Electromagnetic Braking System with Regeneration: A Comprehensive Review and Analysis

Shaunak Gosavi[1] Vyanketesh Tak[2] Govind Mahale[3] Krushna Shere[4] Prof. BhalekarB.D[5]
[5]Assistant Professor
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]MGM's Polytechnic Chh.Sambhajinagar, Maharashtra, India

Abstract — This innovative braking system utilizes electromagnetic forces to slow down and stop vehicles, offering several advantages over traditional friction-based braking systems. By harnessing the power of electromagnetic fields, this system not only provides efficient braking performance but also enables energy regeneration. This means that the kinetic energy generated during braking is converted into electrical energy and stored for later use, enhancing the overall energy efficiency of the vehicle.

Keywords: Braking, Electromagnet, Regeneration

I. INTRODUCTION

A. Background and Significance of Electromagnetic Braking Systems

The traditional braking systems used in vehicles rely on friction to slow down the vehicle. This results in energy being converted into heat, which is dissipated into the atmosphere. This energy loss has been a major concern for vehicle manufacturers and researchers. To overcome this issue, an alternative braking system known as the Electromagnetic Braking System (EMBS) with Regeneration has been developed. This system uses electromagnets to slow down the vehicle, converting kinetic energy into electrical energy which can then be stored and reused. This paper aims to provide a comprehensive review and analysis of the Electromagnetic Braking System with Regeneration.

B. Overview of Regeneration in Electromagnetic Braking Systems

The Electromagnetic Braking System with Regeneration utilizes the principle of electromagnetism to generate braking force. It consists of three main components: the electromagnets, the power converter, and the energy storage system.

The electromagnets are placed on the wheels of the vehicle and are controlled by the power converter. When the driver applies the brakes, the power converter sends a signal to the electromagnets, causing them to generate a magnetic field. This magnetic field interacts with the rotating wheel, creating a braking force that slows down the vehicle.

At the same time, the kinetic energy of the vehicle is converted into electrical energy, which is then sent to the energy storage system. This system can either be a battery or a supercapacitor, which stores the generated energy for future use. This energy can be used to power the vehicle's electrical components or assist in accelerating the vehicle, reducing the load on the engine and increasing fuel efficiency.

II. PRINCIPLES OF ELECTROMAGNETIC BRAKING SYSTEMS

A. Basic principles of electromagnetic braking

Electromagnetic braking is a method of stopping or slowing down a moving object by using the principles of electromagnetism. The basic principle behind this type of braking is the conversion of kinetic energy into electrical energy, which is then dissipated as heat. This process involves the interaction between a magnetic field and an electric current, resulting in the creation of a braking force that opposes the movement of the object.

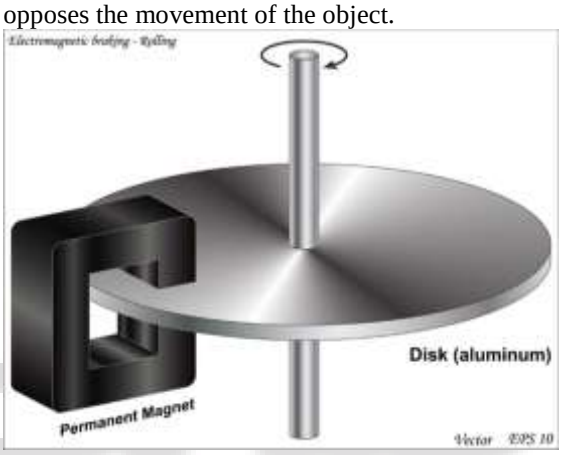

Fig. 1: Principal of Electromagnet Braking

B. Key Components and Their Functions

There are three main components involved in electromagnetic braking: a power source, an electromagnet, and a conductive material. The power source provides the electrical energy needed for the braking process. This can be a battery, generator, or any other source of electricity. The electromagnet is responsible for creating the magnetic field that interacts with the conductive material. It is typically made of a coil of wire wrapped around a metal core, which can be either a permanent magnet or an electromagnet itself. The conductive material, also known as the armature, is the moving part of the braking system and is usually a metal disc or drum.

C. Comparison with Traditional Friction-Based Braking Systems

Friction-based braking systems have been the standard in the automotive industry for many years. These systems work by applying pressure on brake pads to create friction against the rotating wheel, thereby slowing down or stopping the vehicle. However, with the advancement of technology, a new type of braking system has emerged – the electromagnetic braking system. This system uses electromagnets to generate a magnetic field, which in turn creates a braking force to slow down the vehicle.

In terms of efficiency, electromagnetic braking systems also have an edge over traditional friction-based systems. The use of electromagnets means that there is no physical contact between the brake pads and the rotating wheel, resulting in less wear and tear on the braking system. This translates to longer durability and reduced maintenance costs. Additionally, electromagnetic braking systems also have the ability to convert the kinetic energy of the vehicle into electrical energy, which can be stored and used to power other systems in the vehicle. This regenerative braking feature not only increases the efficiency of the braking system but also reduces fuel consumption and emissions

One of the main advantages of electromagnetic braking systems is their ability to provide more precise and controlled braking. Unlike traditional friction-based systems, where the pressure on the brake pads can vary depending on the force applied by the driver, electromagnetic braking systems allow for precise control of the braking force. This is especially beneficial in situations where sudden and precise braking is necessary, such as in emergency situations.

III. Regenerative Braking: Working Mechanism

A. Overview of Regenerative Braking

The concept of regenerative braking is based on the principle of energy conservation. When a vehicle is in motion, it possesses kinetic energy, which is the energy of motion. This energy is created by the engine and is used to propel the vehicle forward. When the brakes are applied, the kinetic energy is converted into heat energy, which is dissipated into the environment. This is the reason why brakes get hot after prolonged use.

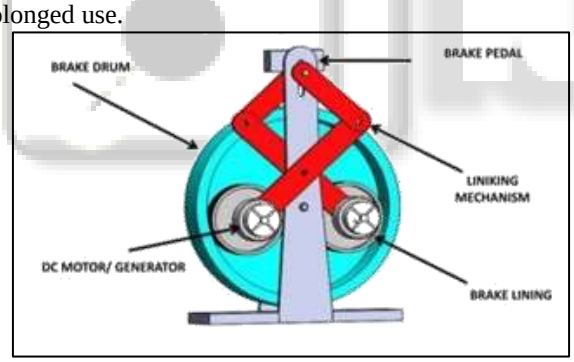

Fig. 2: Working of regenerative braking

With regenerative braking, the kinetic energy of the moving vehicle is captured and converted into electrical energy, which is then stored in the vehicle's battery. This energy can then be used to power the vehicle's electrical systems, reducing the load on the engine and ultimately leading to improved fuel efficiency.

This generated electrical energy is stored to recharge battery of vehicle. It is mostly used in hybrid vehicles and also modern trains.

IV. Advantages and Benefits of Electromagnetic Braking Systems with Regeneration

1) Improved Energy Efficiency: One of the most significant advantages of an electromagnetic braking system with regeneration is its ability to recover and reuse the energy that would otherwise be lost during braking. This results in improved fuel efficiency and reduced emissions.
2) Reduced Wear and Tear: Unlike traditional friction-based braking systems, electromagnetic braking systems do not require physical contact between the braking components, resulting in less wear and tear. This leads to longer lifespan and lower maintenance costs.
3) Faster Response Time: Electromagnetic braking systems have a faster response time compared to traditional braking systems. This is because there is no need for physical contact between the braking components, and the braking force is applied directly to the wheels through the magnetic field.
4) Regenerative Braking: The regenerative braking feature of electromagnetic braking systems allows for the recovery of energy during deceleration, which can be used to power other systems in the vehicle, reducing the load on the engine and increasing overall efficiency.

V. Challenges and Limitations

1) Limited Power Output: The amount of energy that can be regenerated using an electromagnetic braking system is limited by the strength of the magnetic field. This makes it unsuitable for heavy-duty vehicles or vehicles that require frequent braking.
2) High Initial Cost: The initial cost of implementing an electromagnetic braking system with regeneration is relatively high compared to traditional braking systems. This may make it less feasible for smaller vehicles or those with lower budgets.
3) Limited Effectiveness at Low Speeds: Electromagnetic braking systems are most effective at higher speeds, as the magnetic field generated is directly proportional to the speed of the vehicle. At lower speeds, the braking force may not be sufficient to bring the vehicle to a complete stop.

VI. Case Study

Integrated both the system together to improve the efficiency of the vehicle braking.

1) Electromagnetic regenerative braking is a technology that allows vehicles to convert kinetic energy into electrical energy during the braking process. This system works by using an electric motor to slow down the vehicle while simultaneously generating electricity that can be stored in a battery or used to power other systems in the vehicle. By harnessing this energy that would otherwise be lost as heat, electromagnetic regenerative braking helps improve the overall efficiency of the vehicle and reduce fuel consumption.
2) Unlike traditional friction braking systems that rely on brake pads to slow down a vehicle, electromagnetic regenerative braking offers a more sustainable and energy-efficient solution. This technology is commonly used in hybrid and electric vehicles to help extend their driving range and reduce their carbon footprint. By capturing and storing energy that would have been wasted during braking, electromagnetic regenerative braking plays a crucial role in making transportation more environmentally friendly and sustainable for the future.

Here are some 3D models of prototype/ research setup

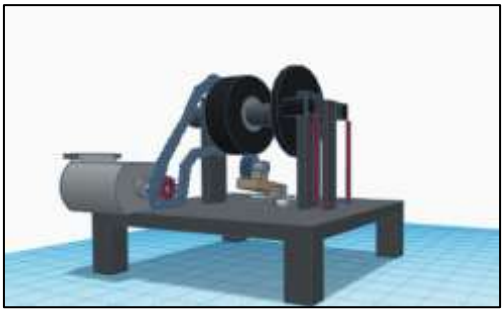

Fig. 3: Design of setup

Here used a 100watt 12v dc motor as a power source.

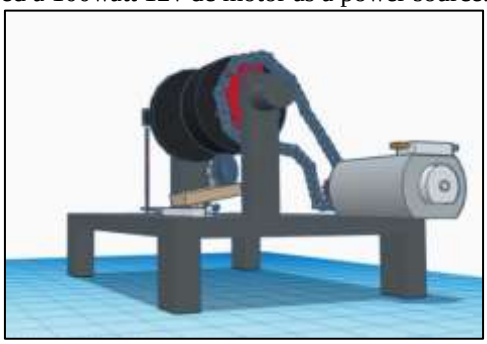

Fig. 4: Design of setup

Motor is supply energy by rotating chain which connects motor and wheel with use of sprockets.

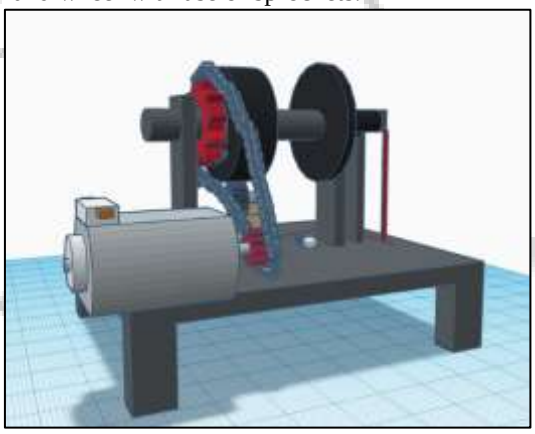

Fig. 5: Design of setup

Used a 24 volt 2 dc electromagnet with magnetic effect of 3kg each. Electromagnets are kept at a distance of 3 mm from brake disc

For regeneration, principal is discussed in Point 3, a limiter switch is attached to the base, the other side of pedal is connected to a dc motor a wheel.

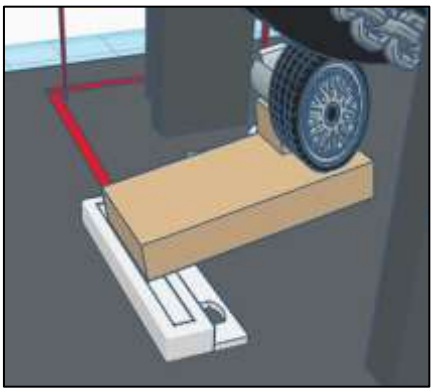

Fig. 6: Limiter switch

When the accelerator padel is released the motor stops and wheel idles.

If paddle is pressed the switch get actuated and electromagnet get charged, as brake pedal is in effect of magnetic field it stops hence the wheel. At other end regenerative kit of the system convert the kinetic energy into electrical energy. This helps to regain some energy which can be used I axillaries.

VII. Application

- Modern Railways
- Aerospace Industry
- Automobile Industry
- In high speed rotating machine or setups
- Machinery
- Defense
- Trams
- Medical Systems
- Robots
- Automation equipment

VIII. Future Trends

The future trends of electromagnetic braking also extend beyond the automotive sector. As electric vehicles gain popularity, electromagnetic braking systems will play a crucial role in ensuring efficient energy regeneration. By harnessing the power of electromagnetic forces during braking, these systems can convert kinetic energy into electrical energy, which can then be stored and used to power the vehicle. This not only enhances the overall energy efficiency of electric vehicles but also reduces their reliance on external charging sources. As a result, electromagnetic braking has the potential to revolutionize not only the automotive industry but also the broader renewable energy landscape.

IX. Conclusion

In conclusion, the electromagnetic braking system offers a sophisticated and efficient solution for braking in modern vehicles. By harnessing the power of electromagnetism, this system provides reliable and consistent braking performance while minimizing wear and tear on components. With its ability to convert kinetic energy into heat energy through magnetic fields, the electromagnetic braking system is a key technology that enhances the safety and efficiency of vehicles on the road.

References

[1] Electromagnetic Braking System IRE Journals | Volume 5 Issue 1 | ISSN: 2456-8880|2021
[2] Khurmi & Gupta “Machine Design” S Chand Publication.
[3] Research on Regenerative Braking Systems: A Review | IJSR Journal | ISSN: 2319-7064 | Volume 9 Issue 9 | DOI: 10.21275/SR20902143703 |2020|

