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A Review On Regenerative Braking Method For Energy Saving

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Abstract:

In recent years, the environmental effects concerns of the traditional car (ICE-Internal Combustion Engine) have led to the enhancement and growth of the electric vehicle (EV). The evolution of the regenerative braking system leads to increase overall vehicle performance (RBS) whenever driver applies the brake the energy which is completely lost in the form of kinetic energy due to friction loss between wheel of vehicle and road must be used and recycled, increasing the vehicle's efficiency. The reputed car companies such as BMW, Toyota, Lexus, Mercedes Benz, Land Rover, Volkswagen and General Motors have been using this technique for their EV's. This paper explores the applicability of the regenerative braking system and its applicability in various sectors to solve the existing problems

Keywords: Braking, Braking system, Efficient, Electric drives, Electric vehicle, Regenerative braking

Introduction:

Due to the advances in technology, environment condition is deteriorating day by day due to petrol and diesel based vehicular emissions, hence many countries have started developing electrical vehicles (EVs) with a serious pursuit. Historically the electrical vehicles were confined to motor drive technology and inadequate battery power and these couldn't contend with diesel- petrol engines. More recently, there has been advancement in electrical vehicle technology, but motor propulsion performance and improvement in energy efficiency has been the focus of majority of the players in this industry. Drum brakes, disk brakes, and antilock brake systems (ABS) are usually chosen at intervals the standard petrol or diesel engine vehicles or electrical vehicles (EVs). Throughout the course of steep decline, the gasoline vehicles apply conventional brake which produce deceleration force, due to which kinetic energy of the vehicle is lost but this does not take place in electric vehicles. Regenerative braking systems are among the important energy saving applications.

There are three types of electric braking namely Plugging, Rheostatic braking and Regenerative Braking among which Regenerative braking is the most efficient braking system because all the kinetic energy wasted during braking is returned to the battery in the form of electrical energy.

Electrical vehicles (EV) are among the alternates of internal combustion engine vehicles thanks to air pollution, high cost and depletion of crude oil reserves. These cars can be driven by DC or AC type electrical motor. DC motor is utilized for propulsion because battery is the prime source of power. More recently, thanks to progress in power electronics, components like converters, brushless DC (BLDC) motors with Hall Effect sensors, permanently magnetic synchronous motor (PMSMs) & SRMs are utilized.

Working principle of regenerative braking system

Regenerative braking is an essential feature of electric vehicles. Thanks to recovering energy via the generator operation of electric propulsion motor and boosting operation of the motor driver, it is possible to regain some part of kinetic energy as electrical energy for battery charging. The efficiency of generated electrical energy is dependent on combined operations of the electrical machine and power electronic circuit. If the battery is fully charged, regenerated energy can be consumed in a braking resistor, i.e., dynamic braking.

Regenerative braking is the type of electrical braking which slows down the moving vehicle by converting its kinetic energy into electrical energy. In regenerative braking mode, the car's motor slows down on an incline. When force is applied to the brake pedal, the vehicle slows down and the motor runs in the opposite direction. When operating in the opposite direction, the engine acts as a generator and converts torque energy into electrical energy. In this way, fuel consumption and emissions are reduced. The new electro-hydraulic powertrain is a parallel hybrid system that includes a traction motor, battery pack, hydraulic pump/motor (secondary component), hydraulic accumulator, reservoir, and a set of hydraulic valves. The hydraulic circuit includes the drive circuit and the drain circuit. The drive circuit consists of a oneway valve, a cartridge valve, and a two-position four-way valve. When the vehicle is braking, the valve is shifted to the left; this directs the oil from the reservoir to flow towards the accumulator using the secondary component pump / motor. The second component operates in pump mode by using the kinetic energy of the vehicle to pressurize the oil in the reservoir to flow into the accumulator. The vehicle slows down by storing the energy in the accumulator. The hydraulic system works in the regenerative braking mode. These brakes work very effectively in urban braking situations**.**

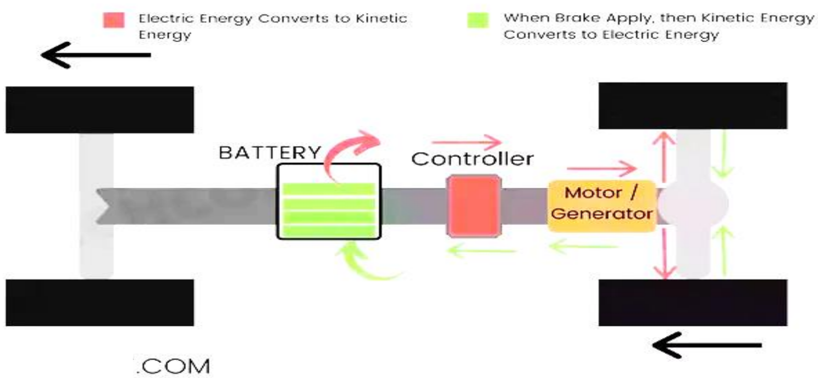

Figure 1 Block Diagram of Regenerative Braking System

The regenerative braking is classified as:-

•Series regenerative braking

•Parallel regenerative braking

- **Series regenerative braking**

Series regenerative braking is based on the combination of friction-based adjustable braking system that transfers electrical energy to the electric motors and batteries under an integrated control strategy. The overall design of serial regenerative braking is to estimate the retardation required and distribute the required braking force between the regenerative braking system and mechanical braking system. Series braking system needs brake by wire system and has more consistent pedal feel due to good torque blending capability. It can increase the efficiency by 15-30%

The most promising and technologically advanced method for implementing the serial braking strategy consists of reducing the frictional braking force by means of automatized braking system control. The service brake may be operated hydraulically, pneumatically, or electromechanically. As one of the electro-mechanical methods, the “brake-by-wire” system may be mentioned, where the pneumatic, hydraulic, and electrical sources of the braking force are controlled by an additional electrical signal coming from e.g. the brake pedal. In the case of hydraulic braking systems, the braking force is limited by means of the final control elements of the ABS/ESP systems required for some vehicle categories, thanks to which the costs of implementation of advanced braking strategies are reduced

•Parallel regenerative braking

Parallel braking system is based on the combination of friction-based system and the regenerative braking system, operated without an integrated control. The braking force is calculated from the control unit by comparing the required brake torque and the motor torque available. Parallel regenerative braking system requires more effort in achieving good torque blending. This system increases the efficiency by 9-18%.

When the brake pedal is pressed and a braking torque is required, it is passed through the brake control strategy block and check if state of charge is less than the maximum permissible level of charge. Then the requested brake torque is compared with the maximum limit of regenerative torque of the motor or generator. The vehicle brakes purely by friction If the brake torque required is less than or equal to the maximum regenerative torque, and if the requested brake torque is greater than the maximum regenerative torque, it Is checked if the total brake torque requested from Front (70% of requested brake torque) is less than or equal to maximum regenerative torque. If the condition is satisfied. Then the vehicle brakes purely by friction. If not, then the Vehicle brakes by front friction and regenerative braking and Rear friction braking.

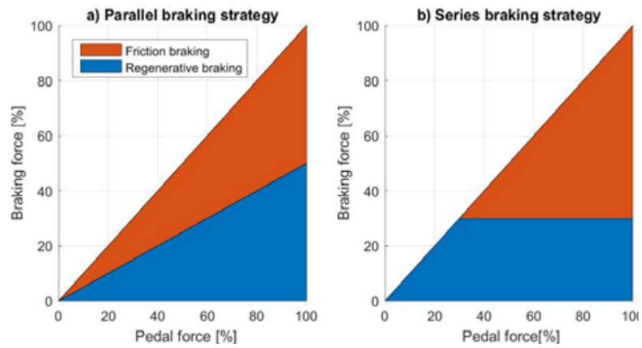

Fig 2. Division of braking forces into frictional braking and regenerative braking: a) Parallel strategy; b) Serial strategy

Various RBS classification systems (i.e. systems of the braking torque being split into regenerative braking and frictional braking) are proposed. As an example, the author of the study [2] proposes the following three strategies of regenerative braking.

1. The electric machine alone is used for the vehicle braking until the electrically generated braking torque becomes insufficient for braking the vehicle with a required deceleration; then, the friction brakes are additionally applied [4].

This strategy is advantageous in energy recuperation terms, as the driven axle wheels are usually braked. Of course, this strategy is inacceptable from the safety point of view, because the vehicle is retarded by the wheels of only one axle, i.e. the whole braking force in the tyre-road contact area is transmitted by the tyres of only one vehicle axle. This phenomenon results in a higher degree of utilization of the tyre-road adhesion, it may cause tyre slip and a loss of the side force transmission capability of a tyre and, in consequence, a loss of the directional stability of vehicle motion.

2. The vehicle is braked in accordance with the ideal braking force distribution curve, which is implemented by combining the braking forces generated by both the electric machine and the friction brakes so that the tyre-road adhesion is utilized in the best possible way [4]. This strategy ensures the best driving safety. On the other hand, the amount of the energy recuperated is smaller than it is in the case of the first method. Therefore, the author of study [4] has proposed the third strategy.

3. When the vehicle is driven straightforward or along a road bend with a large radius (when the steering wheel angle is insignificant), strategy 1 is used. When the road bends becomes too sharp (its radius becomes smaller than a predefined limit), the regenerative braking is turned off.

Such a combination of the strategies can only be implemented in vehicles with a braking system where the braking forces can be regulated. According to another RBS classification system, proposed in publications [15] [6] and often mentioned in the literature, parallel and serial strategies of regenerative braking are discerned. In the parallel strategy, the vehicle is simultaneously braked by its electric machine and friction brakes. The functioning of the serial system is different, i.e. the braking force generated by the friction brakes is reduced and superseded by the braking effect caused by the electric machine of the vehicle. The division of braking forces in the parallel and serial strategies has been presented in Fig. 2.

CONCLUSION

The Regenerative braking is the most efficient braking system among the various electrical braking with a good efficiency in long run assisting with two control strategies named series and parallel regenerative braking.

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