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Regenerative Braking System for Better Fuel Economy and Power

Abstract

As the basic law of "Thermodynamic", says 'Energy can neither be created nor be destroyed it can only be converted from one form to another'. During this huge amount of energy is lost to atmosphere as heat. 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. Regenerative braking refers to a system in which the kinetic energy of the vehicle is stored temporarily. Regenerative braking is a small, yet very important, step toward our eventual independence from fossil fuels. These kinds of brakes allow batteries to be used for longer periods of time without the need to be plugged into an external charger. These types of brakes also extend the driving range of fully electric vehicles. Regenerative braking is a way to extend range of the electric vehicles. In many hybrid vehicles cases, this system is also applied hybrid vehicles to improve fuel economy.

Keywords: Why RBS, Its Need, Advantages & Disadvantages.

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Introduction

An Energy Regeneration Brake was developed in 1967 for the AMC Amitron. This was a completely battery powered urban concept car whose batteries were recharged by regenerative braking, thus increasing the range of the automobile. Many modern hybrid and electric vehicles use this technique to extend the range of the battery pack. Examples include the Toyota Prius, Honda Insight, the Vectrix electric maxi-scooter, and the Chevrolet Volt.

In automobiles the brakes are having the most important function to perform. When a conventional vehicle applies the brakes, kinetic energy is converted to heat as friction between the brake pads and wheels. This heat is carries away in the airstream and the energy is effectively wasted. The total amount of energy lost is depended on the time and hardness that's brakes are applied. It will be good if we could store this energy somehow which is reuse it next time we started to accelerate.RBS refers to a process in which a portion of K.E. of the vehicle is stored by a system. That energy is held until required again by the vehicle, whereby it is converted back into K.E. and used to accelerate the vehicle. 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 energy is stored in a battery or bank of capacitors for later use. Energy may also be stored by compressing air or in a rotating flywheel. These are widely used in electric trains and the latest electric cars.

According to a research it is found that a minimum energy storage of 78kwh is required to give the automobile a range of 200-250 inn. This is based on a total vehicle weight of 2200 kg and is significantly less if a lighter vehicle is used The power requirements depend upon the maximum acceleration and deceleration rates of the vehicle and the allowable time to recharge the batteries or flywheel. A minimum power of 94 kW is required to meet the specified acceleration deceleration rates.[1] Since RBS results in an increase in energy output for a given energy input to a vehicle, the efficiency is improved. The amount of work done by the engine is reduced, in turn reducing the amount of prime energy required to propel the vehicle.[2]

Need for Regenerating System

1. At present where the price of the fuel is increases there requirement of various research and development efforts for the energy conservation.

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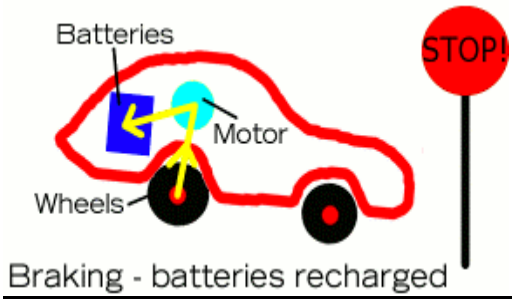
2. In low speed, stop and go traffic where little deceleration is required RBS can provide the majority of the total braking force. This vastly improves the fuel economy with a vehicle and the attractiveness of vehicle using RBS for driving.
3. At higher speeds, RBS has been shown to contribute to improved fuel economy by as much as 20%. If all brake energy could be regenerated with no loss in this system, fuel consumption would be improved by 33%.
4. Most American manufacturers believe that these systems are the way to achieve more flexibility and range out of electric vehicles
5. European manufacturers believe that these vehicles are a way to achieve high fuel efficiency and very low emissions.


Basic Idea of RBS

Concept of the RBS is better understood from bicycle with a dynamo (a small electricity generator). If bicycle has a dynamo on it for powering the lights, we'll know it's harder to peddle when a dynamo is engaged. That's dynamo and convert into electrical energy in the lights. Now imagine a bicycle with a dynamo that's 100 times bigger and more powerful, which convert the kinetic energy into electricity, which could store in a battery and use again later. That's the basic idea behind regenerative brakes. So a good proportion of energy we lose by braking is returned to the batteries and can be reused when we start off again.

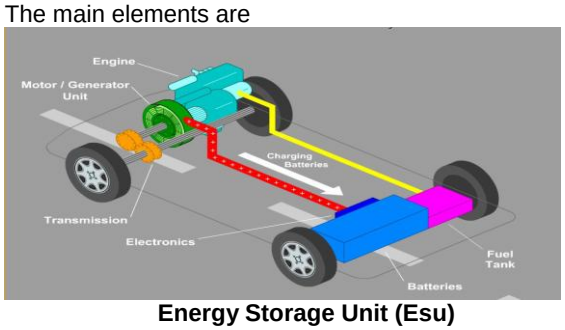


Motor As A Generator

Vehicles driven by electric motors use as the motor as a generator when using regenerative braking, it is operated as a generator during and its output is supplied to an electrical load; the transfer of energy to the load provides the braking effects.Regenerative braking is used on hybrid gas/electric automobiles to recoup some of the energy lost during stopping. The energy is saved in a battery and used later to power the motor whenever the car is in electric mode.

Basic Elements of System

The main elements are



Energy Storage Unit (Esu)

It performs two primary functions

1. To recover & store braking energy
2. To absorb excess engine energy during light load operation

The energy recaptured by regenerative braking might be stored in one of three devices:

1. An Electrochemical battery
2. A flywheel
3. Compressed air

Batteries

When the brake pedal is depressed, the battery receives a higher charge, which slows the vehicle down faster. The further the brake pedal is depressed, the more the conventional friction brakes are employed. The motor/generator produces AC, which is converted into DC, which is thenused to charge the Battery Module. So, the regenerative systems must have an electric controller that regulates how much charge the battery receives and how much the friction brakes are used.

Fly Wheels

A flywheel used as a reservoir, which stores energy during the period when the supply of energy is more than the requirement and release it during the period when the requirement of energy is more than the supply.

In this system, the translational energy of the vehicle is transferred into rotational energy in the flywheel, which stores the energy until it is needed to accelerate the vehicle. The benefit of using flywheel technology is that more of the forward inertial energy of the car can be captured than in batteries, because the flywheel can be engaged even during relatively short intervals of braking and acceleration.[3]

Continuosly 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.

Controller

An "ON-OFF" engine control system is used. That means that the engine is "ON" until the energy storage unit has been reached the desired charge capacity and then is decoupled and stopped until the energy storage unit charge fall below its minimum requirement.[4]

Regenerative Brake Controller

Brake controllers are electronic devices that can control brakes remotely, deciding when braking begins ends, and how quickly the brakes need to be applied.

During the braking operation, the brake controller directs the electricity produced by the motor into the batteries or capacitors. It makes sure that an optimal amount of power is received by the batteries, but also ensures that the inflow of electricity isn't more than the batteries can handle.

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. If it isn't, the brake controller turns the job over to the friction brakes. In vehicles that use these types of brakes, 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.[5]

Application

Hi-tech flywheels are now being used as regenerative systems in such things as F-1 cars, where they're typically referred to as kinetic Energy Recovery systems (KERS)

Comparisons

Advantages of RBS Over Conventional Braking

Energy Conservation

The flywheel absorbs energy when braking via a clutch system slowing the 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 conserved rather than wasted as heat and light which is what normally happens in the contemporary shoe/disc system.

Wear Reduction

An electric drive train also allows for regenerative breaking 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 use 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 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. The Delhi Metro saved around 90,000 tons of carbon dioxide (CO2) from being released into the atmosphere by regenerating 112,500 megawatt hours of electricity through the use of regenerative braking systems between 2004 and 2007. It is expected that the Delhi Metro will save over 100,000 tons of CO2 from being emitted per year once its phase II is complete through the use of regenerative braking. The energy efficiency of a conventional car is only about 20 percent, with the remaining 80 percent of its energy being converted to heat through friction. The miraculous thing about regenerative braking is that it may be able to capture as much as half of that wasted energy and put it back to work. This could reduce fuel consumption by 10 to 25 percent. Hydraulic regenerative braking systems could provide even more impressive gains, potentially reducing fuel use by 25 to 45 %.schedules.[6]

Comparison of Dynamic Brakes and Regenerative Brakes

Dynamic brakes ("rheostat brakes" in the UK), unlike regenerative brakes,Dissipate the electric energy as heat by passing the current through large banks of variable resistors. Vehicles that use dynamic brakes include forklifts, Diesel-electric locomotives, and streetcars. This heat can be used to warm the vehicle interior, or dissipated externally by large radiator-like cowls to house the resistor banks. The main disadvantage of regenerative brakes when compared with dynamic brakes is the need to closely match the generated current with the supply characteristics and increased maintenance cost of the lines. With DC supplies, this requires that the voltage be closely controlled. Only with the development of power electronics has this been possible with AC supplies, where the supply frequency must also be matched (this mainly applies to locomotives where an AC supply is rectified for DC motors). A small number of mountain railways have used 3-phase power supplies and 3-phase induction motors. This results in a near constant speed for all trains as the motors rotate with the supply frequency both when motoring and braking.

Advantages & Disadvantages

Advantages

1. Provide greater fuel economy
2. Greater improvement in emission reduction
3. Energy conservation will be carefully controlled in the interest of max. efficiency
4. Provide ample power drive and power for sudden acceleration

Disadvantages

The main disadvantage of RBS when compared with dynamic brakes is the need to closely match the electricity generated with the supply. With DC supplies this requires the voltage to be closely controlled and it is only with the development of power electronics that it has been possible with AC supplies where the supply frequency must also be matched (this mainly applies to locomotives where an AC supply is rectified for DC motors).

Conclusion

Regenerative braking allows for a vehicle to recover its kinetic energy when braking. Up to now, there have been no systems that fully rely on regenerative, braking, however this paper presents a method to use regenerative braking for all kinds of deceleration. The energy gathered during the deceleration can then be used again during acceleration. The proposed system allows a smooth braking experience while also dealing with full stop and emergency brake situations. The smooth braking experience is achieved by controlling the connection between the generator and its load. Full braking is achieved by using multiple generators, each connected to the shaft with a different gear ratio. This setup ensures that there is always one generator working efficiently and therefore extracting kinetic energy from the system[7].

Additionally, the system can be reversed when the generators are used as motors to drive the vehicle. Since each motor is connected to the shaft with a different gear the system benefits from an improved acceleration independent of vehicle speed. The switching between both functionalities can be achieved by using a double H-Bridge, which has been expanded with extra circuitry for reliability and to allow for fast switching speeds.

References

1. www.http://eprints.whiterose.ac.uk/2118/1/ITS105_WP471_uploadable
2. Cibulka, J. Kinetic energy recovery system by means of flywheel energy storage Advanced engineering 3(2009)1, ISSN 1846-5900
3. Theory of machine, topic- flywheel by- R.S. Khurmi
4. Juan W. Dixon, Micah Ortúzar and Eduardo Wiechmann*, "Regenerative Braking for an Electric Vehicle Using Ultracapacitors and a Buck-Boost Converter"
5. Su, G J., McKeever J.W. Samons K.S., "Design of a PM Brushless Motor Drive for Hybrid Electrical Vehicle
6. Yoong, M.K. (2010) 'Studies of regenerative braking in electric vehicle', in Proceedings of the IEEE Conference on Sustainable Utilization and Development in Engineering and Technology, p. 40-41.
7. Wikepidia.org(http://en.wikipedia.org/wiki/Regenerative_brake)