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Design and Control of Braking System in Electric Vehicles by Energy Regeneration

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ABSTRACT

Law of conversion of energy expresses that "Energy can nor be made nor destroyed yet must be converted starting with one structure then onto the next". This law is the very basis behind the working of regenerative working. Regenerative braking energy recovery is an amazing component of new energy vehicles. This paper proposed a technique with acknowledge energy recovery by utilizing a variable voltage system as the motor drive system, which can understand the braking energy regeneration of large scale change of speed. Simultaneously, the trial of regenerative braking energy recovery was performed to dissect the regenerative performance of new energy vehicles. The effectiveness of the regenerative braking system for electric vehicles is confirmed, which gives another approach to additionally improve the regenerative braking performance of new energy vehicles.

Keywords: Regenerative braking, variable voltage, electronics power converter.

INTRODUCTION

Regenerative braking is a remarkable strategy that is utilized in EVs to catch the energy that the vehicle has because of its movement or, as it were, it's active energy that would have been squandered when the vehicle decelerates or grinds to a halt while braking. By taking a proportion of the underlying and last vehicle speed, the measure of motor energy that is lost to braking can be determined. Drive cycles have a lot of increasing speed and decelerating periods because of traffic control systems set up around towns and urban communities, and along these lines, while decelerating,noteworthy energy is lost. Notwithstanding, with regenerative braking, this energy can be caught, and 'squander' energy can be saddled and used for vehicle impetus. Taking the Renault Zoe EV for instance with one inhabitant with the vehicle mass as ~1600kg with a speed of 120km/h (33.33 m/s), the motor energy has an estimation of 0.25 kWh. In a regular ICEV, on moving toward an end, this energy is completely squandered. Information got over various drive cycles in the Renault Zoe show that this vehicle has energy effectiveness of ~0.2kWh/km. An investigation of the energy proficiency of the vehicle and dynamic energy the vehicle has lost due to braking shows that the energy equal for the vehicle to travel 1.25km is squandered when brought to a stand-still. This range misfortune identifies with a full pattern of the battery from 100% ability to a totally released battery.

In an EV, the power source is the battery that provisions electric energy to work the motor. The motor supplies energy to turn the vehicle wheels delivering active energy. The motor can work backward. At the point when a motor works backward it goes about as a generator. At the point when the vehicle eases back down, the generator changes over the motor energy into electrical energy to charge the vehicle's battery. At the point when the regular vehicle slows down, the energy is lost to warm energy coming about because of the contact between the brake cushions and wheels. Regenerative braking permits the scope of the EV to be broadened; be that as it may, the effectiveness of catching this energy is accounted for to change from 16% to 70% [1]. The purpose behind this critical contrast in productivity will rely upon the driver's style of driving whether they brake step by step or harshly. Moreover, temperature of the system and outside surrounding temperature influence the proficiencyincredibly. The driving procedure of the driver is a significant factor while figuring the proficiency of the regenerative braking system. Rubbing brake cushions are introduced in the EV to take into consideration increasingly fast braking rather than moderate braking with the regenerative braking system. The use of the grating brakes brings about the effectiveness of the regenerative system to fluctuate. This property affirms that shopper instruction is required to advise the EV proprietor regarding diverse driving procedures of how to expand the proficiency of the vehicle energyrecovering system to broaden the life span of the battery.

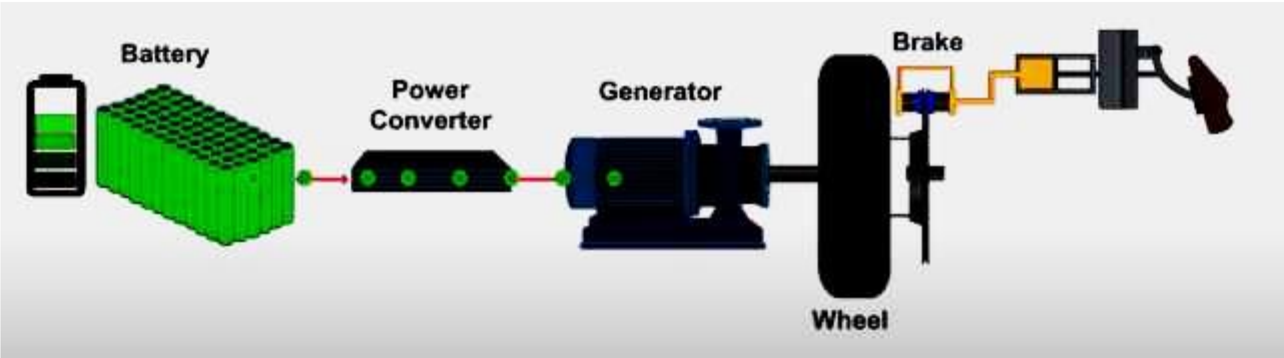


Figure 1. Regenerative -Braking Mechanism

Not exclusively does regenerative braking improve eco-friendliness in EVs, yet in addition it very well may be adjusted for the ICEV to help lower vehicle discharges [2]. There are different energy catching devices that are appropriate to be utilized in regenerative braking systems. The flywheel is a device that when pivoted, can store dynamic energy during braking. The ultra-capacitor is the mostregularly embraced device in regenerative braking systems. The ultra-capacitor incidentally stores an

electrical charge. This short charge and release period is less expensive than the flywheel system andmoreover has a higher energy thickness. This device likewise has less unsafe materials that will affectthe earth contrasted and other capacity machines. The ultra-capacitor is a superior option in contrastto an electrical battery for short excursion times inferable from extremely high related efficiencies [3]. Reports have expressed that ultra-capacitor's coulomb effectiveness can arrive at efficiencies over99% [4].

LITERATURE REVIEW

In [5] this paper the requirement for infrastructure development, challenges and opportunities for design and deployment of emerging infrastructure, related to Plug in Electric Vehicle (PEV) and thepotential benefits are summarized in detail. The author had addressed the crucial points to maximize the benefits from the opportunity for reducing fuel consumption, from battery manufacturing to communication and control between the vehicle and the electric power grid to provide for clean electricity with safety.

In [6] explained in their report the working of electric vehicle and compared it with the conventionalinternal combustion engine and hybrid electric vehicle. The report provided the details of advantagesand disadvantages of Electric Vehicles along with the future views of technology.

In [7] their paper on “The 21st Century Electric Car”, had experimented Tesla Roadster EV with lithium ion batteries, for well – to – wheel energy efficiency and well – to – wheel level of emission. When compared with Natural gas engine, hydrogen fuel cell, diesel engine, gasoline engine and hybrid gas/electric car, well –to – wheel energy efficiency found to be high and well –to –wheel emission found very low for Tesla Roadster EV.

In [8] studied the power converter and its control for an electric traction vehicle and solutions encountered during development were discussed in this paper. The focus was directed towards strategies and construction problems for the power converter (controllers), the protection and control of the power train. The vehicle considered for the study used 11 KW –48 V DC motors. The safety concerns were important to be considered for the proposed architecture because these motors needed a high current value of 200 A (approximately). A

DC-DC power converter was discussed in detail to achieve energy conservation and low power dissipation depending upon the motor operation demands, in forward and reverse direction movement of the vehicle. The paper stated the reasons for need/importance for the control of variable output current of the converter rather than voltage control under intuitive correlation between throttle control and torque developed w.r.t. ICE as well as for the protection and safety of Motor, controller and several electrical & mechanical components. The methods of current control, in-particular sliding mode control were discussed.

In [9] his paper indicated the potential requirement of the design and development of globally competitive small electric concept vehicles for India and concluded that EVs are the best solution to reduce pollution in cities, and important societal and economic benefits would result by implementation of EVs and HEVs. The paper also outlined the role played by the Government and communities worldwide to promote and accelerate EV program.

PROPOSED METHODOLOGY

The conventional drive system can just acknowledge two working methods of the electric advance down power flexibly and the lift criticism braking, and the energy input can be done inside a specificspeed extend. At the point when the vehicle speed is lower than a specific worth, the motor can't give a high charging voltage to charge the power source, and the energy input productivity is low so the urban transport with moderately low vehicle speed and continuous braking can just recuperate less energy in the braking procedure [10-12]. The new kind of energy storage system appears in Figure.1. Set the appraised voltage of each supercapacitor module to UC and set the inductance of the motor M to LM, the inside protection from rM, and the actuated electromotive power to ε.

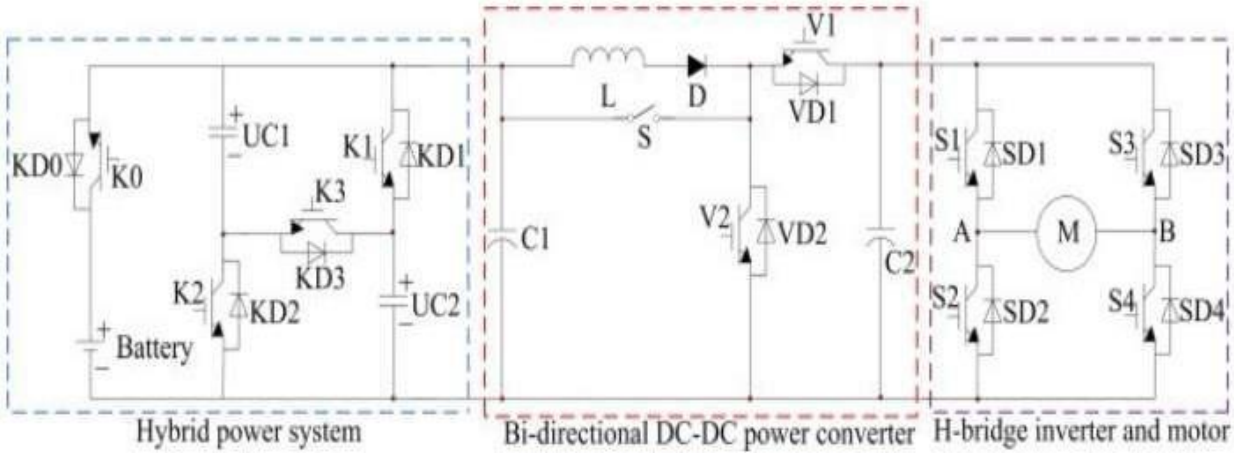


Figure 1. ESS with BDPC optimized

Under braking, the motor works in as a generator, charging back energy to UC1 and UC2. In the criticism braking, UC1 and UC2 at the same time are charged and understand the equalization of charging between the supercapacitor pack. Brake torque is gotten from the motor armature flow simultaneously, understand the electric braking. Braking power is relative to the motor normal armature current, the greatest braking force is corresponding to the motor armature current breakingpoint and the speed. Electromagnetic braking torque is gained by controlling the motor armature current.

The significant parameters of the regenerative braking performance are characterized as follows:

The underlying active energy of flywheels, E0; The energy recouped by the energy storage devices, E1; The successful recovery energy recuperated by flywheels recaptured from capacity devices, E2.

The proportion of compelling energy to the underlying active energy of flywheels is characterized as viable recovery proficiency. The estimation technique is as per the following:

$$\eta = \frac{E_2}{E_0} = \frac{N_1 \times \frac{1}{2} \times J_1 \times \omega'^2 + N_2 \times \frac{1}{2} \times J_2 \times \omega'^2 + ... + N_n \times \frac{1}{2} \times J_n \times \omega'^2}{N_1 \times \frac{1}{2} \times J_1 \times \omega^2 + N_2 \times \frac{1}{2} \times J_2 \times \omega^2 + ... + N_n \times \frac{1}{2} \times J_n \times \omega^2}$$

Where ω and ω' are the most elevated rakish speed of flywheels, Nn is the quantity of flywheels. The computation of put away braking recovery energy is appeared as follows:

$$E_1 = \int_0^t U_{(t)} I_{(t)} dt$$

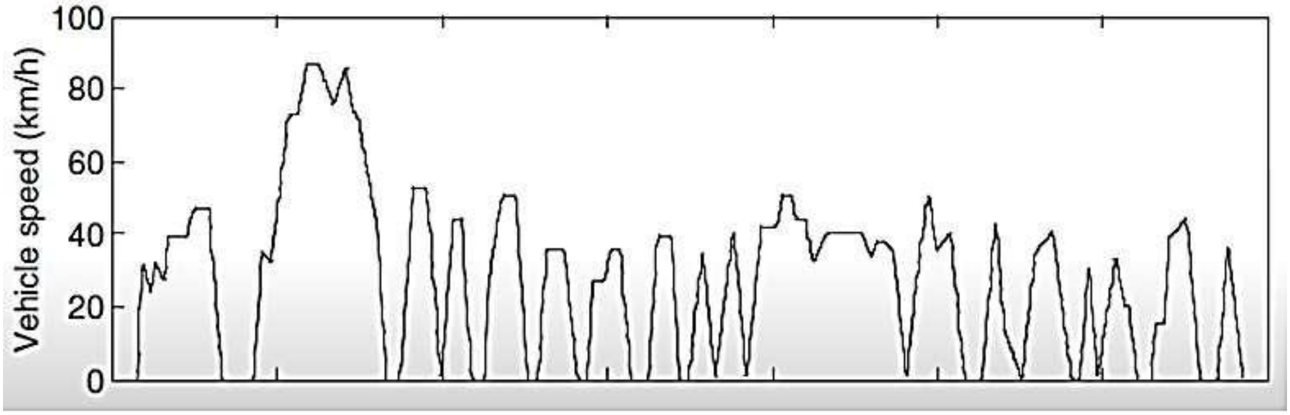


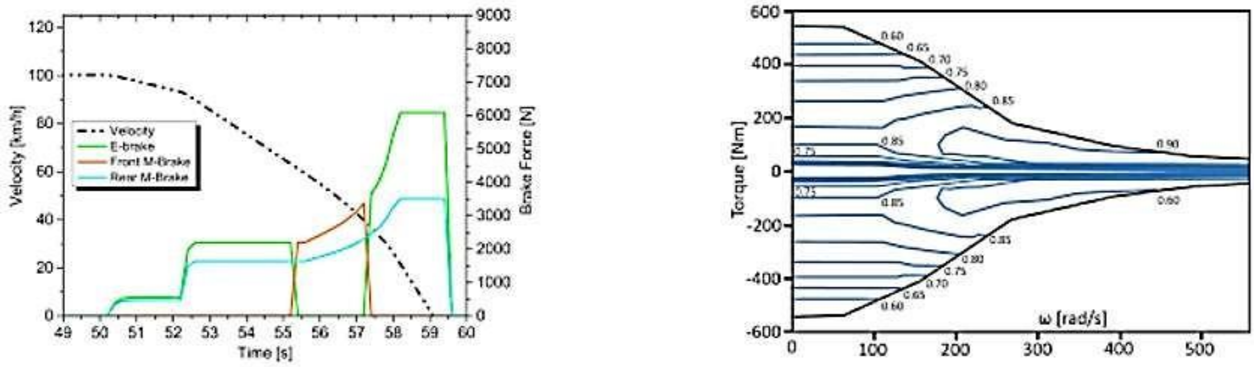
Figure 3. SPEED VS TIME CURVE (Percentage of drive cycle is more than 40 %)

Where U (t) is the terminal voltage of capacity devices, I (t) is charging current of capacity devicesduring the procedure of energy recovery. The proportion of recovery energy to the underlying dynamic energy of flywheels is characterized as recovery productivity. The regenerative braking recovery effectiveness can reflect whether the chose energy storage devices have a decent capacity

of tolerating charging and the productivity of motor age. The recovery proficiency is determined asfollows.

$$\eta' = \frac{E_1}{E_0} = \frac{\int_0^t U_{(t)} I_{(t)} dt}{N_1 \times \frac{1}{2} \times J_1 \times \omega^2 + N_2 \times \frac{1}{2} \times J_2 \times \omega^2 + ... + N_n \times \frac{1}{2} \times J_n \times \omega^2}$$

Under some higher introductory active energy, the electric braking effectiveness trial of various kinds of motor separately with super capacitors was completed, appeared in Figure. 3. As observedfrom the above Figures: (1) Under the equivalent braking quality control, the electric braking proficiency of the blend of super capacitors and perpetual magnet motor is clearly higher than thatof super capacitors and non-concurring motor. (2) The electric braking productivity under high braking power control is a lot higher than that heavily influenced by feeble brake power.



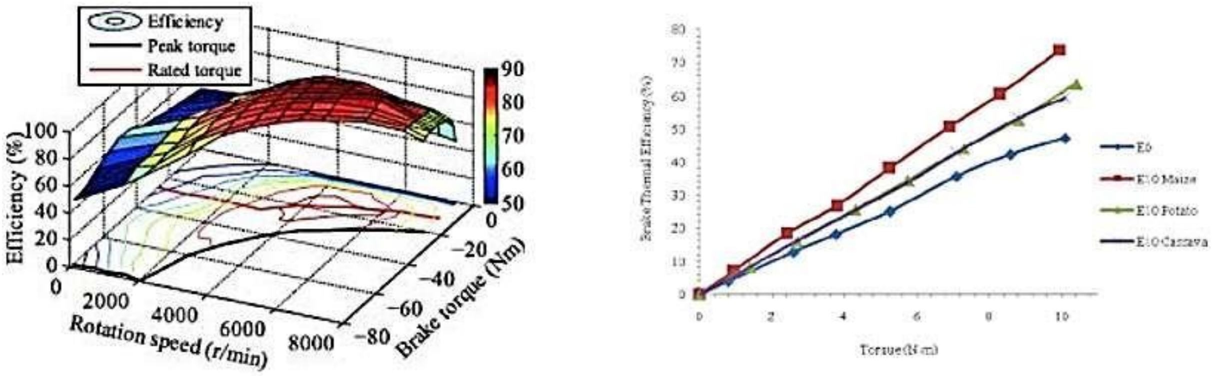
(a) (b)

Figure.4 Combination of motor- storage Electic brake efficiency

SIMULATION RESULTS

In this analysis, supercapacitors, lithium batteries, and Ni-MH batteries are joined with offbeat motorseparately. Under various braking torque, the test outcomes are appeared in Figure. 5. As found in Figure. 5: (1) Under various recovery torque control (charging power), the recovery rate and the successful recovery rate are for the most part extraordinary, yet the distinction of supercapacitors is moderately little, the distinction of the battery pack is generally huge; (2) Under various recovery torque control (charging force), the "no charging pivoting speed" of energy storage devices is unique.In this trial, supercapacitors, lithium batteries, and Ni-MH batteries are joined with nonconcurrent motor separately. Under the equivalent trial conditions, the recovery productivity and compelling

recovery proficiency of supercapacitors are most noteworthy, Ni-MH batteries are the second-most elevated and lithium batteries the third; (2) the recovery rate and the successful recovery pace of Ni-MH batteries are marginally higher than that of lithium batteries, however the thing that matters is little. (3) Under a similar recovery motor, braking torque, and distinctive energy storage devices, the"speed of no charging" of the motor is unique. (4) In the higher speed of motor, the brake recovery rate is higher and immutable, yet the recovery bend of super-capacitors is higher than that of other energy storage devices.



(a) (b)

Figure 5. Analysis of different braking torque and motors regenerative braking efficiencies

CONCLUSIONS

The energy storage system structured in this paper can accomplish braking energy criticism with a wide scope of vehicle speeds, and improve the energy productivity of the traditional driving system at low speed. The relating assessment pointers of regenerative braking recovery are considered and the trials are utilizing various mixes are performed. Exploratory investigations have demonstrated that under similar conditions, the recovery pace of the mix of changeless magnet synchronous motoris higher than that of the blend of the asynchronous motor; Under similar conditions, the recovery pace of supercapacitors is the most elevated; The recovery pace of various charging quality is extraordinary, the distinction of supercapacitors is little, and the distinction of battery pack is enormous. In the higher speed of flywheels, the braking recovery rate is high and the change is nearlynothing.

References

1. Ren Guizhou, Chang Siqin. A High-Efficiency Regenerative Braking for Electric Vehicles. Power System Technology, 2011, 35(1): 164~169.
2. A. Khaligh, Z. Li. Battery, Ultracapacitor, Fuel Cell and Hybrid Energy Storage Systems for Electric, Hybrid Electric, Fuel Cell and Plug-In Hybrid Electric Vehicles: State of the Art. IEEE Transactions on Vehicular Technology, 2010, 59(6): 2806~2814.
3. Gonzalez-Gil A, Palacin R, Batty P Sustainable urban rail system: Strategies and technologiesfor optimal management of regenerative braking energy. Energy Conversion & Management,2013, 75(5):374-388.
4. Han J, Park Y. Cooperative regenerative braking control for front-wheel-drive hybrid electricvehicle based on adaptive regenerative brake torque optimization using under-steer index.International Journal of Automotive Technology, 2014, 15(6): 989-1000.
5. Guang-Hui, C., Yi, Z., & Bing, S. 2017. Raw material inventory optimization for MTO enterprises under price fluctuations. Journal of Discrete Mathematical Sciences & Cryptography, 20(1), 255-270.
6. Vandana, P.T., & Kumar, V.A. 2016. A note on V4 magic labelings of graphs. Journal of Information and Optimization Sciences, 37(6), 873-880.
7. P. Thounthong, S. Raël, and B. Davat, “Control strategy of fuel cell and supercapacitors association for a distributed generation system,” IEEE Trans. Ind. Electron., vol. 54, no. 6, pp.3225–3233, Dec. 2007.
8. Y. P. Yang, J. J. Liu, T. J. Wang, K. C. Kuo, and P. E. Hsu, “An electric gearshift with ultracapacitors for the power train of an electric vehicle with a directly driven wheel motor,”IEEE Trans. Veh. Technol., vol. 56, no. 5, pp. 2421–2431, Sep. 2007
9. Juan, J.C.A.; Javier, P.F.; Juan, M.V.G.; Juan, A.C.C. Regenerative Intelligent Brake Controlfor Electric Motorcycles. *Energies* **2017**, *10*, 1648.
10. National Highway Traffic Safety Administration. *Laboratory Test Procedure for 2005*; National Highway Traffic Safety Administration: Washington, DC, USA, 2005.
11. Duran, A.; Earleywine, M. GPS data filtration method for drive cycle analysis applications. In Proceedings of the SAE 2012 World Congress & Exhibition, Detroit, MI, USA, 24–26 April 2012; SAE: Warrendale, PA, USA, 2012.
12. Kamble, S.H.; Mathew, T.V.; Sharma, G.K. Development of real-world driving cycle: Case study of Pune, India. *Transp. Res. Part D Transp. Environ.* 2009, *14*, 132–140.
13. Hung, W.T.; Tong, H.Y.; Lee, C.P.; Ha, K.; Pao, L.Y. Development of a practical driving cycleconstruction methodology: A case study in Hong Kong. *Transp. Res. Part D Transp. Environ.*2007, *12*, 115–128.