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DESIGN AND FABRICATION OF REGENERATIVE BRAKING SYSTEM (RBS): A REVIEW

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ABSTRACT
A regenerative braking system is a type of energy generation process used in electric vehicle technology. Since charging the batteries in electric vehicles is becoming a concern for automobile manufacturers, this system allows a vehicle to generate its power for the battery, which acts as an emergency service and also increases the mileage of the vehicle. A slew of studies has recently been implemented in compound braking control strategy to improve the working distance and braking performance of EVs. The regenerative braking system and energy recovery mode are designed using an electric vehicle with front wheels as a platform. We proposed in this paper to create a robust wheel slip controller for in-wheel motor-driven electric vehicles that includes both hydraulic anti-lock braking systems (ABS) and regenerative braking systems (RB). We will look at optimal predictive control design and Lyapunov theory in this section. Regenerative braking systems (RBS) can improve energy usage and efficiency. RBS is an adapted brushless dc motor (BLDC) that describes braking force distribution and BLDC motor control using PID (proportional integral derivative). There are two modes of control or testing on different road conditions that are speed reducing and stopping mode efficiency converting lost energy to a useful source to batteries that it reaches 30% at speed of 10 km/hr. Braking energy dissipates as thermal energy, which can account for more than 70% of motor energy. Low energy conservation may destroy or create, to reduce energy loss in hybrid vehicle regenerative braking system and energy saved RBS 8%to25% of lost energy based on braking conditions. Control of regenerative braking systems is proposed here, and input-to-state stability theory y is used to demonstrate that the estimation error converges to zero.
Keywords
Electric vehicles, Braking torque control, energy recovery, driving range, Down slope driving , Battery aging ,Speed planning, Motor Generator, State of Charge.

1. Introduction

In this world full of vehicles that move at high speeds there should be some opposite reactive force that helps the fast-moving vehicles to slow down and on further application, it comes to rest. This process of slowing moving vehicles is called Braking and the component that does this process is called a Brake. Many types of brakes are classified according to the working principle of that braking setup. Ultimately the focus of the application of the brakes is to slow the moving vehicle. But in the current trends, the conservation of energy has been a major concern for the Automobile industry. Since we came to a situation in which the fuel used to run the vehicles got reduced extensively, this is the main reason for people to think about an alternative for the vehicles that run on fuel. In this situation, people had found Electric vehicles that use batteries for the running of the vehicles as the better alternative the fuel vehicles. Generally, as the brakes are applied due to the friction between the brake lining and the tires kinetic energy is generated which is later converted into Heat and eventually it cools down and comes to the normal state, in this process all the kinetic energy that is generated is not being utilized and it is being wasted. This is the point where the Regenerative Braking application plays a key role in converting the kinetic energy into some form of useful energy for the vehicles. The following topics will cover various situations in which the regenerative braking system is utilized.

2. Literature Review

1.The dynamic performance of EVs under four different strategies, including MOOS, efficiency optimization strategy (EOS), braking comfort optimization strategy (BCOS), and current smoothness optimization strategy are compared and analyzed in order to determine the influence of BS on braking performance under sliding braking conditions (CSOS). The working distance, braking comfort performance, and battery lifetime were increased by choosing braking energy recovery efficiency, braking impact, and current fluctuation as optimization goals, respectively. The results of multi-objective optimization were used to construct an angle optimization controller and a braking force optimization controller.

2. This paper presents an energy recovery mode (mode A) for the regenerative braking system of an electric vehicle and suggests an effective regenerative braking control strategy to maximize braking energy recovery, increase the driving range of EVs, as well as meet the requirements of EV braking stability. Fuzzy theory could be used to determine the regeneration torque dependent on the pedal condition. The following three scenarios should be taken into account in that order: BP is depressed; AP is lifted; and AP and BP are fully liberated. (1) When the BP is low.

3. This research proposes an electric car regenerative braking control system that takes a downhill slope into account. The driving cycle simulation validates the suggested algorithm. the regenerative braking process's energy recovery. The precise research contents of this work are as follows, taking into account the limitations of previous research: (1) the alteration in braking force distribution and stability with respect to the downslope; (2) the impact of slope on the safety and recovery of regenerative braking.

4. According to Chetana Kumar et al reviewed the potential need for the design and development of a small, globally competitive electric concept vehicle for India, EVs are the best way to reduce pollution in cities, and the use of HEVs and EVs would have significant positive effects on the economy and society. The major goal of the paper is to design and execute a regenerative braking system that aids in recovering the energy lost while braking and storing it back in the battery for use during subsequent drives with the aid of the circuit.

5. A vehicle's drivetrain must supply enough power to overcome the inertia of the vehicle, which is inversely proportional to weight, for the vehicle to move forward. A vehicle requires less energy to drive the lighter it is. Using lightweight materials and lighter-weight technology can reduce weight. Moreover, there are substantial energy losses within The kinetic energy of the car is increased as the mechanical energy is then transferred to the wheels. This kinetic energy is lost in part as a result of the engine's noise, combustion light, and heat generated by friction between the road and the tires. Only about 20% of the energy in fuel can currently be used by today's automobiles; the rest is lost.

6. The main bottleneck problem of EVs is battery ageing; to extend battery life, regenerative breaking systems is used. Battery degradation is one technological barrier impeding the development of electric vehicles (EVs). How to improve EV energy management and slow battery ageing has long been forgotten. The goal of this research is to improve EV energy management and battery life.

7. Bin Wang and Team proposed a novel predictive-based robust controller for tracking wheel slip, to prevent slip locking foe IWMDEVs by combining the hydraulic and regenerative braking systems. Extensive simulation experiments have been conducted to confirm the suggested controller's efficacy.

8. The authors designed a serial control strategy of regeneration braking systems for electric vehicles under safety-critical driving situations. That paper introduced regenerative blending brakes, which are associated with the primary vehicle components associated with frictional braking. According to phase plane theory, the goal of anti-lock control brake torque is to maximize road adhesion.
9. They took yaw rate and wheel angular velocities as parameter and measures vehicles the vehicle longitudinal velocity. The best and most widely used solution for extending the vehicle's range and battery life is the storage of recuperation energy. Hence, a secondary, quick storage system that operates in tandem with the car battery can store the recuperation energy more effectively.

10. The control performance of regenerative braking system for other type of electric vehicles. The effectiveness of the suggested control approach in light of various vehicle dynamics models.

11.The regenerative braking system of electric vehicles are driven by a BLDC motor, the RBS can generate the mechanical and electrical braking force, in this RBS contain fuzzy and PID control methods to recover energy and to provide safety of braking in a different situation

12.The regenerative Anti-locking braking system is operated by controlling the load torque of the generator while applying braking to reduce speed and recover energy at the low speed of the vehicles

13.The wheel slip ratio is a control scheme for regenerative braking in heavy road vehicles in this sliding mode control was developed today to regulate the wheel slip ratio of an electric field during braking. It consists of both friction and regenerative braking called cooperative braking reduces the slip ratio.

14.The energy consumption for electrical vehicles with different energy storage systems are lead acid battery, lithium-ion battery, and hybrid energy storage systems, in which the lithium-ion battery has higher energy recovering from the regenerative braking and the energy consumption and high weight while comparing to other batteries.

15.The hybrid brake battery charging control method is considered battery conditions, in which the hybrid brake consists of mechanical and electric brakes caused by ISG integrated starter and generator, and ISG is an essential component in automotive and electrical vehicles.

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3. Results and Discussion

Schematic representation of EV thermal and power loops:-

It demonstrates how an EV air conditioner works and clearly explains the process of EV thermal and power loops. The condenser, evaporator, and refrigerants all play important roles.

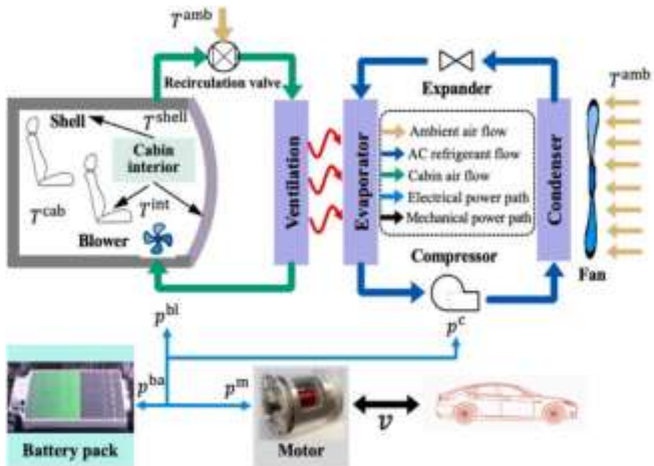

Fig-1: Schematic Representation of EV Thermal & Power Loops

This is how an AC vehicle works. The evaporator absorbs heat from the cabin air, which is then taken away by the refrigerants and released to the ambient via the condenser. The blower for cabin ventilation, the recirculation valve for controlling ambient air inflow, the evaporator for absorbing heat from the cabin air, the refrigerants for transferring heat, and the condenser for releasing heat to the ambient are all part of how the AC system works. The battery and the electric motor power the AC unit, and regenerative braking is used to develop advanced energy management strategies for EVs. A state-space equation based on the control-oriented model for the AC system dynamics is developed to connect the temperature of the cabin air and the energy consumption of the AC system.

Longitudinal dynamics of vehicle:-

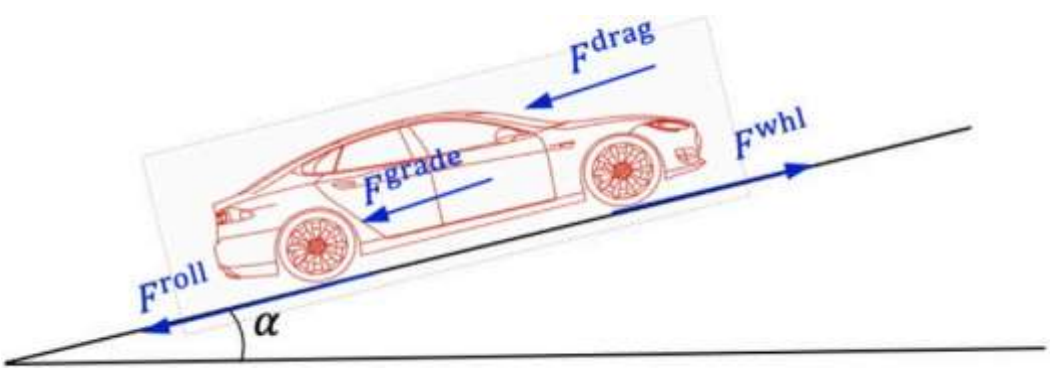

Fig-2: Longitudinal Dynamics of a Vehicle

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The equation includes the system state vector, the system output vector, and control inputs such as the evaporator wall temperature set-point and the blower flow rate. The discrete-time state-space equation is also built using the state transition function and the output function. Overall, the control-oriented thermal model is intended to allow effective control of the cabin air temperature and the energy consumption of an EV's AC system, thereby improving its energy management strategies. The parameters of the EV configuration are based on the Tesla Model S, with the nominal capacity and voltage of the battery pack being 100 kWh and 400 V, respectively.

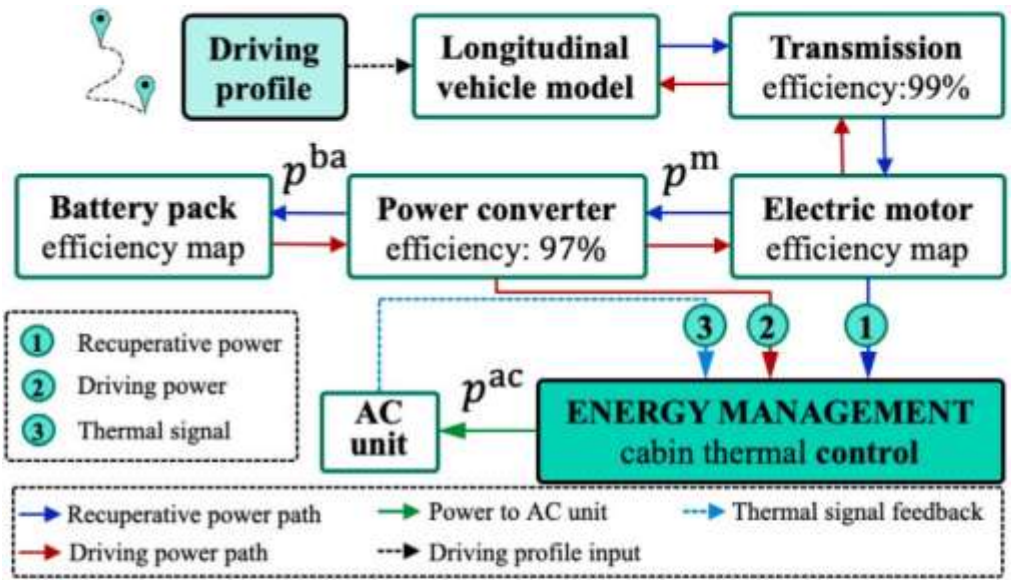

Fig-3: Energy Management System In Electric Vehicles.

The Tesla EM, on the other hand, achieves high efficiencies over a wide range of speed and torque [32], so the efficiency map is simplified into a single efficiency for model simplification. This degradation process is slow, and the charging/discharging efficiencies of batteries can be considered constant across different life cycles.

Concept of the power and thermal load shift:-

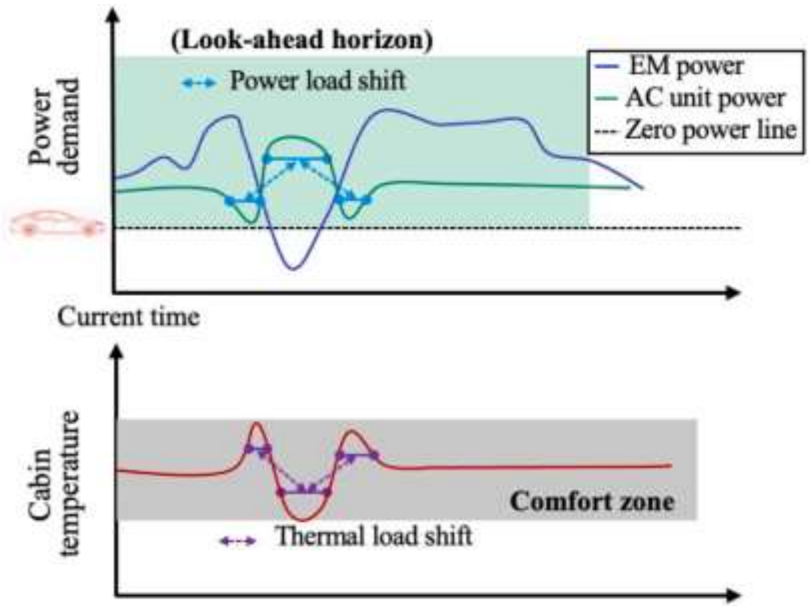

Fig-4: Graphical Representation of Thermal & Power Load Shift

The figure depicts how the energy management strategy promotes power and thermal load shift. As can be seen, the AC unit power is lower before and after regenerative braking (negative EM power) and higher when regenerative braking is turned on, resulting in an AC system power shift.It should be noted that because the AC system can operate at various power levels, it is not necessary to over-design the AC system for the operation of the power and thermal load shift strategy.

Regenerative system dynamic model:

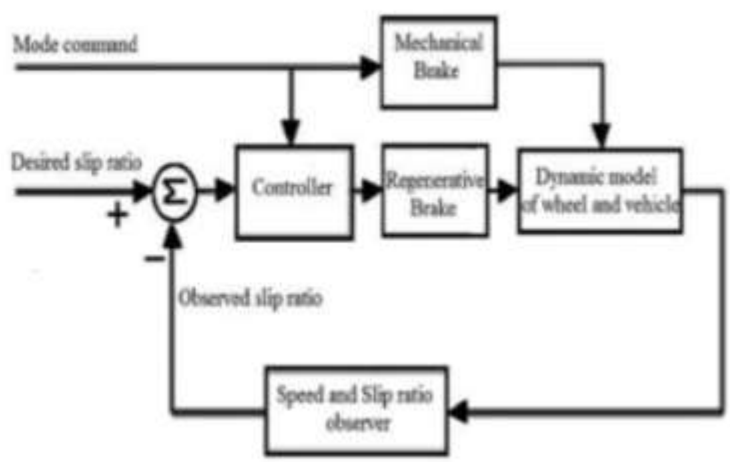

Fig-5: Dynamic Model of RBS

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The dynamic model of wheel and vehicle: wheel and vehicle are used to calculate vehicle dynamics in road conditions. Wind effect force, gradient resistance, and rolling resistance, these terms act in different ways on road conditions when there is gradient resistance is neglected and practical test on the road. Rolling resistance, reduces vehicle speed and distance, rolling resistance force is small concerning braking force, in this wheel model.

Regenerative Brake:
The Regenerative brake considers the motor, generator, batteries, electric fields, transmitters, and motor and generation are connected through the driver and it calculates angular speeds of the front and rear wheels, and slip ratio on-road vehicles. According to that conditions, the transmitters switch to be on and off, and finally, a regenerative brake is defined as the ratio of electric output power to mechanical output power.
Mechanical Brake:
Mechanical brake in RABS (regenerative braking system) acts on rear wheels and it has constant braking torque and it equal to maximum torque. The total mechanical braking and braking torque are provided by the Motor generator.

Speed and slip ratio observes: The function of the speed and slip ratio is calculated as absolute vehicle velocity and both measure angular speed on wheels.
The controller in RABS is the angular speed of the rear and front wheels and the driver is a mode of stopping and speed reduction in the braking controller module.

Proposed cooperative braking control
The sharing of braking force between regeneration braking and friction braking is called co-operation braking. The regeneration braking is applied only to driver wheels and non-driven wheels are subjected to friction braking. The ratio of total brake force is distributed between front and rear wheels, the amount of regenerative braking is applied for constant braking demand, and the amount of regenerative braking applied to driven wheels is vaned to maintain a defined slip ratio. The wheel slip ratio in continuous and discontinuous control input distributive frictional braking and regenerative braking respectively from the above diagram λf,d and slip ratio of front and rear wheels and Tb fric , Tbr regen indicate wheel friction regeneration torque respectively braking torque is larger than RBT the batter soc reaches higher the possibility to store regenerates electrical energy in the battery.
Structure of control strategy system:-

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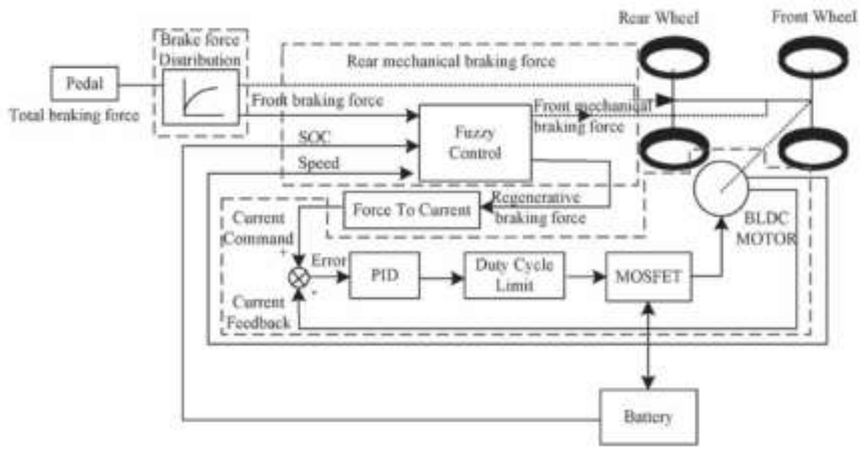

Fig-6: Structure of CSS

The structure of the control strategy system shows through the pedal sensor we can obtain driven required braking force. According to the fuzzy logic controller strategy of electrical vehicle braking force distribution can be easily demonstrated by the influence of different factors. There is three input, electrical vehicle front wheel braking force, speed, and battery charge.
BLDC motor is useful for an electric vehicle because it has high densities and speed torque characteristics high-efficiency speed ranges and BLDC motor requires relatively complex electronics control.
The purpose of the PID controller is to force the rotor speed of the BLDC motor to speed track and PID is used to ensure constant brake torque, when the fuzzy is slower than the PID control, the braking torque can be real fine controller by PID.

4. Conclusion

The regenerative braking system used in vehicles achieves the goal of recapturing some of the energy lost during braking. It can also be used at high temperatures and is more efficient than traditional braking systems. According to the results of some of the tests, the system can recover approximately 30% of the energy delivered. The regenerative braking system has a lot of room for improvement and energy savings. The use of more efficient systems could result in massive savings in any country's economy.

4.1 Future Scope

It takes some more time to design a fully efficient Regenerative braking System that converts the entire energy and converts into electrical energy even more effectively. Designers and engineers will perfect regenerative braking systems over time, so these systems will become more common. These systems can benefit all vehicles in motion by recapturing energy that would have been lost during the braking process. Future regenerative brake technologies will include new types of motors that are more efficient as generators, new drive train designs that are built with regenerative braking in mind, and electric systems that are less prone to energy losses. Of course, problems are to be expected as any new technology matures, but few future technologies have the potential to improve vehicle efficiency like this one.

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