

Comparative Analysis of Electromagnetic and Conventional Friction Braking Systems

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ABSTRACT: The electromagnetic braking system is an advanced and contactless braking technology that uses electromagnetic force to slow down or stop moving vehicles and rotating machinery. Unlike conventional friction braking systems such as drum or disc brakes, electromagnetic brakes operate without physical contact between braking components, thereby reducing wear, heat generation, and maintenance requirements.

In an electromagnetic braking system, when electric current is supplied to an electromagnet, a magnetic field is generated. This magnetic field induces eddy currents in a rotating conductive disc or rail. According to Lenz's Law, the induced eddy currents create an opposing magnetic field that resists the motion of the rotating component, producing a braking torque. As a result, the speed of the vehicle or machine is reduced smoothly and efficiently. In conclusion, the electromagnetic braking system is a reliable, efficient, and low-maintenance braking solution that enhances safety and performance in modern transportation and industrial applications. Its contactless operation, high durability, and precise control make it an important component in the future development of braking technologies.

KEYWORDS: Magnetic field, Eddy currents, Brake, Electromagnetism, Brake power, Torque.

I. INTRODUCTION

An electromagnetic braking system is a modern braking technology that uses electromagnetic force to slow down or stop a moving object without direct physical contact between braking components. Unlike conventional friction-based brakes, electromagnetic brakes rely on the interaction between magnetic fields and conductive materials to produce a retarding force. This makes them highly efficient, reliable, and suitable for applications where smooth and controlled braking is required.

The fundamental principle behind electromagnetic braking is electromagnetic induction. When a conductive material such as a metal disc or rail moves through a magnetic field, eddy currents are induced in it. According to Lenz's Law, these currents generate an opposing magnetic field that resists the motion of the conductor, thereby reducing its speed. The braking force produced is proportional to the speed of motion, allowing for gradual and controlled deceleration.

Electromagnetic braking systems also contribute significantly to energy efficiency and safety. In some applications, such as regenerative braking, the kinetic energy of the moving system can be converted into electrical energy and reused or stored. Furthermore, these systems offer precise control and quick response times, enhancing operational safety. As technology advances, electromagnetic braking is becoming increasingly important in modern transportation and industrial automation systems.

II. LITERATURE SURVEY

Stephen Z:- Oldakowski, Bedford, Ohio A magnetic brake provides braking or locking capability and is remotely controlled by electric power. The magnetic brake comprises a rotatable shaft and a brake disc mounted on the shaft. A nonrotating core housing assembly located around the shaft includes a permanent magnet and a bipolar solenoid. A magnetic armature adjacent to the core housing assembly is capable of movement toward the core housing assembly and toward and into engagement with a brake disc to prevent rotation of the shaft. A spring urges the armature away from the core housing assembly and into engagement with the brake disc. The brake does not use any electric power to maintain the brake in the set mode with the rotating shaft fully locked or in the released mode with the rotating shaft fully released. The permanent magnet is of sufficient strength to hold the armature against urging of the spring until an opposite polarity is supplied by the solenoid.

Karl Erny: - Holzhausen an elevator drive has a brake device with compression springs to actuate brake levers, and brake linings on a brake drum creating a braking force. A sensor is provided to detect the movement of a brake magnet armature tappet. A bracket is attached to the brake magnet tappet on one end and a distance piece carrying the sensor housing is arranged on the other end. A restoring lug is attached to the existing mechanical indicator. A monitor evaluates the sensor signal and turns off the elevator drive in the event of dangerous operational states via a safety circuit. The system allows the state of the brake device to be monitored. The more the brake linings wear off due to abrasion, the smaller the distance between the armature and the brake magnet housing. If the armature is in contact with the brake magnet housing, the braking ability of the brake linings is completely void.

Hung-Chi Wu :- 958-2, Ghung Shan Rd., TaoYuan, Taiwan This invention relates to an adjustable magnetic brake and in particular to one including an aluminium fan, a magnetic conducting ring enclosing the aluminium fan, a permanent magnet disposed within the aluminium fan, a fixing seat for keeping the permanent magnet in position, a sliding seat mounted in the fixing seat and provided with a bearing, a housing, bolts provided on one side of the fixing seat and extending out of the housing, a mounting plate connected with the bolts and a wire connected with the mounting plate such that when the wire is pulled outwards, the permanent magnet will be moved outwards.

Jae-WoongLee:- Seoul, Rep .of Korea Disclose dismagnetic brake system for a vehicle. comprising: a plurality of brake disk solenoids for generating the magnetic force; a plurality of brake pad solenoids for generating the magnetic force; a braking sensor for detecting whether a brake pedal is applied; a wheel speed sensor for detecting wheel speed; a magnetic polarity sensor for detecting magnetic polarity of the brake disk solenoids; and a control unit for controlling the brake pad solenoids using signals from the braking sensor. The wheel speed sensor and the magnetic polarity sensor.

III. PRINCIPLE AND OBJECTIVE

Principle-

Principle of Electromagnetism is employed in Electromagnetic Braking system. When specific amount of current is skilled a round conductor then it produces magnetic flux, which is uniform everywhere the conductor. The magnetic flux strength depends on the present flowing through conductor and therefore the no of turn's more than oof turns and higher the current flowing through conductor higher the magnetic flux gets created. Solenoid is that the coil having more no of turns and it's want to produce high strength magnetic flux which is employed during this Electromagnetic Braking.

Objective-

The main objective of is to design and fabricate Electromagnetic Braking System model. Besides the main objective, following are secondary objectives: 1. To understand project planning and execution. 2. To understand the fabrication techniques in a mechanical workshop. 3. To make human life easier by using technology.

IV. METHODOLOGY

The methodology explains how the electromagnetic braking system is designed, operated, and tested. This is very useful for final-year diploma projects, viva, and interviews.

1. System Design and Layout

The electromagnetic braking system mainly consists of: Electromagnet (coil) Power supply (battery or DC source) Brake disc / rotor (conductive material) Controller or switch Mounting frame and shaft. The electromagnet is fixed near the rotating disc with a small air gap.

2. Selection of Materials Disc Brake

Brake Disc: Copper, aluminum, or steel (good electrical conductivity) Electromagnetic Coil: Insulated copper wire Core: Soft iron (high magnetic permeability) Proper material selection ensures strong magnetic force and efficient braking.

3. Power Supply Arrangement

A DC power supply is used to energize the electromagnet. Voltage is selected based on required braking torque. A switch or electronic controller regulates the current flow.

4. Working Methodology (Operating Principle) Step-by-step operation:

When the brake is not applied, no current flows through the coil and the disc rotates freely. When the brake is applied, electric current flows through the electromagnetic coil.

This creates a magnetic field around the coil...

5. Control Methodology

Braking force is controlled by varying the current supplied to the electromagnet. Higher current → stronger magnetic field → higher braking force. This allows smooth, progressive, and controlled braking.

6. Heat Dissipation Method

Heat generated due to eddy currents is dissipated through: Brake disc surface Cooling fins or ventilation holes. This prevents overheating and brake fade.

7. Safety and Backup Method

In case of power failure, conventional mechanical brakes act as backup. Proper insulation and circuit protection are provided to avoid short circuits.

8. Testing and Performance Evaluation

The system is tested for: Braking time Braking torque Heat generation Energy consumption Reliability under repeated operation.

V. COMPONENTS REQUIRED

Alternate current motor, Resistance type current regulator, 'V' belt, Wheel, Metal disc, Electromagnet, Vertical holding column, Control Switch, Bolt and Nut, Fasteners.

1. DC Motor- DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

2. Transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Electromagnetic induction produces an electromotive force within a conductor which is exposed to time varying magnetic fields. Transformers are used to increase or decrease the alternating voltages in electric power applications. Varying current in the transformer primary winding creates a varying magnetic flux in the transformer core and a varying field impinging on the transformer secondary winding. This varying magnetic field at the secondary winding induces a varying electromotive force E or voltage in the secondary winding due to electromagnetic induction. Making use of Faraday's law discovered in conduction with high magnetic permeability core properties, transformers can be designed to change efficiently C voltages from one voltage level to another within power networks.



FIG: 5.1 DC MOTOR

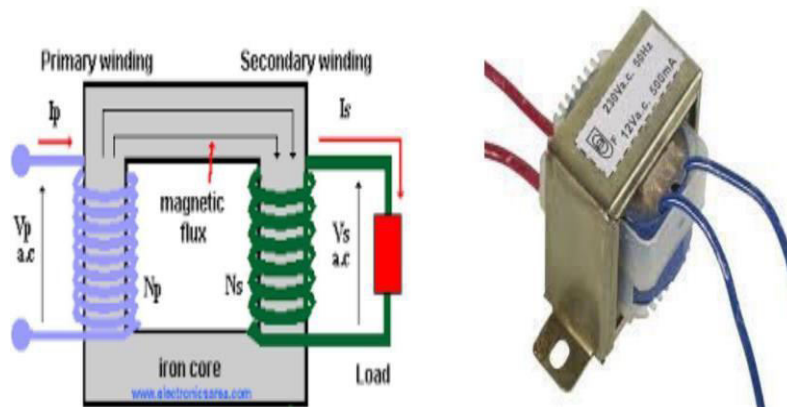


FIG: 5.2 TRANSFORMERS

VI. ADVANTAGES

A brake may be a device, where it restricts motion. It's commonly known that the brakes use friction to convert K.E. into heat. But the Electromagnetic brakes are used as supplementary retardation equipment additionally to the regular friction brakes on heavy vehicles.

- Easy individual wheel braking control.
- This is reduced significantly in electromagnetic disk brake systems.
- Potential hazard of tire deterioration and bursts due to friction is eliminated.
- There is no need to change brake oils regularly. There is no oil leakage
- Electromagnetic brake systems will reduce maintenance cost.
- The problem of brake fluid vaporization and freezing is eliminated.
- Easier integration with anti-lock, traction, and dynamic stability controls

VII. APPLICATION

- a) Already in use under some railway system
- b) Can be used for any road vehicles
- c) Equally applicable to heavy and light vehicles
- d) Can be used as additional retarder for aircrafts

VIII. RESULTS

By using the electromagnetic brake as supplementary retardation equipment, the frictions brakes are often used less frequently and thus practically never reach high temperatures. The brake linings would last considerably longer before requiring maintenance, and therefore the potentially "brake fade" problem might be avoided. In research conducted by a truck manufacturer, it had been proved that the electromagnetic brake assumed 80 percent of the duty which might

otherwise is demanded of the regular service brake (Reverdin 1974). Furthermore, the electromagnetic brake prevents the risks which will arise from the prolonged use of brakes beyond their capability to dissipate heat. This is often presumably to occur while a vehicle descending an extended gradient at high speed. The installation of an electromagnetic brake isn't very difficult. It doesn't need a subsidiary cooling system. It doesn't effect on the efficiency of engine. Electromagnetic brake also has better controllability. Thermal stability of the electromagnetic brakes is achieved by means of the convection and radiation of the warmth energy at heat. The electromagnetic brakes have excellent cooling efficiency. Electromagnetic brakes have better thermal dynamic performance than regular.

IX. CONCLUSION AND FUTURE SCOPE

Electromagnetic brakes have numerous preferences over frictional slowing mechanism. The blend of swirl present and attractive powers makes this brake more successful. This brake is often utilized as assistant stopping mechanism in vehicle. The use of abs is often dismissed by utilizing a smaller scale controlled electromagnetic framework. It is often utilized as a neighbourhood of rail mentors to decelerate the prepare occupation fast. Mixture of these brakes expands the brake life and act like completely stacked brakes. These brakes are often utilized as a part of wet condition, so there's no utilization of against slipping instrument .it is completely electrically controlled which brings about fewer mishaps. The braking power delivered during this brake isn't the maximum amount because the plate brakes. Subsequently, it is often utilized as an auxiliary or crisis slowing mechanism within the autos.

REFERENCES

1. K.D. Hahn, E.M. Johnson, A. Brokken, & S. Baldwin (1998) "Eddy current damping of a magnet moving through a pipe", American Journal of Physics 66:1066–66.
2. M.A. Heald (1988) "Magnetic braking: Improved theory", American Journal of Physics 56: 521–2.
3. Y. Levin, S.L. Da Silveira & F.B. Rizzato (2006) "Electromagnetic braking: A simple quantitative model", American Journal of Physics 74:815–17.
4. Sears, Francis Weston; Zemanski, Mark W. (1955). University Physics (2nd Ed.). Reading, MA: Addison-Wesley.
5. Siskind, Charles S. (1963). Electrical Control Systems in Industry. New York: McGraw-Hill, Inc. ISBN 0-07-057746-3.
6. H.D. Wildrick, N. Gauthier, D.A. Campbell, & P. Rochan (1987) "Magnetic braking: Simple theory and experiment", American Journal of Physics 55:500–3.
7. US patent 7237748, Steven Sullivan, "Landing gear method and apparatus for braking and maneuverings", issued 3 July 2007, assigned to Delos
8. Flemming, Frank; Shapiro, Jessica (July 7, 2009). "Basics of Electromagnetic Brakes"machine design: pp.57–58
9. Kren, Lawrence; Flemming, Frank (August 5, 1999). "Getting a Handle on Inertia". Machine design: pp.92–93.
10. Auguston, Karen; Flemming, Frank (September 1999). "Floating Armature Speeds Response". Global Design News: pp.46–47.



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