed as we already know that the motors are inefficient at lower speeds, whereas the losses at higher speeds are mainly mechanical losses like friction losses and air drag.

5. Conclusions

The regenerative braking system used in the vehicles fulfills the purpose of saving a part of the energy lost during braking. This system can be operated at high temperature range and are efficient as compared to conventional braking system. This system requires further research to develop a better system that captures more energy, stops faster and has less weight. All vehicles in motion can benefit from these systems by recapturing energy that would have been lost during braking process due to excess heat produced due to friction. If we could use more efficient systems, the huge savings in the economy of any country can be obtained.

5.1 Recommendations

As this project is completely based on the experimental test rig and if this system is applied in the current working vehicles there are may be some problems which may cause uncomfortable for drivers. As regenerative braking system don't provide braking at high speed so this system should be implemented with other forms of Braking system like Anti-Lock Braking System (ABS).

Implementing this system in the current working vehicle will increase the mass of the vehicle and occupies additional space. So this factor should be considered before design of the vehicle so that this factor could be overcome.

Integrating regenerative braking into a vehicle requires some changes in the driving style which depends on the technical configuration of the system. This takes some time getting used to, but studies have shown that drivers respond positively and try to maximize the energy they can recapture and hereby extend their range.

Additionally, the usage of regenerative braking is closely linked to eco-driving. If eco-driving approaches are applied by the drivers, this could have considerable effects on traffic flow.

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