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REGENERATIVE BRAKING SYSTEM IN HYBRID VEHICLES USING SUPER CAPACITORS USING MATLAB

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ABSTRACT: Regenerative braking system (RBS) integration in hybrid cars has emerged as a key development in increasing energy efficiency.The application of supercapacitors as a means of storing the energy acquired during braking is investigated in this research. With an emphasis on the dynamics of energy recovery, storage, and use through supercapacitors, the main goal is to use MATLAB to model and simulate the regenerative braking system.The design of the system, simulation findings, and the possible advantages of supercapacitors over traditional battery-based systems are all covered in the study.

Keywords: Regenerative Braking, Hybrid Vehicle, Supercapacitor, MATLAB Simulation, Energy Recovery, Energy Storage, Efficiency.

I. INTRODUCTION

Hybrid vehicles (HVs) combine an internal combustion engine with an electric propulsion system. The goal of hybrid technology is to reduce fuel consumption and greenhouse gas emissions. One of the most promising energy-saving technologies in HVs is the regenerative braking system (RBS). Regenerative braking captures kinetic energy during braking and stores it for later use, thereby improving fuel efficiency and reducing energy wastage.

Traditional hybrid systems use batteries for energy storage. However, batteries are not ideal for high-power demands such as braking. Supercapacitors, on the other hand, offer superior power density and faster charging/discharging capabilities, making them an attractive alternative for regenerative braking systems.

This paper presents a simulation model of an RBS using supercapacitors, developed using MATLAB. The aim is to evaluate the performance of the regenerative braking system and compare the energy recovery efficiency using super capacitors.

II. LITERATURE REVIEW

Several studies have explored regenerative braking in hybrid and electric vehicles. These systems usually rely on battery storage for recovered energy. However, the use of supercapacitors has gained attention due to their high power density, long cycle life, and ability to rapidly charge and discharge, making them more suitable for regenerative braking.

Supercapacitors have lower energy density compared to batteries, but their ability to provide instantaneous power makes them ideal for capturing and delivering energy during braking events. The integration of supercapacitors into regenerative braking systems has been shown to improve the overall efficiency of energy recovery and reduce the burden on the vehicle's battery.

III. METHODOLOGY

3.1 Regenerative Braking System (RBS)

The regenerative braking system works by converting the vehicle’s kinetic energy into electrical energy. During braking, the electric motor switches to generator mode, and the vehicle’s motion drives the motor to generate electricity. This electricity is stored in the energy storage system, which in this paper is a super capacitor.

3.2 Supercapacitor Model

Supercapacitors are modeled based on their equivalent series resistance (ESR), capacitance, and voltage characteristics. The energy stored in the supercapacitor during braking is given by:

E=12CV2E = \frac{1}{2} C V^2E=21CV2

Where:

- EEE is the energy stored,
- CCC is the capacitance,
- VVV is the voltage across the supercapacitor.

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3.3 MATLAB Simulation

The MATLAB/Simulink model used for the simulation consists of:

1. **Vehicle dynamics model**: Represents the motion of the vehicle and its interaction with the braking system.
2. **Braking system model**: Simulates the braking force and energy conversion during braking.
3. **Supercapacitor model**: Models the charging and discharging behavior of the supercapacitor during regenerative braking.

The simulation includes:

- Vehicle speed as a function of time.
- Braking force and energy conversion efficiency.
- Supercapacitor charging and discharging cycles.

3.4 Energy Recovery Efficiency

The efficiency of the regenerative braking system is evaluated based on the amount of energy recovered compared to the energy dissipated as heat in traditional braking systems. Energy efficiency is calculated using the ratio of recovered energy to the total energy that could have been dissipated during braking.

IV. RESULTS AND DISCUSSION

4.1 Simulation Setup

The MATLAB simulation was run under various driving conditions, including different vehicle speeds, braking intensities, and supercapacitor sizes. The simulation results were analyzed to evaluate the performance of the regenerative braking system in terms of energy recovery, storage, and power delivery.

4.2 Energy Recovery Efficiency

The results showed that using supercapacitors in the regenerative braking system increased the efficiency of energy recovery compared to conventional battery-based systems. The supercapacitor allowed for quicker charging and discharging cycles, leading to a higher amount of energy being recovered during each braking event.

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4.3 Supercapacitor Performance

The supercapacitor exhibited rapid voltage fluctuations during high-power braking events. However, due to its lower energy density, the super capacitor could not store as much energy as a battery but was able to provide faster power delivery for acceleration or other high-power demands.

4.4 Comparative Analysis

A comparison between the supercapacitor-based regenerative braking system and a battery-based system showed that:

- Supercapacitors have a higher power density, making them ideal for quick energy recovery.
- Batteries have a higher energy density, which is better suited for long-term energy storage.

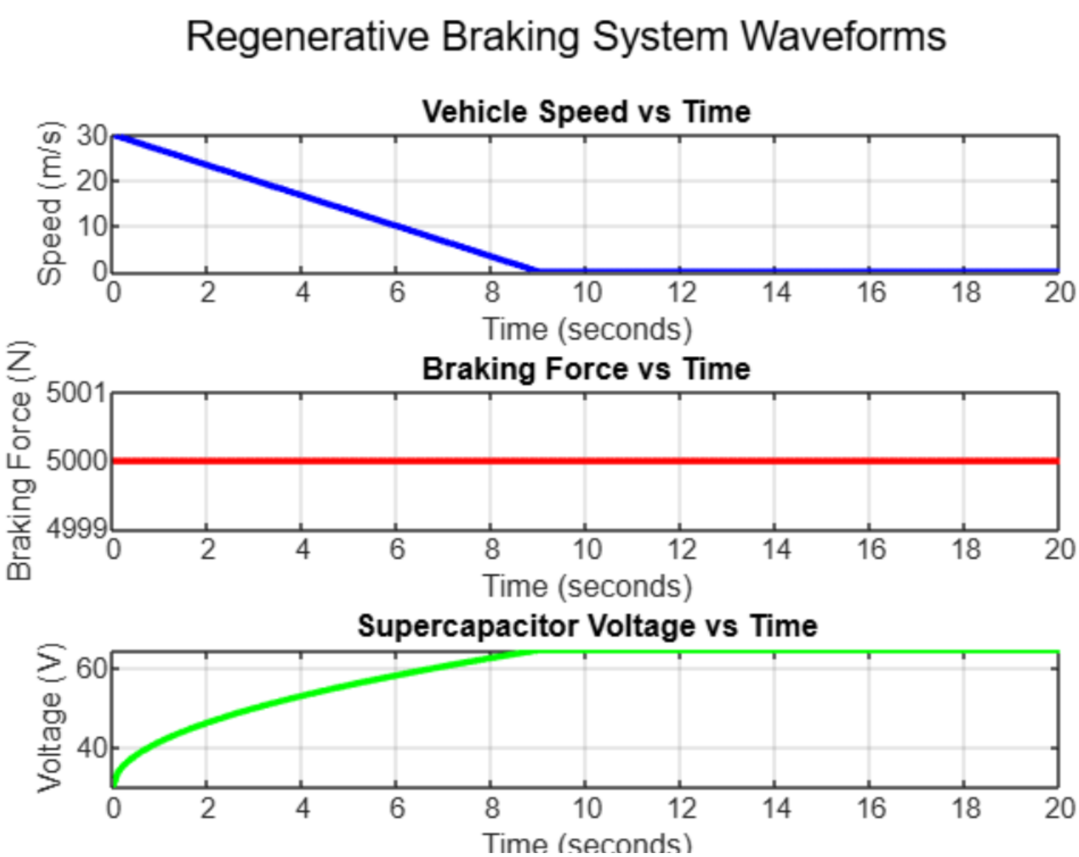

Fig1. Output wave from

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V. CONCLUSION

In this work, a MATLAB simulation of a hybrid car's supercapacitorbased regenerative brak ing system is shown.The outcomes of the simulation show how supercapacitors are superior in terms of power density, quick charging and discharging, and overall energy recovery effe ctiveness.Supercapacitors work best when combined with a battery for longterm energy stor age, however there is a trade-off between power density and energy density.Future work could explore hybrid energy storage systems that combine supercapacitors and batteries, optimizing the strengths of both technologies for enhanced regenerative braking performance in hybrid vehicles.

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