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Enhancement Of Battery Efficiency By Using Vehicle Suspension And Regenerative Braking System- A Review

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Abstract: By incorporating two required mechanisms, this study goals to increase the effectiveness of electric vehicle batteries: vehicle suspension and regenerative braking. By optimizing the suspension design, this study focuses on minimizing energy losses resulting from road irregularities and vibrations, thus maximizing energy conversion and storage within the battery. To recover and retain energy that would ordinarily be lost as heat in conventional braking systems, researchers are looking into regenerative brakes. The integration of these approaches holds the great possibility of significantly increasing the electric vehicle's overall effectiveness and range, contributing to the progress and sustainability of electric transportation**.**

***Index Terms* - Regenerative braking, power generation, vehicle suspension, and electric automobiles.**

I. INTRODUCTION

Electric and hybrid electric cars have drawn a lot of interest because of their distinct qualities, which include low emission levels, excellent fuel consumption, and quiet operation. In the era of environmentally friendly technology, electric vehicles and HEVs have the potential to replace traditional automobiles that rely on internal combustion engines (ICEs), thereby further enhancing vehicle efficiency. Still, electric vehicle rates are very high and hybrid electric vehicles have hindered their widespread adoption. This project aims to simplify electric vehicle settings and make them more approachable. The study's primary goal is to find strategies to increase the energy saved while braking. Based on this paper's results, to improve the vehicle's entire braking efficiency, a control technique has been created.

The consumption of fossil fuels is rising rapidly, leading to an increment in the price of petroleum. Battery-operated electric vehicles (EVs) face challenges related to their primary power source, the battery. These challenges include an absence of charge and recharge periods and an insufficient response of the driving range [2-5]. Various energy sources such as ultra capacitors, flywheels, electrochemical batteries, and other alternatives have the potential to address the aforementioned challenges [5-7].

To tackle this problem, regenerative braking is among the techniques employed. A portion of the energy generated by the momentum of the vehicle is captured during deceleration, transformed into electric current, and then captured to be preserved in the supercapacitor or battery [7–10]. Regenerating brakes may occasionally malfunction on a smooth street surface. Its functionality becomes evident in areas where vehicles need to engage the braking system, such as bumpy streets, path defects, and inclines.

Regeneration becomes noticeable only when the power source reaches full charge.; otherwise, electric vehicle rely on mechanical brakes. Mechanical brakes are used in electric vehicles (EVs) to increase wheel friction for deceleration. However, applying the mechanical brake results in the Kinetic power being converted back into electrical power, leading to a significant energy waste. In contrast, regenerative braking can be achieved with easily controlled motors. The entire kinetic power of the car is lost while two-wheel electric vehicles use mechanical brakes to slow down or stop [11-15]. The power lost while braking can be recovered and stored as the electric current in battery and ultracapacitors. The power bank may retain this power under proper management and control of the motor, driving system, and batteries. As the market continues to grow, the demand for electric vehicles has been steadily increasing.

II. LITERATURE REVIEW

Y. Kim and N. Chang's research highlights various approaches to enhance the effectiveness of combined systems for storing energy, including design automation. Each energy storage strategy presents its own advantages and disadvantages, creating an opportunity to develop a cost-effective battery with superior performance through a hybrid approach. The study introduces novel design optimization techniques and energy-efficient operational systems. The author further provides an extensive overview of a 300 W prototype hybrid battery device.

According to a study that recently appeared in the Storage of Energy for Automobile Technologies journal [2], the ability of new electrically powered vehicles to store energy successfully and effectively had an enormous effect on both their performance and gasoline consumption. The study examines how energy storage technologies are currently used in the automotive sector. The study thoroughly investigates different battery technology possibilities, focusing on techniques for battery executives, safety, adjusting, and supervision. Furthermore, the research acknowledges alternative energy storage system (ESS) choices such as fuel cell technology, flying wheels, and a super-capacitor. In the final part of the research, the idea of integrating many systems for energy storage to generate hybrid energy sources—a more reliable power source—is examined.

The work by S. G. Wirasingha and A. Emadi on the analysis and assessment of control techniques for plug-in rechargeable electric cars [3] highlights it that a correct choice of the drive train construction and execution of a reliable power motion control method are crucial to achieving decreases in gasoline pollution and utilisation. Although plug-in rechargeable electric cars can go long distances on energy alone, control systems for hybridised electric cars have been developed and provided. The latest control strategies are evaluated and arranged in depth in this work. Although rules-based and optimisation-based plug-in hybrid electric vehicles (PHEV) control algorithms have benefits, they do not appear to conflict with others. Thoroughly examining the control systems, we have a review available to identify the most efficient method for improving performance of plug-in rechargeable electric cars in various driving circumstances. Additionally, we utilize simulation findings to establish and validate a novel classification of plug-in rechargeable electric cars control methods according to the car's performance.

In the research conducted by M. Montazeri and M. Soleymani titled "Exploration of Restoration of Energy in Hybrid Electric Vehicles Using Active Suspension System" [4], it discovers that hybrid electric cars using mechanical suspension technology can produce power. This is achieved through simulation and control approaches, enabling the simultaneous simulation of the mechanical suspension and powertrain systems of hybrid electric cars. Ultracapacitors (UCs) and electrochemical batteries make up the hybrid system for storing energy that was recently recommended. The outcomes of the experiment show that recovering energy from the AS system leads to improved fuel efficiency. Additionally, to further optimize battery lifespan and efficiency, a hybrid ESS is recommended, enabling the transfer of load fluctuations from the batteries to the UCs.

In the research conducted by L. Wang et al. titled "Enhancing Electric Vehicle Energy Management: Optimal Design and Real-Time Control" [5], To increase the cycle life of batteries made with lithium-ion in electric cars and plug-in hybrid electric cars, it is shown that the effective use of a super-capacitor and a powerful lithium-ion battery is a promising strategy. An efficiency issue to decrease gasoline consumption is used in this article to address both battery and super-capacitor sizing as well as the level of hybrids between the batteries and the super-capacitor energy. An energy planning method that generates a battery power guidance controls the super-capacitor state-of-charge, and applies future control upon driver commands is suggested to achieve optimal power distribution in real-time. To demonstrate that this strategy effectively lowers battery stress and boosts fuel efficiency, simulations and tests using a spinning wheel, power source, and regulated load are carried out.

In the study titled "Development of Lightweight Electric Vehicles with Regeneration Brakes Management Systems" by Cheng-Hu Chen, Wen-Chun Chi, and Ming-Yang Cheng [6], An electric car equipped with a brushless direct current (DC) motor provides a simple and effective energy recovery system for the electrical brakes. The recommended solution focuses on managing inverse torque during braking by simply modifying the switching sequences of the inverter. This enables the recovery of braking energy back into the battery. The innovative technology accomplishes the dual goals of electronic braking and energy regeneration simultaneously, eliminating the necessity for an ultracapacitor, converters, or complicated coil-switching procedures.

III. Types of braking

Different types of motors require different types of braking systems. The most prevalent braking methods include:

- Frictional braking
- Electromagnetic braking
- Pumping braking

IV. Traditional braking system

Braking refers to the process of slowing down moving machinery like cars and trains by using a mechanical or electronic brake mechanism. However, every time the brakes are applied, energy is wasted. According to the principles of physics, energy cannot be destroyed. Hence, the kinetic energy that propelled the car forward must be transferred somewhere when it slows down. Unfortunately, a significant portion of this energy is lost as heat, rendering it inefficient and unutilized, despite its potential for more productive applications.

V. Regenerative braking system

The regenerative brake system converts the energy generated from the motion of moving objects or vehicles into a usable form by instantaneously or later decelerating them. Unlike traditional braking systems that waste extra kinetic energy as heat through friction, regeneration preserves this energy. Minimizing wear and tear not only does it improve the vehicle's fuel efficiency but also extends the service life of the brake technology equipment. By capturing the excess heat energy generated when brake pads contact the wheels, regenerative braking technology channels it back into the system, effectively charging the battery.

5.1 Need of regeneration braking system

Compared to a car with only mechanical brakes, the system of regenerative brakes has many benefits. When there is slow speed, traffic stops and begins, A regenerative brake mechanism can generate a significant amount of stopping power. This greatly enhances fuel efficiency, making regenerative braking particularly appealing for city driving. Regeneration braking is recognised for its ability to improve fuel efficiency, even at higher speeds, by up to 20%.

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5.2 Understanding Regenerative Brakes

Consider a bicycle with a flywheel to better understand the idea of braking that is regenerative, a small generator used to power the lights. It is harder to pedal when the generator is running since it uses a bit of our electrical power to provide electricity to run the lamps. Similarly, if we abruptly stop pedaling while moving swiftly and activate the generator, our bike will show up around a quicker halt due to the extraction of kinetic energy. Now, envision a bicycle equipped with a much larger and more efficient dynamo. using a battery for storing the electricity created by the conversion of kinetic energy, the bike could theoretically bring to a sudden halt. In essence, it's how regeneration brakes work.

VI. Operation of an electric vehicle motor

Regenerating brakes operates under the tenet that an electric motor can function both as a consumer and a generator of electrical energy. When a motorised vehicle operates in its regular mode, in doing so, it transforms electrical power into mechanical power to perform tasks such as turning wheels. However, when the motor operates in reverse, it transforms into a power generating. When referring to brake regeneration, electric vehicles utilize the generator mode to generate electricity by harnessing the rotational energy of the wheels. The electrical load is then permitted to use this energy, effectively generating a braking effect. This process is based on Faraday's first law.

VII. ENERGY STORAGE

In emerging technologies, energy storage is a critical aspect, especially when it comes to connecting the power system in electric vehicles. Key components like ultra-capacitors, batteries, and converters play a significant role in this regard. There are various types of battery kinds on the market, including lead-acid, silver-cadmium, nickel metallic hydride, silver-zinc, and others. On the other hand, the electrochemical double-layer capacitor serves as the foundation for ultra-capacitors. The most prominent advantages of ultra-capacitors are their superior cycle life and ability to rapidly absorb energy peaks. In case ultra-capacitors or batteries are utilized, a power converter is necessary to regulate the output energy to the required level.

VIII. ULTRACAPACITORS

Supercapacitors and ultracapacitors are two different names for electric double-layer capacitors, compared to standard capacitors, they have an incredible energy content that is frequently many orders of magnitude higher than that of high-capacity electrolysis capacitors. In a magnetic field across the surfaces of the plates, these capacitors store electric current as charge, resulting in a potential difference or voltage. During charging, current flows across the ultracapacitor from the connected source, leading to the storage of electricity between its plates. Once fully charged, the flow of current ceases, and the voltage at the end of the supercapacitor is the same as the source voltage. As a result, the supercapacitor serves as an energy storage device by maintaining the electricity it has collected even when it is not attached to the power source. The supercapacitor's capacitance perfectly matches the amount of energy it can archive, ensuring that it doesn't use power but instead retains and discharges electricity as needed.

IX. Requirements for regenerative braking system design

Prerequisites for Designing a Rechargeable Brakes Mechanism are as follows:

9.1 Power Retention

The basic objective of any regeneration brake equipment is to effectively save power while brakes are applied.

9.2 Power Recharge for Startup

A straightforward mechanism is required to efficiently return the captured energy back to the system for later use.

9.3 Vehicle Compatibility

The system must be designed to fit within the limited space constraints of the vehicle.

9.4 Compact Size

The system should be designed to have a small and space-efficient footprint.

9.5 Optimal Stopping Distance

The system should be adjustable to achieve the shortest possible stopping distance, while ensuring adequate stopping force and cost-effectiveness.

9.6 Environmental and User-Friendly

Considerations for environmental impact and user-friendliness are crucial during the design process.

9.7 Safety

Safety is of utmost importance when developing a consumer product.

9.8 Reliability

The system should be designed to be dependable and operate consistently over time.

X. PROS OF REGENERATIVE BRAKES

10.1 Wear Reduction

The Regeneration brakes in electric drive systems improves efficiency and minimizes brake wear. Whenever the batterypack failed to provide power to the motor, regenerative braking is a technique that stops the wheels from rolling and turns the energy of the motion into electricity. The energy storage pack gets the transformed electricity after that. This technology extends the lifespan of mechanical brakes and reduces their usage. As a result, there is less wear and tear on the brakes, leading to increased durability.

10.2 Fuel Consumption

In a series of urban driving tests, it examined how much gasoline ordinary cars and cars with rechargeable brakes used. The results revealed that regenerative braking is highly fuel-efficient, providing significant cost savings for vehicle owners. An impressive example is the Delhi Metro, which utilized the use of the method of regenerative braking between the years 2004 and 2007, generating 112,500 megawatt hours of power. By implementing this environmentally beneficial strategy, we were able to keep an estimated ninety thousand metric tonnes of greenhouse gas carbon dioxide (CO_2) out of the earth's atmosphere.

10.3 There's a benefit to brakes

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XI. ADVANTAGES OF COMBINING REGENERATIVE BRAKES WITH FRICTIONAL BRAKES

The friction brake remains necessary to fully stop the car since regenerative braking becomes less effective at lower speeds. The rotor must be locked to stop the vehicle from sliding downhill.

In case the regenerative brakes fail, the mechanical brake acts as an essential backup.

Cars on roads utilise brake regeneration, where power is only applied to certain wheels (e.g., two-wheel drive cars), there is a demand for friction-based braking on both tyres for controlled braking, especially in challenging conditions like wet roads.

The ability of the power system, the battery's capacity, or the charge level of the capacitor limits how much electrical power the process of regeneration brakes can recover. Regeneration of energy won't happen if there aren't any other electrical devices using electricity or if the power source or capacitors are fully energised. Dynamic braking is often used to dissipate the excess energy in such cases.

During emergency braking, it is necessary to apply as much force as the ground's resistance with the wheels and tyres permits.

XII. LIMITATIONS OF REGENERATIVE BRAKING SYSTEMS

When comparing regenerative brakes to dynamic brakes, the main challenge is ensuring that the generated electricity aligns seamlessly with the power source. For DC supplies, this requires accurate voltage control, while for AC sources, matching the supply frequency has become possible due to recent advancements in power electronics (This is particularly relevant to locomotives when the alternating current supply is converted to DC for the drives).

When the batteries are fully charged, regenerative braking needs to be limited. In such cases, the motor controller restricts the regenerative braking torque to prevent the fully charged battery from exceeding a safe voltage level.

Adds approximately 25 to 30 kg to the vehicle's total weight.

XIII. FUTURE SCOPE

Renowned automakers are actively incorporating regenerative braking systems (RBS) into the designs of their hybrid and electric vehicles, including Ferrari, Renault, BMW, McLaren, and Tesla.

Vehicles with gasoline or diesel engines are typically 20–25% efficient. On the other hand, electric cars provide a significant improvement, with an improvement in efficiency of 50% (reaching 70–75%). By capturing and utilizing energy that would otherwise be wasted, RBS contributes to the overall efficiency of electric vehicles, resulting in an additional boost of approximately 15% (reaching 85-90%).

The implementation of RBS enables upcoming cars to operate with optimal efficiency.

XIV. CONCLUSIONS

To reduce our dependency on energy generated from fossil fuels, regenerative braking is needed. Batteries can be operated for a longer amount of time without requiring an external charge due to these brakes. They also, helpfully for electric cars, have longer ranges while on the road, as demonstrated by the Tesla Roadster. It makes sense that effective flywheel hybrids would become more popular given the losing power in hybridised battery-electric mechanisms. The best energy storage solution for hybrid vehicles seems to be a system that combines wheels and energy storage from batteries, although the situation is not entirely straightforward. As engineers and designers continue to improve regenerative braking technologies, their adoption is expected to increase. Any moving vehicle can utilize regeneration to recover otherwise wasted energy.

REFERENCES

[1] Y. Kim, and N. Chang, ''Design and management of energy-efficient hybrid electric energy storage systems,'' springer, pp.19-25, 2014.

[2] S. M. Lukic, J. Cao, R. C. Bansal, F. Rodriguez, and A. Emadi, "Energy storage systems for automotive applications," IEEE.

[3] S. G. Wirasingha, and A. Emadi, ‘‘Classification and review of control strategies for plug-in hybrid electric vehicles,’’ IEEE Trans. Veh. Technol., vol. 60, no. 1, pp. 111-122, Oct. 2010.
[4] M. Montazeri, and M. Soleymani, ‘‘Investigation of the energy regeneration of active suspension system in hybrid electric vehicles,’’ IEEE Trans. Ind. Electron., vol. 57, no. 3, pp. 918-925, Oct. 2009.
[5] L. Wang, E. G. Collins, and H. Li, ‘‘Optimal design and real-time control for energy management in electric vehicles,’’ IEEE Trans. Veh. Technol., vol. 60, no. 4, pp. 1419-1429, Mar. 2011.
[6] Cheng-Hu Chen, Wen-Chun Chi, Ming-Yang Cheng, “Regenerative Braking Control for Light Electric Vehicles “IEEE PEDS 2011, December 5-8, 2011.
[7] B. Enache et al., “Comparative study for generic battery models used for electric vehicles,” 8th International Symposium on Advanced Topics in Electrical Engineering (ATEE), pp. 1-6, 23-25 May 2013.
[8] H. L. Chan, “A new battery model for use with battery energy storage systems and electric vehicles power systems,” in Proc. 2000 IEEE Power Engineering Society Winter Meeting, vol. 1, pp. 470-475, 2000.
[9] H. L. Chan, “A new battery model for use with battery energy storage systems and electric vehicles power systems,” in Proc. 2000 IEEE Power Engineering Society Winter Meeting, vol. 1, pp. 470-475, 2000.
[10] Lijun Gao et al., “Dynamic lithium-ion battery model for system simulation,” IEEE Trans. Compon. Packag. Technol., vol. 25, no. 3, pp. 495-505, Sep 2002.
[11] H. A. Hairik et al., “Proposed scheme for plugging three-phase induction motor,” 15th IEEE Mediterranean Electro technical Conf., MELECON, pp. 1-5, 26-28 April 2010.
[12] H. A. Hairik et al., “Proposed scheme for plugging three-phase induction motor,” 15th IEEE Mediterranean Electro technical Conf., MELECON, pp. 1-5, 26-28 April 2010.
[13] Okan TUR, Ozgur USTUN, Member IEEE, and R.Nejat TUNCAY, “An Introduction to Regenerative Braking of Electric Vehicles as Anti- Lock Braking System”,IEEE june 13-15 2007.
[14] Beck et al., “Plugging an Induction Motor,” IEEE Trans. Industry and General Applications, vol. IGA-6, no. 1, pp. 10-18, Jan.1970.
[15] A. Fazeli, M. Zeinali, and A. Khajepour, ‘‘Application of adaptive sliding mode control for regenerative braking torque control,’’ IEEE/ASME Trans. Mechatronics, vol. 17, no. 4, pp. 745-755, April 2011.
[16] S. de la Torre, A. J. Sánchez-Racero, J. A. Aguado, M. Reyes, and O. Martianez, ‘‘Optimal Sizing of Energy Storage for Regenerative Braking in Electric Railway Systems,’’ IEEE Trans. Power Syst., vol. 30, no. 3, pp. 1492-1500, Aug. 2014.
[17] M. Mortazavi, M. Mastali, and A. A. Safavi, ‘‘Enhanced Neural Network Based Fault Detection of a VVER Nuclear Power Plant with the Aid of Principal Component Analysis,’’ IEEE Trans. Nucl. Sci., vol. 55, no. 6, pp. 3611-3619, Dec. 2008.
[18] K. Inoue et al., “A Study on an Optimal Torque for Power Regeneration of an Induction Motor,” Conf. IEEE Power Electronics Specialists, pp. 2108-2112, 17-21 June 2007.
[19] S. D. Sudhoff et al., “An induction machine model for predicting inverter-machine interaction,” IEEE Trans. Energy Convers., vol. 17, no. 2, pp. 203-210, Jun 2002.
[20] O. Wasynczuk et al., “A voltage control strategy for current-regulated PWM inverters,” IEEE Trans. Power Electron., vol. 11, no. 1, pp. 7-15, Jan. 1996.
[21] M. Ehsani et al., “Propulsion system design of electric and hybrid vehicles,” IEEE Trans. Ind. Electron., vol. 44, no. 1, pp. 19-27, Feb. 1997. [39] N. Mutoh et al., “A torque controller suitable for electric vehicles,” IEEE Trans. Ind. Electron., vol. 44, no.1, pp. 54-63, Feb. 1997.
[22] G. Hongwei, G. Yimin, and M. Ehsani, ‘‘A neural network based SRM drive control strategy for regenerative braking in EV and HEV,’’ Electric Machines and Drives Conference, pp. 571-575, June 2001.
[23] Yang, M.-J.; Jhou, H.-L.; Ma, B.-Y.; Shyu, K.-K. A cost-effective method of electric brake with energy regeneration for electric vehicles. IEEE Trans. Ind. Electron. 2009, 56, 2203-2212.
[24] M. K. Yoong et al., “Studies of regenerative braking in electric vehicle,” Conf. IEEE Sustainable Utilization and Development in Engineering and Technology (STUDENT), pp. 40-45, 20-21 Nov. 2010