Regenerative Braking Systems (RBS)

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ABSTRACT :- *A regenerative braking is a system that converts a portion of a vehicle's kinetic energy into electrical or mechanical energy, which can be stored for later use. This technology aims to improve efficiency by reducing the energy required to drive the vehicle. Our project focuses on studying and demonstrating this innovative braking system, which has the potential to significantly save energy, especially in vehicles with frequent braking events like buses, taxis, and delivery vans. By harnessing this technology, we aim to contribute to the conservation of non-renewable energy sources.*

Keywords*:* Regenerative Braking, Generator, Brake pad, Energy Recovery,

I. Introduction

Regenerative braking fundamentally shares the same objective as conventional braking: to slow down or stop a vehicle safely. However, the mechanism and outcomes of regenerative braking differ significantly, offering additional benefits beyond simple deceleration.

Conventional braking systems rely on friction between brake pads and rotors to dissipate kinetic energy as heat, thereby slowing down the vehicle. While effective, this process results in significant energy loss, as much of the kinetic energy is converted into heat and dispersed into the environment. This wasted energy contributes to reduced fuel efficiency and increased environmental impact.

Regenerative braking, on the other hand, seeks to capture a portion of this kinetic energy that would otherwise be lost and convert it into a usable form, such as electrical or mechanical energy. This captured energy can then be stored in batteries or other storage devices for later use, such as powering electric motors during acceleration. By harnessing this otherwise wasted energy, regenerative braking offers several advantages:

1. **Improved Fuel Efficiency**: By recycling kinetic energy back into the vehicle's system, regenerative braking reduces the amount of energy needed from the engine to propel the vehicle forward. This can lead to significant improvements in fuel efficiency, with some estimates suggesting increases of up to 33% over conventional braking systems.

2. **Reduced Environmental Impact**: By minimizing energy waste and reducing the need for fuel consumption, regenerative braking helps lower greenhouse gas emissions and other pollutants associated with conventional vehicles. This contributes to a cleaner and more sustainable transportation ecosystem.

3. **Extended Range for Electric Vehicles**: In electric and hybrid vehicles, regenerative braking plays a crucial role in extending the vehicle's range by recapturing energy that would otherwise be lost during braking. This captured energy can then be used to recharge the vehicle's battery, effectively increasing its driving range between charges.

4. **Enhanced Brake Lifespan**: Regenerative braking systems can also reduce wear and tear on traditional friction brakes, as they help dissipate some of the braking force and heat generated during operation. This can lead to longer brake lifespan and reduced maintenance costs over time.

While regenerative braking offers numerous benefits, its effectiveness can vary depending on driving conditions. For instance, it is most efficient in stop-and-go traffic situations, where frequent braking occurs. Conversely, its effectiveness diminishes during constant-speed driving, such as on highways, where braking events are less frequent.

II. LITERATURE REVIEW

A. Tushar L. Patil, Rohit S. Yadav, Abhishek D. are, Mahesh Saggam, Ankul Pratap, 'Performance Improvement of Regenerative braking system', International Journal of Scientific & Engineering Research Volume 9, Issue 5, (2018). 2229-5518

In this paper To enhance the effectiveness of regenerative braking systems, a few methods are suggested. Firstly, trimming the weight of the vehicle can notably improve its performance. By shedding excess weight, the vehicle requires less energy for acceleration and deceleration, thereby enabling the regenerative braking system to efficiently capture and utilize kinetic energy.

B. Siddharth K. Sheladia, Karan K. Patel, V. raj D. Savalia, Rutvik G. Savaliya, 'A Review on Regenerative Braking Methodology in Electric Vehicle', International Journal of Creative Research Thoughts, Volume 6, Issue 1 (2018). 2320-2882

In this paper ,Regenerative braking systems have been upgraded with cutting-edge power electronics like ultra-capacitors, DC-DC converters (Buck-Boost), and flywheels.

These advancements have significantly improved efficiency, enabling regenerative braking to save approximately 5% to 8% of wasted energy.

C. Y. Luo, D. Huang and X. Gao's "Research on energy recovery for electric vehicle based on motor-generator integration system,"

In this paper,The research focused on electric vehicles and specifically investigated their energy recovery systems. One significant proposal was the integration of motor-generator units. Detailed explanations were provided regarding the theory and methodology behind this integration. Furthermore, a novel addition to the study was the incorporation of an intelligent gearbox into the vehicle model, representing a pioneering effort in electric vehicle research. This study was conducted by Zhang Guirong in the paper titled "Exploring Regenerative Braking and Energy Recovery Systems for Electric Vehicles.

D. M. Boisvert, D. Mammosser, P. Micheau, A.Desrochers, "Comparison of two strategies for optimalregenerative braking, with their sensitivity to variations inmass," IFAC Proceedings Volumes, vol.46, pp.626-630,2013

In this paper,This study examines regenerative braking control in a three-wheeled recreational vehicle. Unlike traditional methods based on vehicle speed, it introduces a new strategy focused on controlling rear wheel slip. Using a MatLab/Simulink simulator validated with experimental data, the study compares the effectiveness of both approaches and finds that slip-based regenerative braking is less affected by changes in parameters, ensuring optimal energy recovery and vehicle stability even with fluctuations in mass, slope, and road conditions.

III. CONVENTIONAL BRAKING SYSTEM

Traditional braking systems, like hydraulic and pneumatic systems, rely on friction pads to slow down or stop the wheels. These systems use mechanical or fluid linkages to activate the brakes. In hydraulic systems, brake fluid transmits the force from the brake pedal to the brake calipers, while pneumatic systems use compressed air. However, despite their widespread use, these systems have limitations. They can be prone to wear and heat buildup, reducing effectiveness and requiring frequent maintenance. Additionally, they waste energy in the form of heat during braking. Therefore, there's a need for improvement to enhance efficiency, reduce maintenance, and minimize energy loss.

IV. WORKING PRINCIPLES

Faraday's first law states that when the magnetic flux linked with a conductor changes, an electromotive force (emf) is induced in the conductor.

Faraday's second law states that the magnitude of the induced emf is directly proportional to the rate of change of magnetic flux with time.

Lenz's law asserts that the induced emf in a conductor always opposes the change in magnetic flux that causes it.

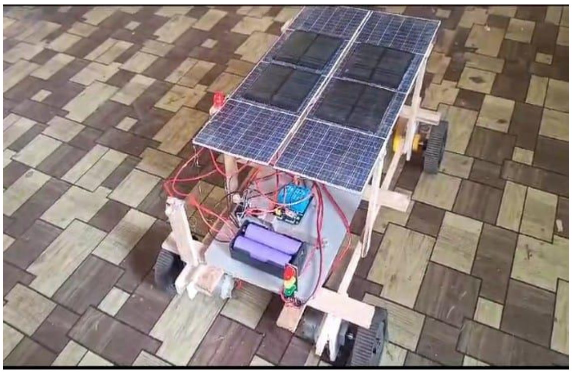

Fig. 1. Regenerative braking systems

V. COMPONENT'S

Arduino UNO:- The Arduino Uno is a versatile microcontroller board used for electronics projects.It features input/output pins, USB connectivity, and is programmed using the Arduino IDE. It's popular for beginners and experts alike, allowing for a wide range of projects including robotics and sensors.

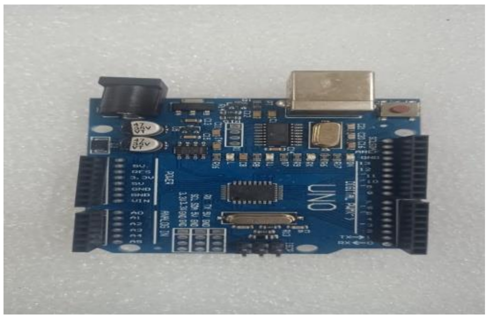

Fig. 2. Arduino uno

MOTER DRIVER :- A motor driver is an electronic device that controls the speed and direction of a motor. It typically takes input signals from a microcontroller or other control system and converts them into the necessary power and voltage levels to drive the motor. Motor drivers can vary in complexity and features, but they generally include components such as power transistors or MOSFETs to switch the motor on and off, as well as circuitry to regulate current and protect against overloads or short circuits. They are commonly used in robotics, automation, and other applications where precise motor control is required.

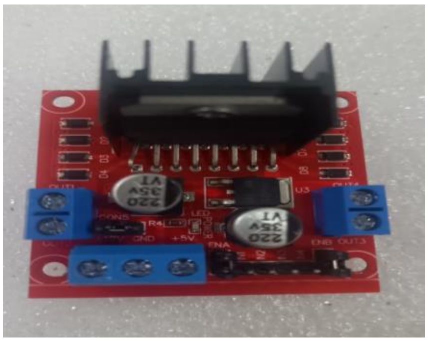

Fig. 3. Motor driver

RELAY :- A relay is an electromechanical switch that uses an electromagnet to mechanically operate a set of contacts. When an electrical current is applied to the coil of the relay, it creates a magnetic field that attracts or repels the contacts, causing them to open or close. Relays are commonly used to control high-power or high-voltage circuits with low-power control signals, providing isolation between the control circuit and the circuit being controlled. They are widely used in applications such as automation, electrical circuits, and industrial control systems.

Fig. 4. Relay

DC GEAR MOTOR :- A DC gear motor is a type of electric motor that combines a DC motor with a gearbox to control speed and torque. The DC motor provides the rotational motion, while the gearbox reduces the speed of the motor and increases its torque output. This gearing mechanism allows DC gear motors to be used in applications where precise control over speed and power is required. They are commonly used in robotics, automation, electric vehicles, and various other applications that require controlled movement.

Fig. 5. DC gear motor

SOLAR PANEL:- Solar panels can complement regenerative braking systems by providing additional electrical energy. They can charge auxiliary systems, recharge batteries, and increase overall efficiency, extending the vehicle's range. This integration enhances sustainability and reduces reliance on traditional energy sources.

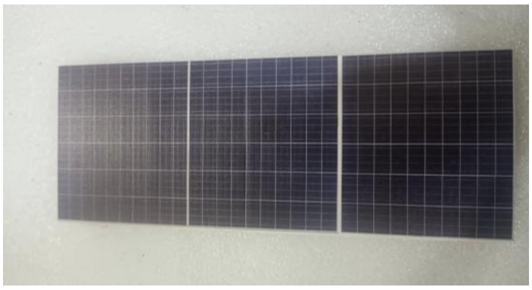

Fig. 6. Solar panels

VI. CONCLUSION

Although regenerative braking systems offer significant benefits, such as improved fuel economy and energy capture, they still require friction brakes for emergency stopping situations. This indicates the potential for further innovation in this field. However, current models are still valuable, as studies have demonstrated their ability to enhance engine efficiency and reduce fuel consumption by capturing energy that would otherwise be wasted. In summary, the outcomes of this project are deemed satisfactory, highlighting the effectiveness of the regenerative braking system in optimizing vehicle performance.

VII. REFERENCES

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