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A Review on Performance Analysis of Regenerative System and its Application

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***Abstract*: Every time we step on our bicycle's brakes, we are actually wasting energy. As we know that energy can neither be created nor be destroyed. It can be just converted from one form to another. So when our car slows down, the kinetic energy that was propelling it in the forward direction has to go somewhere. Most of it simply gets released in the form of heat and becomes useless. That energy, which could have been used to do work, is essentially wasted. The solution for this kind of this problem is Regenerative Braking System. This is a new type of braking system that can recollect much of the bicycle's kinetic energy and convert it into electrical energy or mechanical energy. Regenerative braking is one of the emerging technologies of automotive industry which can prove to be very beneficent. Using regenerative braking system in a bicycle not only results in the recovery of the energy but it also increases the efficiency of vehicle (in case of electrical vehicles) and saves energy, which is stored in the auxiliary battery. As we know that the regenerative braking, the efficiency is improved as it results in an increase in energy output for a given energy input to a vehicle.**

***Keywords*: Regenerative system, storage cost optimization, hybrid vehicle, electric vehicle (EV), energy saving capability.**

1. Introduction

Storage device have long been common in power system, their use in continuity device and more generally their applications in residential or similar appliances [1]. Start…. stop... start... stop... start. If you make a habit of driving in city traffic, you'll know it can be a huge waste of time. What's less obvious is that it's also a waste of energy. Advances in battery technology and significant improvements in electrical motor efficiency have made electric vehicles and attractive alternative, especially for short distance commuting [2]. An attempt to increase the battery efficiency by restoring energy back into the battery, which is not possible to do in the ICEs [3]. As now days the all vehicles run on fossil fuels that made pollution that is harmful. Every time we step into automobile's brake, we are wasting energy [4]. So the regenerative braking system has used for generate the power that back to battery if we press brake then energy has lost in the form of heat so in regenerative system. Kinetic energy stored in moving parts can be directly used during braking for supplying power to the other drives of same plant, whereas the excess energy [1]. Regenerative breaking works on principle of energy conversation law. Energy conversation law states that "energy neither can be created nor be destroyed, but it can be converted from one form to another form."

Now a days, every person use vehicles which required fossil fuel like petrol, diesel, CNG, LPG etc. So they pollute our environment (like air pollution, noise pollution etc.) and increase global warming effect. To reduce pollution and global warming effect we can use EV (Electric Vehicles).

As the global economy strives towards clean energy in the face of climate change, the automotive industry is researching into improving the efficiency of automobiles. Electric Vehicles (EV) are an answer to the crisis the world is about to face in the near future. But the question that is being constantly asked is, how can the driving range of electric vehicles be increased?

The answer to this question lies in the success of the research for an efficient and power. Packed energy source like a magic battery or success with fuel cells, efficient regenerative braking systems etc. In conventional braking system, kinetic and potential energy of a vehicle is converted into thermal energy (heat) through the action of friction. Studies show that in urban driving about one-third to one-half of the energy required for operation of a vehicle is consumed in braking. With regenerative braking, this kinetic energy can be converted back into electrical energy that can be stored in batteries for reuse to propel the vehicle during the driving cycle. Therefore, regenerative braking has the potential to conserve energy which will improve fuel economy while reducing emissions that contribute to air pollution. Now discuss some limitations of Regenerative system.

2. Literature review on the specific problems:

Author V. Musolino, A. Pievatolo, E. Tironi A. Politecnico di Milano try to solve the problems in electrical storage sizing with application to the recovery of braking energy. It is economically convenient to equip a number of drives, having randomly shifted work cycles, with a storage system for the recovery of braking energy. It indicated a theoretical framework potentially encompassing different concrete situations, based on Markov chain modelling. With the help of an illustrative example concerning bridge cranes, built and optimized a random cost function spanning the life-cycle of the storage system, giving also a criterion for delimiting the search region. It showed that plants with more drives require relatively smaller storage systems. The optimization was achieved through Monte Carlo simulation of the life-cycle of the storage system.

The bridge-crane example shows that it is possible to achieve not only energy but also economical savings during the whole life of the storage system, even though the possible energy recovery from the traction profile has been disregarded. Furthermore, an ever-increasing importance attributed to the so-called white energy (i.e. saved energy) makes it reasonable to expect economical incentives from the public authorities for applications with recovery of braking energy.

Further research is needed to be able to evaluate the transition kernel and the stationary distribution of the Markov chain, in order to take full advantage of the theoretical framework. Finally, a more complex plant design optimization can also include a surplus of storage to be filled with back-up energy taken from the mains. After selecting a re-fill strategy of the back-up storage, its cost should be balanced against the saving coming from a front-end rectifier with a rated power smaller than the maximal load. The back-up energy would in fact help to smooth the peaks of power required from the mains, allowing for a less expensive power supply contract [1].

Author Jarrad Cody, Özdemir Göl, Zorica Nedic, Andrew Nafalski, Aaron Mohtar carried out a research activity focused on the Regenerative braking in an electric vehicle The system employs the Independent Switching strategy to control the flow of current during various stages of the cruise profile. The work is in progress to fit with the commercial BLDC motor and a commercial power supply together with the controller developed in-house [2].

The latest research done by on an effective method of regenerative braking for electric vehicles the results of simulation show that the proposed method was able to maintain the battery charging characteristics as it should be. When the state-of-charge SoC(State of Charge) of the battery was less than 10%, the charging current could not be more than 2 A, when the SOC was in the range between 10% and 90%, the charging current could not exceed 15 A, whereas when the SOC was higher than 90%, the charging current could not be more than 1 A.

The results of experiment indicated that for the speeds below 100 rpm, the electric braking was not favorable anymore because the regenerative power was smaller than the power system losses. Consequently, the proportion of the electric braking should be zero for the speed less than 100 rpm. The simulation results showed that the proportion of the electric braking for the speeds below 100 rpm was 0.05. It was also shown that within the speed range of 100-400 rpm the achieved maximum braking current was not more than 20 A, while beyond the speed of 400 rpm it was not more than 15A. It means that the desired sharing proportions between the braking modes were achieved [3].

S. Suyambazhahan worked on Regenerative brakes system used in an Automobile Engine. Hybrid concept has gained momentum nowadays at the height of energy crisis. Moreover, pollution control and strict emission norms has resulted in fast development of electric vehicle and Hybrid vehicle. This regenerative braking system envisages charging of a 12V automobile battery by operating an alternator engaged to the main shaft by using a magnetic clutch while braking. In the present experimental study up to 2.9kW of energy is recovered while braking. Electrical energy thus obtained is used in operating various electrical fittings in the automobile and converting the vehicle into a Hybrid Electric Vehicle (HEV). Vast reduction in emission levels and overall improvement in efficiency is achieved [4].

In 2009author J. Guo, J. Wang and B. Cao work on the “Regenerative braking strategy for electric vehicles.” Regenerative braking is an effective approach for electric vehicles to extend their driving range. The control strategy of regenerative braking plays an important role in maintaining the vehicle's stability and recovering energy. In this paper, the main properties that have influence on brake energy regeneration are analyzed. Mathematical model of brake energy regenerating electric vehicles is established. By analyzing the charge and discharge characteristics of the battery and motor, a simple regenerative braking strategy is proposed. The strategy takes the braking torque required, the motor available braking torque, and the braking torque limit into account, and it can make the best use of the motor braking torque. Simulation results show higher energy regeneration compared to a parallel strategy when the proposed strategy is adopted [5].

3. Overview of the research

A. Electric vehicle
B. Regenerative system

A. Electric vehicle

Electric Vehicle (EV)’s enjoyed popularity between the mid-19th century and early 20th century, when electricity was among the preferred methods for automobile propulsion, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time.

The Internal combustion engine (ICE) is the dominant propulsion method for automobiles, but electric power has remained commonplace in other vehicle types, such as trains and smaller vehicles of all types. During the last few decades, increased concern over the environmental impact of the petroleum-based transportation infrastructure, along with the specter of peak oil, has led to renewed interest in an electric transportation infrastructure.

EV’s are differ from fossil fuel powered vehicles in that the electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, and wind power or any combination of those. The electricity may then be stored onboard the vehicle using a battery, flywheel, super capacitors. A key advantage of electric or hybrid electric vehicles is their ability to recover energy normally lost during braking known as regenerative braking. Also, quick and precise torque generation of the electric motor holds an important advantage with respect to the performance and drivability of an EV.

It can summarize the EV into the following three points:

1. Torque generation of an electric motor is very quick and accurate. This is an essential advantage. The electric motor's torque response is several milliseconds, Viz. 10-100 times as fast as that of the internal combustion engine or hydraulic braking system. This enables fast responsive feedback control and hence we can change vehicle characteristics without any change in characteristics from the driver. Moreover, an Anti-lock braking systems (ABS) and Traction control system (TCS) can be integrated, because a motor can generate both acceleration or deceleration torques.
2. A motor can be attached to each wheel Small but powerful electric motors installed into each wheel can generate even the anti-directional torques on left and right wheels. Distributed motor location can enhance the performance of Vehicle Stability Control (VSC) such as Direct Yaw Control (DYC).
3. Motor torque can be measured easily: There is much smaller uncertainty in driving or braking torque generated by an electrical motor, compared to that of an IC engine or hydraulic brake. It can be known from the motor current. Therefore, a simple 'driving force observer' can be designed and we can easily estimate the driving and braking force between tire and road surface in real time.

This will contribute greatly to application of new control strategies based on road condition estimation. For example, it would be possible to alert the driver with warnings like, "We have now entered a slippery surface!" in a more efficient and timely manner.

B. Regenerative system

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.

Regenerative braking is an effective approach to extend the driving range of EV and can save from 8% to as much as 25% of the total energy used by the vehicle, depending on the driving cycle and how it was driven. Generally, the regenerative braking torque cannot be made large enough to provide all the required braking torque of the vehicle. In addition, the regenerative braking system may not be used under many conditions, such as with a high state of charge.

State of Charge (SoC) or a high temperature of the battery. In these cases, the conventional hydraulic braking system works to cover the required total braking torque. Thus, cooperation between the hydraulic braking system and the regenerative braking system is a main part of the design of the EV braking control strategy and is known as torque blending. This torque blending strategy helps to avoid the driveline disturbance.

4. Objective and scope of research

The conclusion of research is to solve such difficulties occurred can be narrated as below:

- Implementation of regenerative system
- To create a working model of a hybrid vehicle.
- Energy saving capability of the model is to be tested.
- Pollution control and cost analysis are to be worked out.

Energy has also wasted in the form of heat whenever the brake is applied. However, the energy lost can be utilized for the power production. In this present study, an alternator is connected to the driver shaft through pulley and a belt. The alternator is activated and the energy lost is utilized to generate electrical energy. An experimental setup made for the present study to make the loss of energy into useful form. In the present experimental study of energy is recovered and in turn it can be charged in a battery as chemical energy.

5. Conclusion

This paper presented an overview on performance analysis of regenerative system and its application.

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