A Review Paper on Regenerative Braking System

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Abstract— The most common form of regenerative brake technology re-purposes an electric motor as a generator, because of which regenerative brakes are often found in hybrid and electric vehicles. During normal operation, the electric motor draws power from the battery and uses it to move the vehicle. When the brake pedal is depressed, the electric motor is able to reverse this process, become a generator powered by the rotating wheels, and feed electricity back into the battery. Since regenerative brakes effectively charge the battery without plugging into a charger, in the case of an electric vehicle, or using the alternator in a hybrid, the overall efficiency of the vehicle is increased. That translates into more miles between charges or fuel-ups. Since, regenerative brakes effectively turn kinetic energy into electricity; they are able to slow a vehicle down in addition to charging the battery. However, there are limitations to the efficiency of a regenerative brake system. One of the main issues is that regenerative brakes don't work as well at low speeds as they do at high speeds. Due to that inherent limitation in regenerative braking, most vehicles are also equipped with a supplemental traditional braking system. In the same way that traditional steering, braking, and acceleration controls are often included as a backup for drive-by-wire systems, traditional brakes can serve as a backup for regenerative braking. Traditional systems may only kick in when there's an equipment failure, or they can be in used inconcert with regenerative braking all the time.

Keywords: Regenerative Braking, Generator, Brake pad, Energy Recovery

I. INTRODUCTION

In recent years, there is the lack of reliable alternative energy sources, increasing efficiency and reducing exhaust gas emissions has become the focus of the modern automotive research. Commercial vehicles such as refuse trucks and delivery vehicles lose a tremendous amount of kinetic energy 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 have been made to improve type of vehicles. The technological combination of Exhaust Gas Recirculation (EGR) and Diesel Particulate Filter (DPF) after treatment is one of the effective ways to solve the vehicle emission, especially for NOx and soot. However, this method is not able to reduce the GHG emission since the low temperature combustion of this technology results in increasing the fuel penalty. Sacrificing engine efficiency in exchange for reduced pollutants cannot fundamentally solve the energy crisis. In order to achieve overall GHG reduction targets, a strong reduction is needed particularly for commercial vehicles.

Regenerative energy technology is one of the key features of electrified vehicles. It allows the vehicle to capture a tremendous amount of the kinetic energy lost during braking or decelerating for reuse. That is saying, energy recovery technology can significantly bring down the energy consumption of electrified vehicle, particularly in urban operated route. Generally, there are two regenerative energy approaches which have been applied to commercial vehicles: Regenerative Braking System and Boost Recuperation System. The former is usually applied in series hybrid architecture; the latter in the parallel architecture. The regenerative braking system is equipped in the driven axle to recuperate the braking energy loss. The boost recuperation system is parallelly coupled with the mechanical propulsion system to recuperate kinetic energy during the deceleration process. Both technologies allow commercial vehicles to have a significant improvement of reducing fuel consumption as well as emissions. However, few researchers have addressed the regenerative energy rate of hybrid commercial vehicles. The more energy the regenerative braking recuperates; the less fuel is consumed. Typical hybrid commercial vehicles are generally designed as rear drive and the regenerative braking system is equipped in rear driven axle(es) to recuperate the braking energy loss. Due to the change of the center gravity in the vehicle under different load conditions, braking energy loss may vary in both front and rear axles.

Current braking research indicates that around 50-80% of braking energy loss of commercial vehicles occurs in the front axle and the braking energy loss varies slightly under different load states. Therefore, the majority of the regenerative energy potential is not taped.

II. LITERATURE REVIEW

A. Sayed Nashit, Sufiyan Adhikari, Shaikh Farhan, Srivastava Avinash and Amruta Gambhire, 'Design, Fabrication and Testing of Regenerative Braking Test Rig for BLDC Motor', 2016, 1881-84.

In this paper, Brushless DC Motor is design and then fabricated. The project creates awareness to engineers towards energy efficiency and energy conservation. It concludes that the regenerative braking systems are more efficient at higher speed and it cannot be used as the only brakes in a vehicle. 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 bright future.

B. Khushboo Rahim, and Mohd. Tanveer, 'Regenerative Braking System: Review Paper', International Journal on

Recent and Innovation Trends in Computing and Communication, 5.5 (2018), 736-39.

In this paper the advantages of regenerative braking system over conventional braking system has been mentioned. Regenerative braking systems can work at the high temperature ranges and are highly efficient when compared to the conventional brake.

C. Tushar L. Patil, Rohit S. Yadav, Abhishek D. are, Mahesh Saggam, Ankul Pratap, 'Performance Improvement of Regenerative braking system', International Journal of Scientific & Engineering Research Volume 9, Issue 5, (2018). 2229-5518

In this paper the techniques to increase the efficiency of the regenerative braking system is mentioned. The technique mentioned was to reduce the weight of the automobile which increase performance, using super capacitor also improves the conversion rate of energy in regenerative braking system, making the automobile compact also tends to increase the efficiency of the system.

D. C. Jagadeesh Vikram, D. Mohan Kumar, Dr. P. Naveen Chandra, 'Fabrication of Regenerative Braking System', International Journal of Pure and Applied Mathematics Volume 119, (2018). 9973-9982.

In this paper the Fabrication process on the Regenerative Braking System had been implemented as per the prescribed measures has been taken and the future enhancements should be processed on basis of the need of the study. The Implementation of the regenerative braking system be quite essential in automotive transportation with maximized performance in braking.

E. Ketan Warake, Dr. S. R. Bhahulikar, Dr. N. V. Satpute, 'Design & Development of Regenerative Braking System at Rear Axle', International Journal of Advanced Mechanical Engineering. Volume 8, Number 2 (2018), 2250-3234.

In this paper the regenerative braking system used in the vehicles satisfies the purpose of saving a part of the energy lost during braking. The regenerative braking system is designed to partially recover the battery charge wasted in braking of the vehicle. The energy is converted into heat by friction brake which is dissipated to the environment.

F. Siddharth K. Sheladia, Karan K. Patel, V. raj D. Savalia, Rutvik G. Savaliya, 'A Review on Regenerative Braking Methodology in Electric Vehicle', International Journal of Creative Research Thoughts, Volume 6, Issue 1 (2018). 2320-2882.

In this paper it is mentioned that Regenerative braking can save up to 5% to 8% of waste energy. The systems have been enhanced with advanced power electronic components such as ultra-capacitors, DC-DC converters (Buck-Boost) and flywheels.

G. M. Grandone, M. Naddeo, D. Marra, G. Rizzo,

"Development of a regenerative braking control strategy for hybridized solar vehicle," IFAC-Papers online, vol.49-11pp.497-504, 2016.
This paper focuses on the development of a braking control strategy that allows the best tradeoff between mechanical and regenerative braking on a hybridized vehicle. The research work is part of a project for the development of an automotive hybridization kit aimed at converting conventional cars into Through the Road hybrid solar vehicles. The main aspect of the project is the integration of state-of-the-art components (i.e. in-wheel motors, photovoltaic panels, batteries) with the development of an optimal controller for power management. A mild parallel hybrid structure is obtained by substituting/integrating the rear wheels with in-wheel motors and adding photovoltaic panels and a lithium-ion battery.

H. M. Boisvert, D. Mammosser, P. Micheau, A.Desrochers, "Comparison of two strategies for optimalregenerative braking, with their sensitivity to variations inmass," IFAC Proceedings Volumes, vol.46, pp.626-630,2013.

A three wheels recreational vehicle is studied for the purpose of regenerative braking control. Most of the existing literature proposes optimal methods which consist in defining the braking torque as a function of the vehicle speed. The originality of this study is to propose a new strategy based on the control of the rear wheel slip. A simulator based on Mat lab/Simulink and validated with experimental measurements compares the two strategies and their sensitivities to variation in mass, slope and road condition. Numerical simulations show that the regenerative braking based on a slip controller is less affected by parametric changes. It thus becomes possible to ensure optimal recovery of energy and vehicle stability even in case of parametric fluctuations.

III. Scope of RBS in Future

The Regenerative Braking System is designed to partially recover the battery charge wasted in braking of the vehicle. This Energy is utilized to rotate the rotor of generator converting mechanical energy of wheels into useful charge of battery.

Regenerative braking systems require further research to develop a better system that captures more energy and stops faster. As the time passes, designers and engineers will perfect regenerative braking systems, so these systems will become more and more common. All vehicles in motion can benefit from these systems by recapturing energy that would have been lost during braking process and thereby reducing fuel consumption and increased efficiency.

IV. Conclusion

Driving is an extremely wasteful process. Large amounts of kinetic energy is turned into heat and gone from the car. Thankfully, a regenerative braking system makes use of this heat to regenerate the batteries of the electric vehicle. Despite the amount of research and development that has done into regenerative braking, there is still significant room for improvement. Regenerative braking is still very limited and dependent on uncontrollable variables. Also, danger can arise if regenerative braking is applied to two-wheel-drive brake systems. However, regenerative braking does have various benefits. A proper implementation of regenerative braking system extends driving range, improves braking efficiency, reduces brake wear, and improves energy conservation.

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