

Performance Improvement of Regenerative braking system

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Abstract: Regenerative braking system is one of the most used techniques of recovery of braking energy. Various methods to be used while using regenerative braking or electric vehicle so as to increase the efficiency of the electric vehicle. The regenerative braking weighs a lot due to which the weight of the electric vehicle increases and hence there is a need to reduce the weight of the whole regenerative system. Making it compact and increasing its efficiency by using various methods of optimization techniques used while driving.

Key words: Electric Vehicle RBS, Increased Performance of RBS, Regenerative Braking System, RBS, and Compact RBS.

INTRODUCTION

A Regenerative Brake is an Energy Recovery Mechanism, which slows a vehicle or object by converting its Kinetic Energy into a form, which can be either used immediately or stored until needed. This contrasts with conventional braking systems, where the excess kinetic energy is converted to unwanted and wasted heat by friction in the Brakes, or with Dynamic Brakes, where energy is recovered by using Electric Motors as generators but is immediately dissipated as heat in resistors. In addition to improving the overall efficiency of the vehicle, regeneration can greatly extend the life of the braking system, as its parts do not wear as quickly.

Due to the limited capacity of electric vehicle energy storage system, the driving range of the pure electric vehicle is limited, thus the widespread use of electric vehicle is under constraint. If the kinetic energy of electric vehicle can be transformed into electrical energy by the regenerative braking system and recovered into the storage system during vehicle braking process the

energy efficiency of the electric vehicle will be improved, and the driving range of the electric vehicle will be extended.

Conventional braking (mechanical braking) is very different from electrical braking. In a conventional vehicle, the kinetic energy is dissipated as heat by the brake pads. During regenerative braking, the electric motor imposes a negative torque to the wheels and thus slows down the vehicle. By doing so, energy is recovered and the batteries are recharged.

In these papers, the characteristics of Regenerative Braking and how efficiency of Regenerative Braking is discussed. The most recent researches efforts focusing on the regenerative braking mode showed that the increase of the re-gen ratio (defined as the recaptured braking energy to the sum of energy recaptured and the energy dissipated in the friction brakes) achieved by a increase in the deceleration over 0.1gm may cause a stability event, especially for low friction surfaces. With the development of regenerative braking the use of RBE has been studied widely. Optimization of the train braking speed trajectory has been studied by most of researchers to increase the total regenerative braking energy in a blended braking mode.

Due to Limited capacity, space and charging station constrain it is very hard to manufacture ELECTRIC VEHICLES in mass just like other regular cars which uses conventional fuels sources. Hence a step forward in decreasing the charging time and improving efficiency by running a vehicle few extra mile's or km's. This project will also cover anti-braking system, increasing recovery of energy from brakes, and storing capacity.

2.1 LITERATURE SURVEY

The survey considered in this work is categorized in the following subsections separately as: -

- Optimization Techniques of Regenerative Braking.
- Increasing recoverable energy and battery power/efficiency.
- Less consumption of Energy and Space utilized by battery.
- Use of regenerative braking in Electric bike (Application)

2.1.1 Literature Survey Optimization Techniques of Regenerative Braking

The following literature review is based on the arrangement of parts required in Regenerative Braking e.g. multiple motors are to arrange or multiple fuel cells/ batteries to arrange. Cheng-Kuo Sung [1] experimented on four stroke air engines for regenerative braking & installation of buffer region, which revealed that after installing buffer region in RBS the cylinder pressure could be effectively regulated thus reducing the peak value of pressure. Kai Liu [2] The experiment shows analyses of the impact of road gradient on the electricity consumption OF EV's by combining GPS tracking data from EV's with road elevation information. Which gave them a result of 5% to 8% improvement.

Jiaseng Ruan [3] experimented various braking testing maneuvers which were used to test possible safety issues due to redistributing the braking force between the front/rear axles in a Regenerative braking. Chaofeng Pan [4] they experimented several aspects of the causes of motor speed measurement error. They pointed out the motor rotational speed measurement method by using the AND square wave through AND operation and OR operation of Three phase hall position sensor signals. Ricardo Maia [5] this paper presents a fuzzy logic model of regenerative braking for modeling EV's regenerative braking systems. They concluded that using the proposed fuzzy expert system methodology could successfully learn RBS model of particular EV. Priya Sharma [6] in this paper she described three methods the technology can be adapted for that purpose. Which not only reduces the operations cost but also improves the "Green points" of the system. Those three methods are Flywheel energy storage system, Super Capacitors, Batteries storage system. M. Boisvert [7] they experimented on identifying the optimal control law and its sensitivity to different parametric variations as the vehicle mass, the inclination of the road and the road type. In this paper a corresponding algorithm is implemented in the vehicle to validate the simulations of the experiments. Zhang Junzhi [8] they experimented control strategies, which considerably improves the regeneration efficiency compared with the baseline control strategy. They carried out test simulations in MATLAB/SIMULINK and to further verify the effectiveness of the control strategies, they developed a real-time braking controller.

2.1.2 Literature Survey on Increasing Recoverable Energy and Battery Power/Efficiency

Now a days acid battery are replaced by dry batteries (Li-ion batteries), which are more convenient as in, they utilize less space and store more power compared to acid batteries. The

recoverable energy from heat dissipation is only around 10%. We need to increase this percentage as much as possible to increase the efficiency.

Siddharth Mehta [9] in this paper, a cascaded bi-directional DC/DC buck-boost converter with dual control strategy during regenerative braking is used for a two-wheeler application. The dual control strategy with the cascaded converter is used to increase the average power stored during the braking period and to reduce vehicle's stopping time. By implementing this strategy, the average power stored by the battery is increased by 2.5 times and the vehicle comes to halt faster in comparison with the existing control strategy. Khaled Itani [10] this paper presents the comparative study of two hybrid energy storage systems (HESS) of a two-front wheel driven electric vehicle where the primary source of HESS is a Li-Ion Battery, whereas the secondary energy source is either an ultra-capacitor (UC) or a flywheel energy system (FES). The Results shows that FES is more advantageous than the UC solution in terms of volume, energy & power density and even cost. It also came in light that UC is encouraged if weight, specific energy and power are major criteria. L. Pugi [11] they experimented on prototype of the system of internal combustion engine involving poor efficiency. They designed, assembled and tested showing a relevant improvement of system efficiency and the feasibility of the proposed approach. In this paper they have shown a simulation model and preliminary validation results including experimental devices assembled to perform the tests. M. Grandone [12] 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 and different braking strategies have been then investigated, in order to maximize the benefits of regenerative braking. The preliminary results shows that the model is a useful tool to design real-time braking strategies, if properly combined with estimation of slipping coefficient and use of ABS system. V.A. Kalmakov [13] they experimented on difficult operating conditions in racecar, which requires careful approach to battery pack design, from choosing accumulator cells to mathematical, modeling. The developed design procedure allows choosing an optimal battery pack design based on given initial parameters. Zhongyue Zou [14] in this paper they have used super-capacitors for their project. As the super capacitors has high power density and they are employed to withstand high current in the short time and essentially capture more regenerative energy. The result verifies the higher efficiency of energy regeneration system using super-capacitors and the effectiveness of the proposed measurement method. It is also demonstrated that the maximum regenerative energy conversion efficiency can reach to 88%. Byeong Heon Kim [15] this paper aimed at evaluating the characteristics of regenerative energy and suggests solutions to increase regenerative energy using a vehicle simulation. Study in this paper focuses on the use of the polymer electrolyte membrane fuel cell hybrid system, which consists of generator, a super-capacitors, and a battery, to obtain regenerative energy. The super-capacitors, which feature an excellent power density and capacity of 30V and 100F, can minimize its power consumption via a cell balancing circuit. Reza Teymourfar [16] in this paper a useful method is proposed to predict the maximum instantaneous regenerative energy which is delivered to each station before applying energy storage systems (ESS's) and based on that

the ESS configuration for each station is determined. Result of this study is confirmed by economic evaluations and benefit/cost analysis on line 3 of Tehran metro network. Seon Hak Kim [17] in this study the fuel cell that is used consists of a fuel/battery or fuel cell/super-capacitors. The motor used in this regenerative braking system revives electrical energy instead of dissipating heat during braking, in this study, an additional generator in a fuel cell/battery hybrid system is equipped and tested as an alternative to using a motor for regenerative braking, resulted in 39% of increase in efficiency.

2.1.3 Literature Survey on Less consumption of Energy

We can also increase efficiency by various strategies and methods to consume less energy by vehicle and hence using such strategies to improve regenerative braking system. Such as implementation of adaption techniques of driving and terrain

Liang Li [18] in this paper, an HEV equipped with an automated manual transmission (AMT) is chosen as the study platform. First, simplified dynamic models of HEV system are built. Then, the process and advantages of AMT downshifting are analyzed and the characteristics of regenerative braking are obtained with different gear positions and different, of which two kinds of downshifting strategy are proposed on basis. Xujian Li [19] in these study two main problems are involved in the downshift process. One is about determination of optimal downshift point, and the other is the cooperative control of regenerative braking and hydraulic braking. The simulation results and hardware in loop test show that the proposed algorithm is effective in improving the energy efficiency of electric vehicles. Effect of downshift on energy efficiency varies with vehicle initial speed and brake strength, and it has a larger value at medium speed and medium brake strength. The designed nonlinear SMO is accurate in estimating the hydraulic brake torque, which is the basis hydraulic control logic. Jian Chen [20] in this paper they have tried to control the regenerative braking system. The two layer controller is designed to track the signal and to improve the energy recovery. The simulation results show that the proposed system can not only track the desired velocity but also improve the energy recovery of vehicles. Peter Clarke [21] this paper represents an analysis of vehicle regenerative braking system as a quick and relatively easy mean of achieving higher overall fuel efficiency and lowering carbon emissions. In the result they have experimentally based evidence is collected and compared for two sample vehicles to deduce the potential fuel and emissions saving. Amedeo Frilli [22] the proposed model has been validated considering an Italian Direct Current High speed line and the high-speed train. Furthermore, the model has been used to perform an efficiency analysis considering the use of energy storage devices. Selim A. Oleksowicz [24] Carbon Technical Project. Moreover, the presented approach meets current challenges; interaction of the re-gen controller with safety systems already installed in a vehicle. The proposed tests include the standard variable parameters of the tests as well as the main reasons of introducing separate tests. The presented study can be elaborated in the future by the OEMs according to their special requirements. The paper presents tests, which are suitable for testing the regen mode for H/EVs. The tests are focused on maximum energy recovery.

The presented use-cases were successfully used within the development of strategies for a regenerative braking controller, namely: the Brake Torque Apportionment Controller (BTAC) during vehicle stability events in the Low. Lars-Henrik Bjornsson [25] in this study they had Good opportunities for charging and regularity in distance traveled between recharging to increase the potential for battery-powered driving and along with a high annual mileage, enhance the viability of the PHEV. Resulting in commuters, which are likely to be dominating among the first drivers for whom the PHEV will be cost effective. Making charging infrastructure available at work places would enhance the opportunity for this group of early adopters, as we show that charging while at work is comparable at the initial stage to halving the marginal battery costs for the average consumer. Chiara Fiori [26] The VT-CPEM model was developed in this paper. The model computes the instantaneous energy consumption of EVs using the instantaneous power exerted. Specifically, the speed profile (instantaneous vehicle speed and acceleration level) are utilized as input variables. Furthermore, the study compared the Nissan Leaf with two other different electric vehicles, the BMW i3 and the Tesla models to evaluate the variation in energy consumption across different EVs. Hong Zhang [27] this paper is focus on power energy distribution control of auxiliary power unit (APU) for a range-extended electric vehicle (RE-EV). Based on the working characteristic of the engine and the generator, a coordination control strategy of RE-EV is proposed. A regulating rule of APU control system speed and torque, which meets the power demand of the RE-EV, is designed. The PID and fuzzy control methods of engine speed are discussed by simulation analysis. In order to investigate the APU control processing, the incremental PID and fuzzy control algorithms are used to achieve speed control in the APU test bench. The influence on tuning parameters, control period and the working condition are analyzed from test results. The coordination control strategies of engine and generator are realized and verified by experimental research. Zhongbei Tian [28] the results in this paper show that the traction energy. Compared with the current ATO operation, the optimized operation within the time constraints can reduce the substation energy consumption by 38.6%, combining low traction energy consumption and high regenerative braking usage. The usage of regenerated energy accounts for 95.5% of the total electricity produced by electrical braking, which benefits from modifying the interstation travel time and dwell time. Using this optimization approach, not only one energy-efficient operation is identified, but numerous results with low energy consumption are found. The robustness can be studied by comparing different energy-efficient operations. The robustness to increases in real dwell times should be examined. Andreas Braun [29] this paper investigates whether the driving pattern parameters that have proved to be relevant for the fuel consumption of internal combustion vehicles (ICVs) also apply to battery electric vehicles (BEVs). The effect of the BEVs' ability to regenerate energy from braking is examined in particular. In order to measure driving patterns, four commercially used BEVs were equipped with tracking devices to record GPS and energy data over the course of several months. The driving patterns are described in 45 parameters that are calculated for segments of the logged driving profiles. Suitable correlation coefficients are

calculated to check for dependencies with energy consumption. The most significant correlations were found for combined speed and acceleration parameters, in particular the relative positive acceleration. The correlations identified, however, were smaller than expected. The regenerative braking effect appears to be one responsible aspect

Conclusion:

The optimization techniques and driving patterns can be adopted in the Regenerative Braking, which can help in improving efficiency obtained in car and bikes. It is also possible to improve performance by reducing weight of the whole system. It was also found that by using super capacitor we could improve the conversion rate of energy in Regenerative Braking.

Future Scope:

There was no work found on making Regenerative Braking less bulky i.e. reducing the weight of whole system so that efficiency of car or bike can be increased. Also by introducing driving patterns to Regenerative Braking system so that energy consumption shall be minimum and more energy shall be regenerated. Super capacitors can be used to improve conversion rate of energy.

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