Regenerative Braking

Yash Lokhande[1], Ayush Gaikwad[2], Abhijeet Bansode[3], Chirag Desai[4]
[1, 2, 3,4]PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

Abstract- *Regenerative braking is an innovative technique that is utilized in EVs to capture the kinetic energy that would have been wasted when the vehicle decelerates or comes to a standstill while braking. Regenerative braking is one of the methods to extend the range of EVs by charging the battery from the energy available during braking. During regenerative braking, the vehicle inertia along with power electronic converters makes the motor to act as the generator to send the energy back to the battery.*

Keywords: Regenerative braking, energy conservation, electric vehicles, efficiency

I. INTRODUCTION

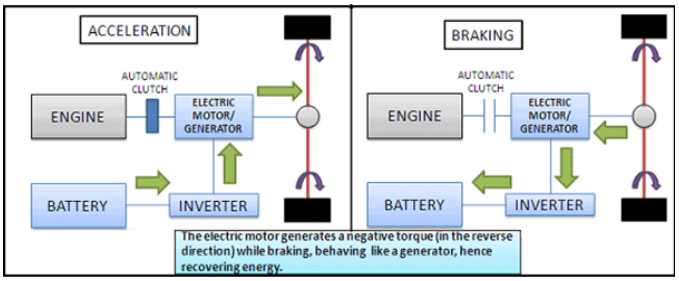
A regenerative brake is a system that allows a vehicle to recover part of the kinetic energy dissipated during braking phases. Recovered energy can be stored in a battery in form of electricity and used during vehicle acceleration phases, increasing efficiency and fuel economy. Every time the driver steps the cars brakes, energy is wasted. This energy can be converted. When the car slows down, the kinetic energy in forward direction needs space and gets released in the system. This energy becomes useless. Regenerative braking helps to recover this energy and at the same increase the efficiency of the vehicle. The energy stored in battery increases and the amount of work done on the vehicle is also reduced, making it beneficial for the vehicle.

EVs with energy storage capacity allow operating within the regenerative braking mode, thus converting the kinetic energy lost during braking or stopping into electricity, which is stored in the battery. The stored energy is later utilized to power the main motor of the vehicle whenever the vehicle operates in electric mode.

Regenerative braking is an efficient method to extend the driving range of Hybrid Electric Vehicles (HEV) by minimizing vehicle fuel consumption. In recent times, hybrid vehicles (HEVs) have received an increasing attention as an alternate mode of transport compared to traditional vehicles powered by IC engines using fossil fuels. A crucial advantage of HEVs compared to standard vehicles is the possibility to save energy during braking phases.

II. METHODOLOGY

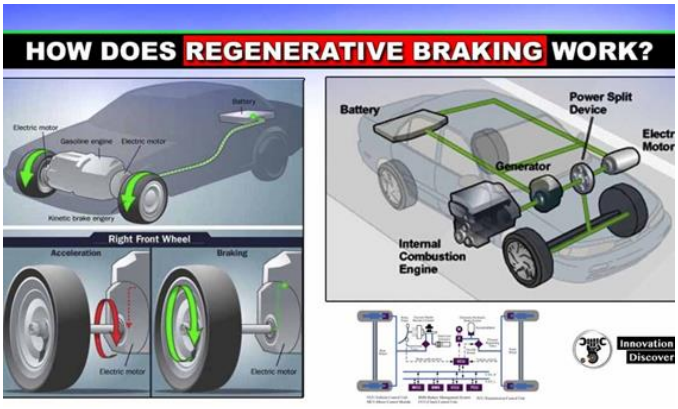
Regenerative braking involves motor as a generator. The work depends upon the working rule of electric motor. When some external force, in the form of braking, is applied to activate the motor, then it acts as a generator and generates electricity.



Whenever the motor runs in one direction the electric energy gets converted into mechanical energy, which is used to accelerate the vehicle. But when the motor runs in opposite direction it functions as a generator, converts mechanical energy into electrical energy, making it possible to utilize the driving axle to turn the vehicle, which regenerates electric energy for storage. This energy can be used for recharging the battery.

III. MECHANISM

The working of the regenerative braking system depends upon the working principle of an electric motor. Generally, the electric motor, is actuated when current is passed through it. But when some external force is employed to actuate the motor during the braking process then it behaves as a generator and converts mechanical energy into electricity. That is, whenever a motor is run in one direction the electric energy gets converted into mechanical energy, which is used to accelerate the vehicle and whenever the motor is run in opposite direction it functions as a generator and converts mechanical energy into electrical energy. This makes it possible to use the rotational force of the driving axle to turn the electric motors, thus regenerating electric energy for storage in the battery and at the same time slowing the car with the regenerative resistance of the electrical motors. This electricity is then used for recharging the battery.



Advantages in regenerative braking system

- Reduction in Engine wears
- Emissions reduction-engine emission is reduced by engine decoupling, reducing total engine revolution.
- Improvement within the fuel economy of the vehicle
- Reduction in wear and tear on the braking system.
- There is more control over braking

IV. 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 instead of wasted as heat and light which is what normally happens within the contemporary shoe/disc system.

Regenerative braking has the ability to save up to 8-25% of the wasted energy. The fuel consumption is also improved by 33%. At higher speeds, regenerative braking has been shown to contribute to improved fuel economy by as much as 20%.

Consider a truck carrying a heavy load having very few stops on the road. It is operated upto maximum engine efficiency limit. The 80% of the energy produced is utilized to overcome the rolling and aerodynamic road forces. The energy wasted in applying brakes is 2%. Also, its fuel consumption on braking is 5%. Engine emissions are reduced by engine decoupling, that reduces total engine revolutions and total time of engine operation.

Now consider a vehicle, which is operated within the main city where traffic maybe a major problem. Here one has got to apply brake frequently. For such vehicles, the energy that is wasted by applying brakes is about 65%. And also, it's inefficient as its brake specific fuel consumption is high.

Cutting vehicle emissions with regenerative braking

To achieve meaningful reductions in future CO_2 emissions, what's ultimately required may be a change from the utilization of fossil fuels to alternative zero or low emission energy sources. Some manufacturers have already begun to incorporate mild regenerative braking systems into their vehicles. The aim is to regenerate the maximum amount of energy possible while preserving vehicle stability and allowing effective operation of control systems.

V. CONCLUSION

Regenerative braking may be a small, yet a vital step towards our eventual independence from fossil fuels. These sorts of brakes allow batteries to be used for extended periods of your time without the necessity to be plugged into an external charger. This technology also extends the driving range of fully electric vehicles. Once you believe the energy losses incurred by battery-electric hybrid systems, it seems plausible to reason that efficient flywheel hybrids would soon become the norm. In the near future a combination of battery-electric and flywheel energy storage is probably the ideal solution for hybrid vehicles. As regenerative braking systems will be developed by designers and engineers, they are going to become more and more common. All vehicles in motion can enjoy from utilizing regeneration to recapture energy that would might rather be lost.

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