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Design and Development of Automatic Electromagnetic Braking System

Jai Raghuveera Samarth, Punith Gowda Y N, Akhilesh Gowda J,
Mr. Sudeep Kumar K S Assistant Professor
Department Of Mechanical Engineering, Bgs Institute Of Technology
B G Nagara, Nagamangala Taluk, Mandya District.

Abstract- Majority of braking systems work on the principle of dissipation of kinetic energy to heat energy. This method has its own drawbacks and must be replaced with a more reliable braking system that is quick in response, doesn't heat up and is maintenance free. In this project the design of an electro-magnetic braking system and optimization for various operational parameters has been done and the advantage of using the electromagnetic braking system in automobile is studied. These parameters have been previously iterated in cited projects and papers and also in the simulation models and are to be cross-checked with the experimental setup. An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. The wheel is connected to a shaft and the electromagnet braking unit is attached to one side of the wheel. Here the braking unit consists of a hollow circular steel plate and a stator which has 3 spokes made of iron wounded with copper wire (or) magnetic wire. Here the round steel plate which is attached to the wheel rotates when wheel rotates with the help of motor. when current is supplied to the stator the spokes gets magnetized and creates an magnetic field which tries to attract or oppose the motion of rotating circular plate with the help of magnetic field created. In this brakes there is no contact between the electro-magnetic coils and rotating circular plate (i.e 2 mm gap between coil and circular plate) so this is also called as contactless braking system which is a main advantage in using these brakes. These brakes can be incorporated in heavy vehicles as an auxiliary brake. The electromagnetic brakes can be used in commercial vehicles by controlling the current supplied to produce the magnetic flux. Making some improvements in the brakes it can be used in automobiles in future.

Keywords- Electromagnetic Braking System (EMBS), Contactless Braking, Magnetic Braking, Electromagnetic Force, Automobile Braking System, Auxiliary Brake, Kinetic Energy Dissipation, Heavy Vehicle Braking.

I. INTRODUCTION

Brake Definition and Background

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction. Brakes may be broadly described as using friction, pumping, or electromagnetic. One brake may use several principles: for example, a pump may pass fluid through an orifice to create friction.

Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed. For example, regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel.

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Since kinetic energy increases quadratically with velocity (KE=1/2 mv2), an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1 m/s, and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed.

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Types of braking systems

The power source which carries the pedal force applied by the driver on brake pedal to the final brake drum or brake disc in order to de accelerate or stop the vehicle the braking systems are of 6 types-

- Mechanical brakes
- Hydraulic brakes
- Air or pneumatic brakes
- Vacuum brakes
- Magnetic brakes

Automatic Braking System

Automatic Braking system (ABS) is defined as a system that constantly keeps track of the road ahead and will automatically halt the vehicle if the driver fails to take action. This technology was first introduced in 2009 to prevent car crashes or at least reduce the seriousness of the impact of an unavoidable one. An automatic braking system is an important part of safety technology for automobiles. It is an advanced system, specifically designed to either prevent possible collision, or reduce speed of the moving vehicle, prior to a collision with another vehicle, pedestrian or an obstacle of some sort. Automatic braking system. As you may have guessed by its name, ABS works autonomously, with no input from the driver. The system can also add braking force if you are pressing the brake, but weaker than a vehicle needs to avoid a collision. Every ABS system monitors vehicles and most of the time, pedestrians and other obstacles.

The goal of the ABS system is to avert or lessen serious crashes by applying the brakes when sudden dangers arise or if the driver is not taking appropriate action quickly enough. So, how does ABS perform its tasks? Many ABS systems use a combination of radar and camera technologies that are either mounted at the front of a vehicle or installed inside the windshield. Normally, these radars and cameras monitor obstacles that may lead to a crash. If they detect such a hazardous object and the system doesn't receive any feedback from the driver, it will autonomously trigger the ABS system. While most automakers provide ABS systems that are similar in function, each system can slightly differ in terms of their names, speed requirements, etc. In regards to Kia's Automatic Braking system (ABS), our system uses a radar sensor installed at the front of the vehicle that keeps an eye on the road ahead all the time.

History

It is found that electromagnetic brakes can develop a negative power which represents nearly twice the maximum power output of a typical engine, and at least three times the braking power of an exhaust b rake. (Reverdin 1994). This performance of electromagnetic brakes make them much more competitive candidate for alternative retardation equipments compared with other retarders. The electromagnetic brakes are supplementary retardation equipment, the friction brakes can be used less frequently and therefore practically never reach high temperatures.

The brake linings would last considerably longer before requiring maintenance and the potentially "brake fade" problem could be avoided. In research conducted by a truck manufacturer, it was proved that the electromagnetic brake assumed 80% of the duty which would otherwise have been demanded of the regular service brake (Reverdin 1974). Further more the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat. This is most likely to occur while a vehicle descending a long gradient at high speed. In a study with a vehicle consist of 5 axles and weighting 40 tones powered by a powered by an engine of 310 B.H.P travelling down a gradient of 6% at a steady speed between 35 and 40 M.H.P, it can be calculated that the braking power necessary to maintain this speed at the order of 450 HP. The brakes, therefore, would have to absorb 300 HP, meaning that each brake in the 5 axels must absorb 30 HP, that a friction brake can normally absorb with self destruction. The magnetic brake is wall suited to such conditions since it will independently absorb more than 300 HP (Reverdin 1974). It therefore can exceed the requirements of continuous uninterrupted braking, leaving friction brakes cool and ready for emergency braking in total safety.

The installation of an electromagnetic brake is not very difficult if there is enough space between the gearbox and the rear axle. It does not need a subsidiary cooling system. It relay on the efficiency of engine components for its use, so do exhaust and hydrokinetic brakes. The exhaust brake is an on/off device and hydrokinetic brakes have very complex control system. The electromagnetic brake control system is an electric switching system which gives it superior controllability

II. LITERATURE SURVEY

The development of Automatic Electromagnetic Braking Systems (AEBS) has gained momentum due to the increasing demand for intelligent, efficient, and safe braking technologies in modern vehicles. This literature review explores foundational and emerging research across five domains: electromagnetic braking principles, sensor integration, control algorithms, material selection, and energy recovery systems.

Electromagnetic Braking Principles

- Electromagnetic braking relies on the interaction between magnetic fields and conductive materials to generate braking force without physical contact. Foundational studies by Rajan et al: explained the Lorentz force mechanism and its application in eddy current braking systems. Their study demonstrated that the motion of a conductive disc through a magnetic field induces eddy currents, which interact with the magnetic field to generate Lorentz forces opposing the motion. This interaction produces a contactless braking torque that effectively slows the rotating component. The authors reported that eddy current brakes provide smooth operation, fast response, reduced wear, and improved reliability, making them suitable for high-speed transportation and industrial braking applications.
- Lorentz force mechanism and its application in eddy current braking. Research by Zhao et al. demonstrates how varying magnetic field strength and rotor conductivity affects braking torque and heat dissipation. These principles form the basis for non- contact, wear-free braking systems suitable for automation: investigated the effects of magnetic field strength and rotor conductivity on the performance of eddy current braking systems. Their study demonstrated that an increase in magnetic field intensity leads to higher induced eddy currents, thereby enhancing the braking torque. The authors also found that the electrical conductivity of the rotor material significantly influences the magnitude of the induced currents and the resulting braking force. Furthermore, the study analyzed heat generation and dissipation during braking, emphasizing the importance of thermal management for maintaining system efficiency and reliability. The research concluded that

optimizing magnetic field strength and rotor material properties can significantly improve braking performance, forming the basis for non-contact, wear-free braking systems suitable for automated and high-speed applications.

Sensor Integration and Obstacle Detection

- Sensor technologies are critical for automating braking decisions. Studies by Kumar and Singh explore the use of ultrasonic and infrared sensors for real-time obstacle detection. Li et al. explore: Their study demonstrated that ultrasonic sensors effectively measure the distance between a vehicle and surrounding objects by transmitting and receiving sound waves, while infrared sensors provide rapid detection of nearby obstacles through infrared radiation. The authors integrated these sensors with a control unit to enable automatic braking decisions when obstacles were detected within a predefined safety range. Experimental results showed improved response time, enhanced collision avoidance capability, and increased operational safety. The study concluded that the use of ultrasonic and infrared sensors forms a reliable foundation for intelligent and automated braking systems in automotive and industrial applications.

Control Algorithms and Automation

- Control systems govern the timing and intensity of electromagnetic braking. Classical PID controllers have been widely used, as discussed by Mehta et al.: Investigated the application of classical Proportional–Integral–Derivative (PID) controllers in electromagnetic braking systems to regulate braking timing and intensity. The study demonstrated that PID controllers continuously monitor system parameters and adjust the braking force by minimizing the error between the desired and actual braking performance. The authors reported that the controller provides stable operation, improved response time, and accurate speed regulation under varying operating conditions. Experimental and simulation results showed that PID-based control enhances braking efficiency, reduces stopping time, and improves overall system reliability. The study concluded that PID controllers are an effective and practical solution for achieving precise and automated control of electromagnetic braking systems.

However, recent advancements include fuzzy logic and neural network-based controllers that adapt to dynamic road conditions and vehicle behavior. Research by Chen et al. shows how AI-driven control improves braking precision and reduces false positives in emergency scenarios: investigated the application of artificial intelligence–based control techniques, including fuzzy logic and neural network controllers, in automated braking systems. The study demonstrated that these intelligent controllers can adapt to changing road conditions, vehicle dynamics, and environmental uncertainties more effectively than conventional control methods. By continuously analyzing sensor data and learning from operating conditions, the AI-driven system accurately adjusts braking force and timing to enhance vehicle safety. Experimental results showed improved braking precision, faster response to emergency situations, and a significant reduction in false-positive braking events. The authors concluded that fuzzy logic and neural network-based controllers offer a robust and adaptive solution for advanced automated braking systems, improving overall reliability, efficiency, and collision avoidance performance.

Regenerative Braking and Energy Recovery

- AEBS systems can be coupled with regenerative braking to convert kinetic energy into electrical energy. Research by Sharma and Bose (9) highlights the use of electromagnetic braking in hybrid and electric vehicles to improve energy efficiency: investigated the integration of Automatic Emergency Braking Systems (AEBS) with regenerative electromagnetic braking in hybrid and electric vehicles. Their study demonstrated that regenerative braking enables the conversion of vehicle kinetic energy into electrical energy during deceleration, which can be stored in batteries for later use. The authors highlighted that combining AEBS with electromagnetic braking not only enhances vehicle safety through rapid braking response but also improves overall energy efficiency by recovering energy that would otherwise be lost as heat. Experimental results indicated reduced energy consumption, extended battery life, and improved vehicle performance. The study concluded that regenerative electromagnetic braking is a promising technology for sustainable and energy-efficient transportation systems, particularly in hybrid and electric vehicles.

- Integration with battery management systems, as shown by Park et al. allows recovered energy to be stored and reused, contributing to sustainable vehicle operation.: investigated the integration of regenerative braking systems with Battery Management Systems (BMS) in electric and hybrid vehicles. The study demonstrated that the electrical energy recovered during braking can be efficiently managed, stored, and reused through an intelligent battery management system. The authors highlighted that the BMS monitors battery parameters such as voltage, current, temperature, and state of charge to ensure management system. The authors highlighted that the BMS monitors battery parameters such as voltage, current, temperature, and state of charge to ensure safe and effective energy storage. Experimental results showed improved energy utilization, enhanced battery performance, and increased driving range. The study concluded that integrating regenerative braking with battery management systems contributes significantly to sustainable vehicle operation by maximizing energy recovery, improving system efficiency, and reducing overall energy consumption.

Akshyakumar S. Puttewar, Nagnath U. Kakde, Huzaifa A. Fidvi, Bhyshan Nandeshwar – Enhancement of Braking System in Automobile using Electro- magnetic Braking

- Previous studies show that electromagnetic braking systems improve vehicle safety and braking efficiency compared to conventional brakes. Researchers developed prototype models and found that these systems reduce brake failure and maintenance requirements. The system works on electro-mechanical principles and can be used in both light and heavy vehicles. Studies also conclude that electromagnetic brakes can be implemented with minor modifications to existing vehicle systems.

Sevvel P., Nirmal Kannan V., Mars Mukesh S. – Innovative Electro-magnetic Braking System.

- Electromagnetic braking systems use magnetic force to produce braking torque and stop the vehicle. Studies show that the system works by generating a magnetic field through an energized coil. Researchers recommend its use as an auxiliary brake in heavy and commercial vehicles. Future improvements may allow its effective application in modern automobiles.

Henry A. Sudano, Jae Sung Bae – Eddy Current in Magnetic Brakes.

- Studies on eddy current magnetic braking explain that braking force is produced due to the proposed this braking system for applications such as elevators and guided rail transportation to improve safety. Experimental investigations also show that constant magnetic field braking systems are simple, effective, and easy to manufacture.

Min Jou, Jaw-Kuen Shiau, Chi-Chian Sun – Design of a Magnetic Braking System.

Research on electromagnetic braking systems shows that braking is achieved through magnetic attraction produced by an energized coil. The generated magnetic field creates braking torque, which slows down and stops the vehicle. Studies suggest that these brakes are suitable as auxiliary braking systems for heavy and commercial vehicles. Researchers also conclude that with further improvements, electromagnetic brakes can be effectively used in future automobiles.

Kapjin Lee, Kyihwan PaMax – Analysis of an Eddy-current Brake Considering Finite Radius and Induced Magnetic Flux.

- Previous studies on eddy current braking systems explain that braking torque is generated due to induced eddy currents in a rotating conductive disc. Researchers analyzed the effects of magnetic flux, boundary conditions, and magnetic Reynolds number on braking performance. The braking torque was calculated using Lorentz force law and compared with experimental results for validation. These studies confirm that electromagnetic braking provides effective and contactless braking with improved reliability.

Max Baermann (1970) – Permanent Magnet Eddy Current Brake or Clutch, US Patent 3,488,535.

- Research on permanent magnet eddy current brakes (ECB) focuses on providing smooth and effective braking for large-scale machinery under strong impact loads. Studies propose design methods to achieve required braking force within a specified displacement limit. Researchers also applied multi-objective optimization techniques to improve braking performance and smoothness under different shock conditions. Experimental verification confirms that optimized ECB designs provide reliable and efficient braking performance.

P. Hanyecz (1982) – Calculation of Braking Force in Eddy Current Brakes,

Department of Theoretical Electricity, Technical University Budapest.

- Studies on magnetic dampers and eddy current brakes analyze braking force and damping characteristics using cylindrical magnets and conductive plates of different shapes. Researchers developed analytical methods to calculate eddy currents, braking force, and damping coefficients by considering magnetic flux distribution and boundary conditions. Numerical and experimental investigations were carried out for rectangular and circular conductor plates. The results showed good agreement between theoretical analysis and experimental observations, confirming the effectiveness of eddy current braking systems.

Pushkin Kachroo (1997) – Modelling and Control of Electromagnetic Brakes, Faculty Publications, University of Nevada, Las Vegas.

Research on electromagnetic braking systems for automatic highway vehicles highlights their importance as a supplementary braking system for improved safety and faster response. Studies proposed mathematical models to analyze the relationship between angular speed and braking torque for better braking performance. Researchers also designed robust control methods to maintain wheel slip and improve vehicle stability during emergency braking. Simulation results confirmed that electromagnetic brakes provide reliable and efficient braking even under disturbances and parameter variations.

Tohuru Kuwahara (1999) – Permanent Type Eddy Current Braking System, US Patent 5,944,149.

- Studies on permanent magnet eddy current braking systems show that braking is achieved through eddy currents induced by permanent magnets in a rotating conductive disc. The induced currents create an opposing magnetic force that reduces the speed of the vehicle or machine. Researchers observed that this contactless braking system provides smooth operation with less wear and maintenance. Due to its reliability and efficiency, the system is widely recommended for heavy vehicles, elevators, and rail transportation systems.

Marc T. Thompson – Permanent Magnet Electrodynamic Brakes: Design Principles and Scaling Laws, Worcester Polytechnic.

- Research on permanent magnet electrodynamic brakes focuses on the design principles and scaling laws governing braking performance. Studies explain that braking force is generated through electromagnetic interaction between permanent magnets and conductive materials. Researchers analyzed the effects of magnet size, air gap, conductivity, and speed on braking efficiency and torque generation. The findings indicate that proper scaling and design optimization improve braking performance, reliability,energy efficiency in transportation and industrial applications.

III. PROBLEM IDENTIFICATION, OBJECTIVES & METHODOLOGY

PROBLEM IDENTIFICATION

Traditional friction based braking systems in automobiles suffer from several limitations that affect safety, efficiency, and maintenance. Key problems identified are:

1. Brake fade and wear: continuous use of friction brakes generates heat, leading to reduce braking efficiency and frequent replacement of brake pads or shoes
2. Delayed response time: Mechanical and hydraulic systems have inherent lag between driver input and brake actuation, which can be critical during emergency situations.
3. Manual dependence: Conventional systems rely entirely on driver reaction time and judgement, increasing risk of collision due to human error, fatigue, or delayed response.
4. Maintenance issues: Friction components are subject to wear, dust, and moisture, requiring regular inspection and replacement, which increases running cost.

PROBLEM STATEMENT

To design and develop an automated electromagnetic braking system that uses sensors to detect obstacles and actuates brakes using electromagnetic force, thereby reducing dependence on driver reaction, minimizing mechanical wear, improving response time, and enhancing vehicle safety. The system must address challenges of high power consumption, heat dissipation, low speed braking inefficiency, and sensor reliability while ensuring it can work as a reliable assistive braking mechanism in compliance with safety standards

OBJECTIVES

1. To design and develop an automatic electromagnetic braking system using the principle of electromagnetic induction
2. To integrate sensing and control mechanisms for automatic brake actuation without manual intervention
3. To fabricate a functional prototype incorporating electromagnets, sensor and control circuitry

Methodology

To fabricate the model it all begins with a systematic plan where the fabrication is of a seven steps of solving process. The steps are as follows:

Analysing The Research Papers:
Collect all the relevant data about the problems and the research problems which are happening around and the outcomes of them and evaluate them by comparing with the other research programs where to sort out the demerits of the conventional types of braking systems in a more effective.

Selection Of The Electromagnetic Brakes To Overcome The Problems:
Selection of the electromagnetic braking system is to minimize the problems which normally occur in the conventional type of braking system where to overcome some problems like efficiency, maintaining parameters, safety. Hence to overcome these problems the electromagnetic braking system is been selected for the further process.

Analysis Of The Electromagnetic Braking System:
To study and analyze about the system where by focusing on to the working principle and the fabrication materials and design required for the model to be done and even a study towards the functioning of the braking system according to the design planned.

Preperation Of Design:
In this step it is more concentrated on the design of part where looking on to several alternatives of designs according to the installation specifications as planned in the previous steps.

FABRICATION:
In this step the process consist of working on to the chosen design and approach into the reality. The model is then fabricated as per the specifications given and check if all the mechanisms work perfectly.

Working Principle
- If a piece of copper wire was wound, around the nail and then connected to a battery, it would create an electro magnet. The magnetic field that is generated in the wire, from the current, is known as the "right hand thumb rule".
- Whenever the current carrying conductor cuts the magnetic field, the "E.M.F" (Electromagnetic force) is induced.
- The electromagnetic braking system is based on the creation of eddy currents within a metal disc rotating between two electromagnets which set up a force opposing the rotation of the disc.
- If the electromagnet is not energized, the rotation of the disc is free and accelerates uniformly under the action of the weight to which its shaft is connected.
- When the electromagnet is energized, the rotation of the disc is retarded and the energy absorbed appears as heating of the disc.

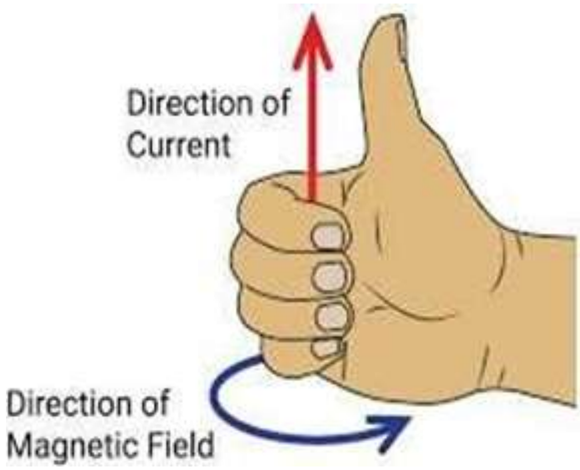

Fig 3.1 Current and Field Direction

Working Of The Model
The model works with the principle of electromagnetic field where the wheel is made to run at a speed with the help of a motor or manually, when the wheel is at a certain speed or rpm the power provided to it is released and the wheel is on the free movement it is then the brakes are applied where the two electromagnets are mounted close the disc and an air gap is maintained between the disc and the electromagnet of 0.5mm. The electromagnets gets engaged only when there is a supply of DC power to it, but before that the model has been automated with a regulator, relay and a RF channel controller.

When the regulator generates a fixed output voltage from the supply and to regulate one or more voltages, whereas the relays are the switches that opens and closes the circuit by electrically or electromechanically and they control the circuit by opening and closing contacts in another circuit. The RF channel is the device used to switching on and off of the application by means

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of a remote controller where by transmitting the signal to the relay and the operation is performed accordingly.

The automated set up is connected to the power supply where then the circuit is connected to the electromagnets so that the automation can be done easily. When the wheel is rotating at a certain revolutions for a period of time the wheel is made to retard or stop with the help of the electromagnets by the help of the electromagnetic field, where the setup is operated by controlling the RF channel remote control where the rotating wheel can be stopped by controlling the RF controller where the controller transmits the signal to the relay where the relay then activates the circuit and then it directly activates the electromagnets where the electromagnets tend to stop the wheel by applying the force to the disk and hence the wheel is made to stop in fraction of seconds and the controller is disengaged where then the automated setup disengages the electromagnets and then the wheel and the disk connected to it is left free. Thus the amount of retardation in the wheel is made to slow down or stop in an efficient way.

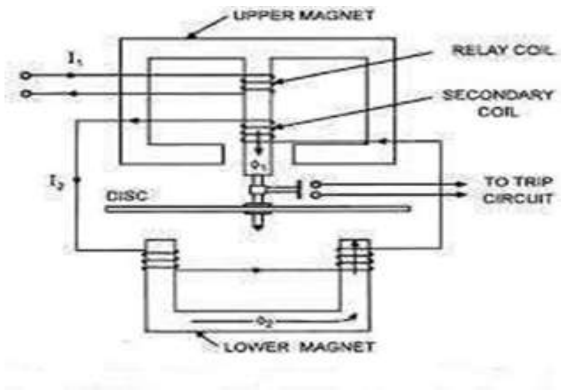

Fig 3.2 Relay Mechanism for Circuit Protection

Step-by-Step Working

Power Supply Activation

The system receives electrical power from a battery or power source.

Sensor Detection

Sensors such as:

- IR sensor
- Ultrasonic sensor
- Detect an obstacle or measure vehicle speed.
- Control Unit Processing

The microcontroller or control circuit processes the sensor signal.

If an obstacle is detected or speed exceeds the limit, the controller activates the electromagnetic brake.

Electromagnet Energizes

Current passes through the electromagnetic coil and produces a strong magnetic field.

Braking Action

The magnetic force attracts the metallic brake disc/drum and creates resistance against wheel rotation.

This reduces the speed of the wheel and stops the vehicle safely.

Automatic Release

When power supply is cut off, the magnetic field disappears and the wheel rotates freely again.

IV. COMPONENTS USED

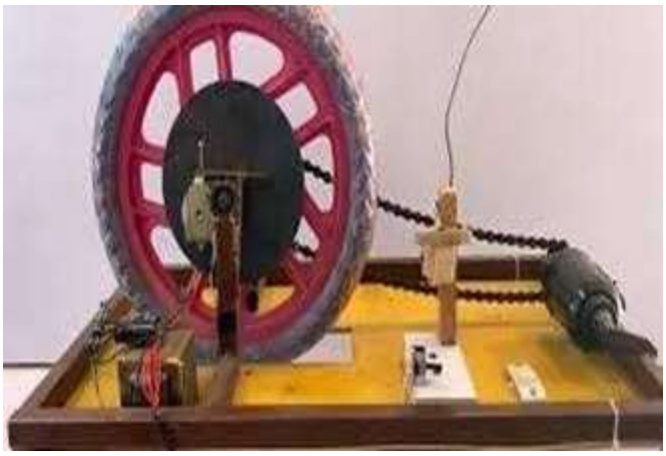

Fig 4.1 Disc Brake with Electromagnet

The electromagnetic braking system is one kind of a technological revolution where the prototype model of it shows a closer look to its design where the model consists of

- Wheel
- Disk
- Electromagnets
- Frame
- Automated circuit
- Battery

Wheel:

The wheel, with a radius of 90 cm, is a key braking component that rotates on an axle bearing to transmit motion and braking

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torque. In electromagnetic braking, its disc interacts with a magnetic field, inducing eddy currents that oppose rotation and slow the vehicle without contact.

Fig 4.2 Rubber Wheels for Light-Duty Applications

Disk:
One of the main key component in the braking system is the disk where it is attached to the wheel and transfers the retardation force to the wheel as well. The disk is the component where it receives retardation force and produces opposing torque force which is having a diameter of 26cm.

Fig 4.3 Brake Disc with Mounting Holes

Electromagnet:
Since the name itself says "Electromagnetic braking system" and the main component required is the electromagnet, whereas the EMF. rule states that the metal is completely winded and it is been enclosed so that it can be ready to use anytime. When the current is passed the coils inside are excited and the magnetic field is produced from the electromagnet. The electromagnets works in the base of induction.

Where the process induction causes electrical field to produce magnetic field thus the electromagnet uses the source of power from the electrical field into the magnetic field. The strength of the magnetic field from the magnet is a static property of the electromagnet. Hence the electromagnets work by a source of power which a magnet naturally produces.

Fig 4.4 Industrial Electromagnet

Automated circuit:
The automated circuit board is one important component in the system where it connects the mechanical components electrically to perform the action. Where the circuit consists of

- Regulator
- Relay
- RF channel
- 7805 Regulator: Regulator is a device that controls and regulates the voltage and the power supplied to the circuit where the amount of supply of voltage to the other automated relays is controlled by the regulator.

Thus the sources in a circuit may have fluctuations resulting in not providing fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. 7805 regulator is a member of 78xx series of fixed linear voltage regulators which is used to maintain such fluctuations and it is a popular voltage regulator integrated circuit.

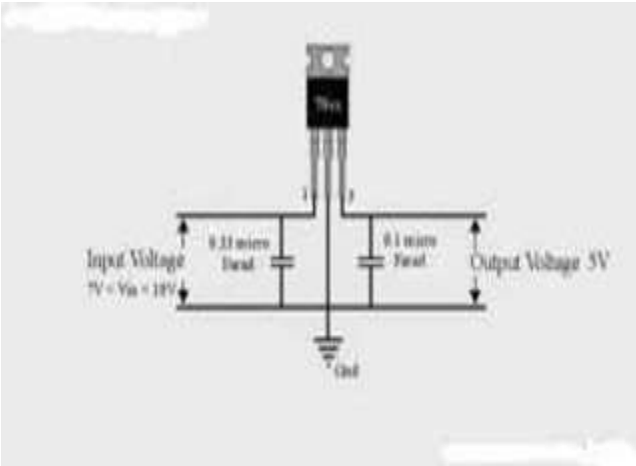

Fig 4.5 7805 Voltage Regulator Circuit

Relay:

Relays are the switches that open and close the circuit by electrically or electromechanically, they control the circuit by engaging and disengaging and even the contacts between another circuit. The Relay Contact is closed and the AC Mains circuit gets a closed path and the Bulb glows. Thus a Relay is DC operated but controls AC. The electro-mechanical relay is an output device (actuator) which comes in a different shapes, sizes and designs, and they have many uses and applications in electronic circuits. But when the electrical relays can be used for low power electronic or computer type circuits to switch relatively high currents or voltages both “ON” or “OFF” some form of relay switch circuit is required to control it.

Fig 4.6 Single-Channel Relay Module

RF channel controller:

The RF channel is a device which is used to switching ON and OFF of the system. Where the RF controller is a small electronic device used to transmit and receive radio signals between two devices. RF controllers are usually subject to regulatory uses just like the controlling the actuation.

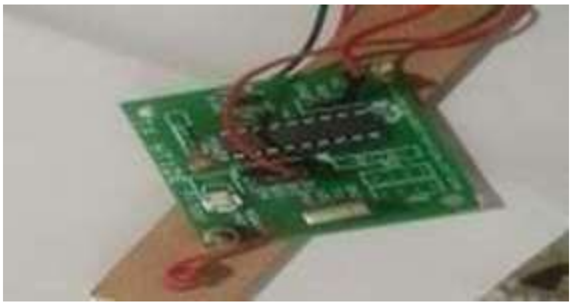

Fig 4.7 Prototype PCB with IC and Wiring

Frame:

The frame is the structural system which supports components of the physical construction such as the axel, wheel, clamps connecting the electromagnet and the automated circuit board holder. Vertical steel columns and horizontal beams, constructed in a rectangular grid that even balances the vibrations which is occurred by the movement of the wheel and even the ability to handle the stopping force of the wheel by the electromagnets.

Fig 4.8 Base frame

Battery:

Battery is a device that converts chemical energy directly to electrical energy where it is used to power up the whole system especially to the circuits. It consists of a number of voltaic cells; each voltaic cell consists of two half cells connected in series by a conductive electrolyte containing anions and cations.

Fig 4.9 Sealed Lead-Acid Battery (APC)

V. RESULT AND DISCUSSION

TESTING:

The model is tested to check if it meets all the objectives and the model is again made to test weather there has to be done any improvement or any modifications to it. After the test is done completely the model is then made to implement.

RESULT:

The output of the model is taken down and tabulated and the result is presented by calculating and submitted issued to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; pleased on alter them.

For example, the head margin in this template measures proportionately more than is customary. This measurement and other sired liberate, using specifications that anticipate our paper a some part of the entire proceedings, and not as an independent document. Pleased on revision of the current designations.

CALUCULATION

- Area of the Electromagnet = 12.4 m
- Current & Voltage supplied (I/V) = 7amp/230volts.
- Length of electromagnet (L) =90 mm.

Let the plate & wheel assembly maximum weight is to be consider approx. 2kg. which is
19.62N so that will be

$$F = \frac{B^2 A}{2\mu_o}$$

F is the force in Newton.
B is the magnetic field in teslas.
A is the area of the pole faces in square meters.
μ is the permeability of free space. In the case of free space (air)
19.62 = B2 (12.4)
2x4πx10-7
B=0.00199wb/m2

TOTAL MAGNETIC FLUX IN CORE:
Ø = B ×A
Ø = 0.00199×12.4 Ø = 0.0246 wb.

THE MAGNETIZING FORCE:
H = B/μ = 0.00199/4π×10-7
= 1583.59 AT/m.
For air

$$\mu_o = 4\pi \cdot 10^{-7}\,\mathrm{H \cdot m^{-1}}$$

$$19.62 = \frac{B^2\,(12.4)}{2x4\pi x10^{-7}}$$

B=0.00199wb/m2

TOTAL MAGNETIC FLUX IN CORE:
Ø = B ×A
Ø = 0.00199×12.4 Ø = 0.0246 wb.

THE MAGNETIZING FORCE:
H = B/μ = 0.00199/4π×10-7
= 1583.59 AT/m.
For air gap of 0.5 mm magnetic force is given by between magnet & plate.
AT = H×L = 1583.59×90×10-3
= 142.52 AT

To find the power of electromagnet which is manually constructed Assuming N = number of turns in the electromagnetic = 800

F= (NxI)2 μa / (2xg)
g = air gap between electromagnet & plate F= (8x1)2 4πx10-7 x0.00199 / (2x0.5)2

F= 16.045N for each electromagnet

If the model is driven by the motor then the calculation will be as follows Assuming, Single phase AC motor. Power = 12v/5A=60 watt. Speed= 0-8600 rpm (variable). Motor Torque

P = 2 Π N T/ 60
T = 60 x 60/ 2 Π x 8600 T = 0.066 N-m

Performance Testing
For constant speed at taking 2000 rpm r= radius of wheel
V= r ώ
V= 0.9×2πn/60
V =0.9×2π×2000/60
V= 188.4 m/s

According to newton's law of motion

V= u+at a= (v-u)/t

where the initial velocity of the wheel u=188.4 m/s and final velocity v=0 therefore a= (0-188.4)/1 = -188.4 m/s2

a=(0-188.4)/3 = -62.8 m/s2

Final Result:

Hence the deceleration of the electromagnetic braking system takes place according to the braking time.

PERFORMANCE TESTING OF THE MODEL WHEN POWERED BY A MANUAL METHOD

For constant speed at taking 200 rpm r= radius of wheel

V= r ώ

V= 0.9×2πn/60

V =0.9×2π×200/60

V = 18.8 m/s

According to newton's law of motion V= u+at

a= (v-u)/t

where the initial velocity of the wheel u=188.4 m/s and final velocity v=0 therefore a= (0-18.8)/1 = -18.8 m/s2

a=(0-18.8)/3 = -6.2 m/s2

VI. CONCLUSION

1. The Electromagnetic braking system is found to be more reliable as compared to other braking systems. In addition, it is found that electromagnetic brakes make up approximately 80% of all of the power applied brake applications.
2. Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction of the brakes. This enhanced braking system not only helps in effective braking but also helps in avoiding the accidents and reducing the frequency of accidents to a minimum.
3. Further more the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat.
4. ABS usage can be neglected by simply using a micro controlled electromagnetic disk brake system. For the brake distribution of the electromagnetic braking system, the abrasion, noise, harmful friction dust, and the risk of thermal failure in braking system were reduced obviously.
5. These electromagnetic brakes can be used in wet conditions which eliminate the anti- skidding equipment, and cost of these brake are cheaper than the other types. The concept designed by us is just a prototype and needs to be developed more.
6. It can not only be used in the field of automotive but also in the field of aeronautic. Hence the electromagnetic braking system can be a better technologies revolution in the future

VII. APPLICATIONS

1. Electromagnetic brakes were before used in the application of locomotives where the set up was a drum brake which is totally different from the present designs and works on the same principle and it is well used in the present high speed electric trains.
2. The electromagnetic braking system is not only used in automobiles it is even used in the industrial fields where to retard or slow down the moving parts which is not efficiently performed by the other conventional methods.
3. Now a days these types of braking systems are used in the field of motorsports where it is more responsive and effective and it is been used in cars like Mclaren P1, La Ferrari
4. Where the electromagnetic brakes are even used as clutches in other fields where they have a high holding power to the other components which will be easier to transfer the work.
5. The electromagnetic braking system is even used in the industrial robotic applications where the requirement of pausing the actions.
6. This type of braking system is even used in the recreational purposes where an example of the climbing devices where the rope gets locked at a particular height with the help of the electromagnetic braking inside.

Scope Of Future Application

This project includes the study of general used Electromagnetic brakes. This excludes the study of its design specification. This project considers working of all parts of Electromagnetic brakes. However we give more stress on some parts like electromagnets etc. This part is chosen because of the fact that this is the part which makes Electromagnetic brakes heavier and efficiency of these brakes depends on this part more than any part.

FUTURE APPLICATION

Fig 7.1 Intelligent traffic safety zones

Since the electromagnetic braking system is used for few applications, looking on to the future uses this method can be implemented for the safety purposes in our daily life where by applying it on to the automobiles we can reduce the amount of road accidents which sometimes takes place at several zones like school zone, traffic signals, pedestrian crossing zones etc. this can be achieved by automatizing the set up and installing a sensor to the automobile where by installing transmitting sensor to the safety zones with a particular range. When an automobile is moving at a speed of assuming 100km/hr and when it comes near the range of the safe zones the sensor form the safe zones emits and hits with the sensing element which is installed in the automobile at a desired range, when the sensing waves comes in contact the sensor gets enabled and transmits the signal to the automated circuit where then the brakes are electrically supplied and activated the automobile is gradually slowed down from a range of 100km/hr to 40km/hr and then brought to a static movement after that when it is at the safety mark.

Hence the electromagnetic braking system can be used in future for the automobile sector in concern of the safety use in day to day life

Advantages of Electro-Magnetic Braking System

- We can use these brakes to charge batteries with the help of rectifiers and regulators
- Which is common for friction-brake drums to exceed 500 °C
- Demands, and at temperatures of this order, a reduction in the coefficient of friction
- ("brake fade") suddenly occurs
- Potential hazard of tire deterioration and bursts due to friction is eliminated.
- There is no need to change brake oils regularly.
- The electromagnetic brakes have excellent heat dissipation efficiency owing to the high temperature of the surface of the disc which is being cooled.
- Due to its special mounting location and heat dissipation mechanism, electromagnetic brakes have better thermal dynamic performance than regular friction brakes.
- Burnishing is the wearing or mating of opposing surfaces .This is reduced significantly
- In the future, there may be shortage of crude oil; hence by-products such as brake oils will be in much demand. EMBs will overcome this problem.
- Electric actuation, no fluid.

Disadvantages of Electro-Magnetic Braking System

- High Battery Consumption Since the braking system relies heavily on electrical energy, continuous use drains the vehicle's battery much faster, which can compromise other electrical functions and reduce overall efficiency.
- Residual Magnetism Effect Electromagnets retain a small amount of magnetism even after power is cut off. This causes a delay in the brake shoe returning to its original position, leading to slower response times and reduced braking precision.
- Space Constraints During Installation Proper installation requires sufficient clearance between the gearbox and rear axle. In compact vehicle designs, this space is often limited, making integration difficult or impractical.
- Reduced Efficiency at Low Speeds Electromagnetic braking is most effective at higher speeds. At lower speeds, the braking force diminishes significantly, which can make stopping less reliable in certain conditions.
- Heat Generation in Coils Continuous operation produces heat in the electromagnetic coils. Excessive heating can reduce efficiency, damage insulation, and shorten the lifespan of the braking components.
- Complex Alignment and Calibration The system requires precise alignment of the electromagnet and brake shoe. Any misalignment or poor calibration can lead to uneven braking, noise, or mechanical wear.
- Higher Initial Cost Compared to conventional braking systems, electromagnetic brakes involve more advanced components and electronics, making them more expensive to manufacture and install.

- Maintenance Challenges Since the system integrates electrical and mechanical parts, maintenance is more complex. Specialized knowledge and tools are often required, increasing service costs.
- Dependence on Electrical Supply If the electrical system fails or the battery is depleted, the brakes may not function properly, posing a serious safety risk in critical situations.
- Limited Adoption in Automobiles Due to design constraints, cost, and reliability issues, electromagnetic braking has seen limited use in mainstream automobiles, restricting its widespread application in the industry

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