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Bachelor of Engineering
In Mechanical Engineering

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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 get magnetized and creates a 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. 2mm gap between coil and circular plate) so this is also called as contactless braking system which is a main advantage in using these brakes. In this 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.

HAPTER-1: 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 ($KE=1/2\ mv^2$), 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.

Almost all wheeled vehicles have a brake of some sort. Even baggage carts and shopping carts may have them for use on a moving ramp. Most fixed-wing aircraft are fitted with wheel brakes on the undercarriage. Some aircraft also feature air brakes designed to reduce their speed in flight. Notable examples include gliders and some World War II-era aircraft, primarily some fighter aircraft and many dive bombers of the era. These allow the aircraft to maintain a safe speed in a steep descent. The Saab B 17 dive bomber and Vought F4U Corsair fighter used the deployed undercarriage as an air brake.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking
then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake. When the brake pedal of a modern vehicle with hydraulic brakes is pushed against the master cylinder, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel Dow.

1.1 Types of Brakes:

➢ **On the Basis of Power Source**

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
- Electric brakes

➢ **On the Basis of Frictional Braking Contact:**

On the basis of the final friction contact made between the rotating brake components i.e. brake drum or disc rotor and the brake shoe the braking systems are of 2 types.

- Internal expanding brakes (e.g.- drum brakes)
- External contracting brakes(e.g. disc brakes)

➢ **On the Basis of Application:**

On the basis of method of applying brakes, braking systems are of 2 types-

- Foot or service brakes
- Hand or parking brakes

➢ **On the Basis of Brake Force Distribution**

- Single acting brakes
- Dual acting brakes

1.1.1 On the Basis of Power Source

Mechanical Brakes:

It is the type of braking system in which the brake force applied by the driver on the brake pedal is transferred to the final brake drum or disc rotor through the various mechanical linkages like cylindrical rods, fulcrums, springs etc. In order to de accelerate or stop the vehicle.

Mechanical brakes were used in various old automobile vehicles but they are obsolete now days due to their less effectiveness.

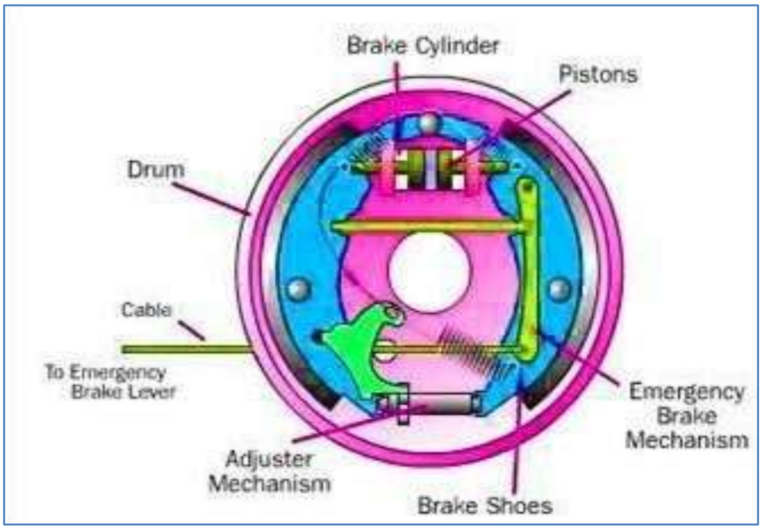


Fig 1.1 Mechanical Brakes

Hydraulic Brakes:

It is the type of braking system in which the brake force applied by the driver on brake pedal is first converted into hydraulic pressure by Master Cylinder (for reference read article on master cylinder) than this hydraulic pressure from master cylinder is transferred to the final brake drum or disc rotor through brake lines.

Instead of mechanical linkages, brake fluid is used in hydraulic brakes for the transmission of brake pedal force in order to stop or de accelerates the vehicle.

Almost all the bikes and cars on the road today are equipped with the hydraulic braking system due to it high effectiveness and high brake force generating capability.

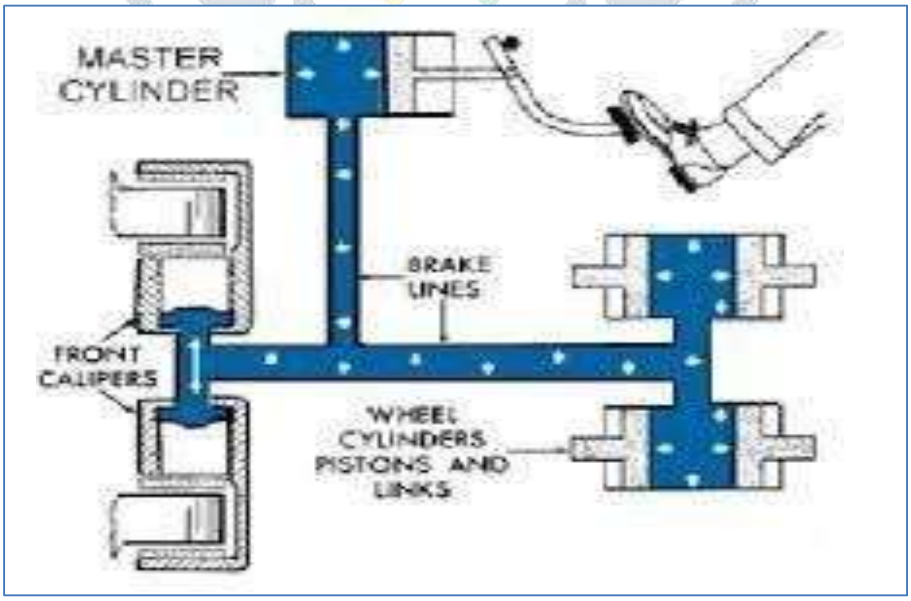


Fig 1.2 Hydraulic Brakes

Air or Pneumatic Brakes:

It is the types of braking system in which atmospheric air through compressors and valves is used to transmit brake pedal force from brake pedal to the final drum or disc rotor.

Air brakes are mainly used in heavy vehicles like busses and trucks because hydraulic brakes fail to transmit high brake force through greater distance and also pneumatic brakes generates higher brake force than hydraulic brake which is the need of the heavy vehicle.

The chances of brake failure are less in case of pneumatic brakes as they are usually equipped with a reserve air tank which comes in action when there is a brake failure due to leakage in brake lines. High end cars these days are using air brakes system due to its effectiveness and fail proof ability.

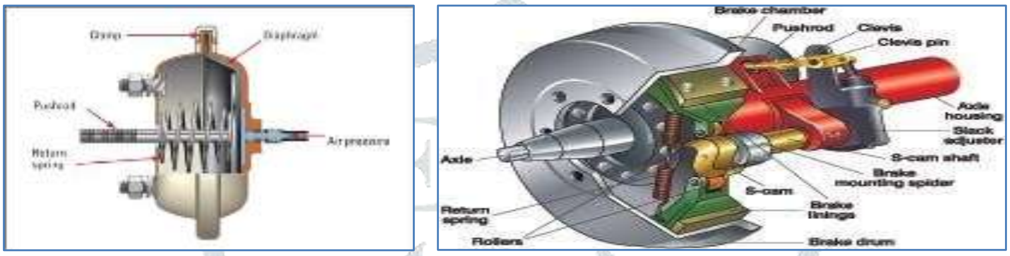


Fig 1.3 Air or Pneumatic Brakes

Vacuum brakes:

It is the conventional type of braking system in which vacuum inside the brake lines cause are brake pads to move which in turn finally stops or de accelerate the vehicle. Exhauster, main cylinder, brake lines, valves along with disc rotor or drum are the main components that combines together to make a vacuum braking system.

Vacuum brakes were used in old or conventional trains and are replaced with air brakes now days because of its less effectiveness and slow braking. Vacuum brakes are cheaper than air brakes but are less safe than air brakes.

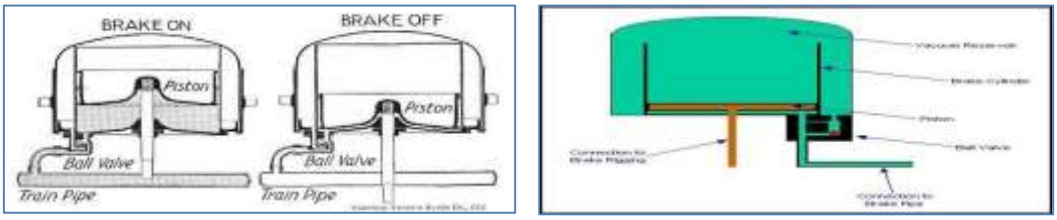


Fig 1.4 Vacuum brakes

Magnetic Brakes

In these types of braking system, the magnetic field generated by permanent magnets is used to cause the braking of the vehicle.

It works on the principle that when we pass a magnet through a cooper tube, eddy current is generated and the magnetic field generated by this eddy current provide magnetic braking. This is the friction less braking system thus there is less or no wear and tear. This is the advanced technology in which no pressure is needed to cause braking. The response to the braking in this is quite quick as compared to other braking systems.

Fig 1.5 Magnetic Brakes

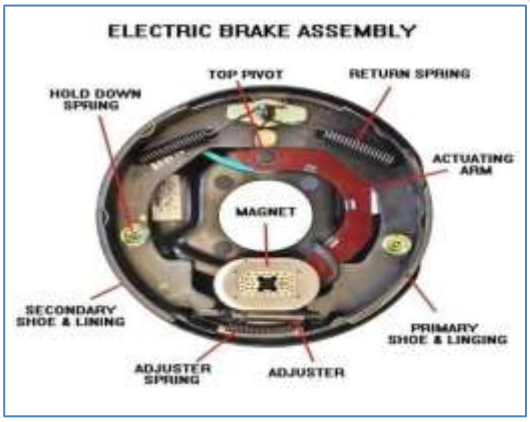
Electrical Brakes

It is type of braking used in electric vehicle in which braking is produced using the electrical motors which is the main source of power in electric vehicles, it is further divided into 3 types. **Plugging Brakes:** When the brake pedal is pressed in the electric vehicle equipped with plugging braking, the polarity of the motors changes which in turn reverses the direction of the motor and causes the braking.

Regenerative Braking: It is the type of electrical braking in which at the time of braking the motor which is the main power source of the vehicle becomes the generator i.e. when brakes are applied, the power supply to the motor cuts off due to which the mechanical energy from the wheels becomes the rotating force for the motor which in turn converts this mechanical energy into the electric energy which is further stored in the battery.

- Regenerative braking saves the energy and are widely used in today's electric vehicles.
- Tesla Model-S provides the most effective regenerative braking

Dynamic or Rheostat Braking: It is the type of electrical braking in which resistance provided by the rheostat causes the actual braking, in this type a rheostat is attached to the circuit that provides the resistance to the motor which is responsible for de acceleration or stopping of the vehicle.



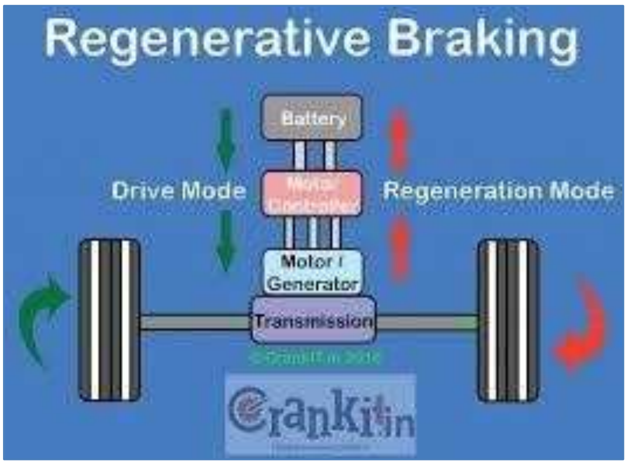


Fig 1.6 Electrical Brakes

1.1.2 On Frictional Contact Basis

Drum Brakes or Internal Expanding Brakes:

It is the type of brake system in which a drum which is the housing of the brake shoes along with actuation mechanism is attached with the wheel hub in such a fashion that the outer part of the drum rotates with the wheel and inner part remains constant.

When brakes are applied the actuating mechanism (wheel cylinder or mechanical linkage.) causes the brake shoes to expand due to which the outer frictional surface of the brake shoes makes frictional contact with the rotating drum part which in turn stops or de accelerate the vehicle.

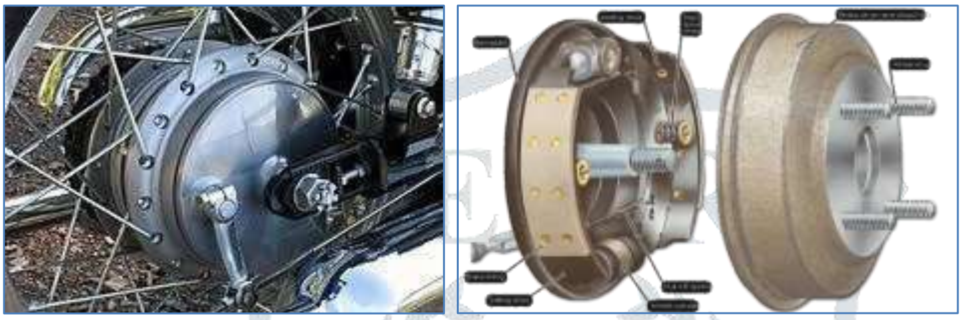


Fig 1.7 Drum Brakes

Disc Brake or External Contracting Brakes:

It is the types of braking system in which instead of a drum assembly a disc rotor attached to the hub of the wheel in such a fashion that it rotates with the wheel, this disc rotor is clamped in between the caliper which is rigidly fixed with the knuckle or upright of the vehicle.

• This caliper used is the housing of the brake shoes along with the actuation mechanism (mechanical linkages or caliper cylinder).

• When the brakes are applied the actuation mechanism contracts the attached brake shoes which in turn makes the frictional contact with the rotating disc rotor and causes the braking of the vehicle

Fig 1.8 Disc Brake

1.1.3 On Application Basis Service Brake or Foot Brakes:

It is the type of brakes in which the brakes are applied when the driver presses the brake pedal mounted inside the cockpit or at the foot space of the vehicle with his foot, this pedal force applied by the driver is further multiplied and sent to the braking drum or disc either by mechanical linkages or by hydraulic pressure which in turn causes braking. In cars foot operated brakes are used and in bikes the combination of foot and hand operated brakes are used.

Hand Brake or Parking Brake:

This type of brakes is also known as emergency brake as they are independent of the main service brake, hand brakes consist of a hand operated brake lever which is connected to the brake drum or disc rotor through the metallic cable.

- When hand brake lever is pulled, tension is created in the metallic rod which in turn actuates the brake drum or disc rotor mechanism and final braking occurs.
- Hand brakes are usually used for stable parking of the vehicle either on flat road or slope that is why it is also called parking brakes.

1.1.4 On Brake Force Distribution Basis Single Acting Brakes:

It is the type of braking in which brake force is transferred to either a pair of wheels(in cars) or to the single wheel(in bikes) through single actuation mechanism(mechanical linkages or master cylinder).

- These types of braking system are commonly used in bikes or in light purpose vehicles.

Dual Acting Brakes:

It is the type of braking in which the brake force is transferred to all the wheels of the vehicle through dual actuation mechanism (tandem master cylinder or mechanical linkages).

- This type of braking is used in cars as well as in heavy purpose vehicle.

1.2 Principle of Braking System

The principle of braking in road vehicles involves the conversion of kinetic energy into thermal energy (heat). When stepping on the brakes, the driver commands a stopping force several times as powerful as the force that puts the car in motion and dissipates the associated kinetic energy as heat. Brakes must be able to arrest the speed of a vehicle in short periods of time regardless how fast the speed is. As a result, the brakes are required to have the ability to generating high torque and absorbing energy at extremely high rates for short periods of time.

1.3 Types of Braking System

1.3.1 Electromagnetic Brake System

A rising style of brake system, electromagnetic brakes use an electric motor that is included in the automobile which help the vehicle come to a stop. These types of brakes are in most hybrid vehicles and use an electric motor to charge the batteries and regenerative brakes. On occasion, some buses will use it as a secondary retarder brake.

1.3.2 Frictional Brake System

A frictional brake system is found in many automobiles. They are service brakes, and typically found in two forms; pads and shoes. As the name implies, these brakes use friction to stop the automobile from moving. They typically include a rotating device with a stationary pad and a rotating weather surface. On most band brakes the shoe will constrict and rub against the outside of the rotating drum, alternatively on a drum brake, a rotating drum with shoes will expand and rub against the inside of the drum.

1.3.3 Hydraulic Brake System

A hydraulic brake system is composed of a master cylinder that is fed by a reservoir of hydraulic braking fluid. This is connected by an assortment of metal pipes and rubber fittings which are attached to the cylinders of the wheels. The wheels contain two opposite pistons which are located on the band or drum brakes which pressure to push the pistons apart forcing the brake pads into the cylinders, thus causing the wheel to stop moving.

1.4 Objective

1.4.1 Primary Objective

The main objective of our project is to design and fabricate an Electromagnetic Braking System model.

1.4.2 Secondary Objective

- Besides the main objective, following are our secondary objectives:
- To understand project planning and execution
- To understand the fabrication techniques in a mechanical workshop
- To understand the usage of various mechanical machine tools and also measuring tools
- To make day to day human life easier by proper use of technology.

1.5 Significance and Scope

- Electromagnetic brakes satisfy all the energy requirements of braking without the use of friction. They have better heat dissipation capability to avoid problems that friction brakes face times.
- They can also be used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles.
- These brake’s component cost is less so these brakes are cheap.
- They can be used as an alternative method for the future crisis of the crude oils.

hapter-2: Literature Survey

2.1 Fundamentals of Electromagnetic Braking

Several researchers have explored the working principles and effectiveness of electromagnetic brakes. Studies by **A. Smith et al. (2018)** emphasize that electromagnetic brakes can significantly reduce dependency on mechanical braking systems, leading to an increase in system longevity.

2.2 Application in Automotive Systems

A study by **Kumar and Patel (2020)** investigates the use of electromagnetic braking in automobiles, highlighting advantages such as minimal maintenance, quick response time, and enhanced safety. The research indicates that integrating electromagnetic brakes with conventional braking systems can improve overall braking efficiency.

2.3 Eddy Current Braking Mechanism

Jones and Lee (2017) discuss the role of eddy currents in electromagnetic braking. Their study examines how different conductor materials affect braking performance. It was found that materials with high conductivity, such as copper and aluminum, produce stronger braking forces.

2.4 High-Speed Rail Applications

Research by **Wangetal. (2019)** focuses on the implementation of electromagnetic brakes in high- speed rail systems. The study shows that electromagnetic braking provides a smoother and more controlled deceleration, reducing the wear and tear experienced by mechanical components.

2.5 Energy Regeneration Potential

Studies, such as those by **Cheetal. (2021)**, explore the potential of energy regeneration in electromagnetic braking systems. The study suggests that the energy dissipated during braking can be converted back into electrical energy, improving overall system efficiency in electric and hybrid vehicles.

Chapter-3: ELECTRO-MAGNETIC BRAKING SYSTEM

3.1 Background and History

Electromagnetic brakes (also called electro-mechanical brakes or EM brakes) slow or stop motion using electromagnetic force to apply mechanical resistance (friction). The original name was "electro-mechanical brakes" but over the years the name changed to "electromagnetic brakes", referring to their actuation method. Since becoming popular in the mid-20th century especially in trains and trams, the variety of applications and brake designs has increased dramatically, but the basic operation remains the same. Electromagnetic brakes are the brakes working on the electric power & magnetic power. They work on the principle of electromagnetism. These brakes are an excellent replacement on the convectional brakes due to their many advantages. The reason for implementing this brake in automobiles is to reduce wear in brakes as it frictionless. Electromagnetic brakes are of today’s automobiles. The working principle of this system is based on faradays first law of electromagnetic induction i.e. when a magnetic flux linking with a conductor changes an emf is induced in the coil. An additional current is supplied to the coils so that it creates an opposing torque. This results in the rotating wheel or rotor comes to rest/ neutral.

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 brake. (Reverdin 1994). This performance of electromagnetic brakes makes them much more competitive candidate for alternative retardation equipment’s compared with other retarders. By using by using 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). Furthermore, 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. Ina study with a vehicle with 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 of 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 well 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 the 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. If did not need a subsidiary cooling system. It relays 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.

3.2 Components of Electro-Magnetic Braking System

The electro-magnetic braking system consists of mainly the following parts. They are:

- Base frame
- Shaft
- Belt and Pulleys
- Dc- motor
- Braking unit
- Tire(or) wheel
- Bearings
- Adapter

3.2.1 Base Frame:

The components require support during the operation. The base frame facilitates necessary support for this purpose.

Fig 3.1 Base frame

3.2.2 Shaft

A **shaft** is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it.

One end of the shaft is connected to motor with the help of pulley and belts and the other end is connected to wheel so that it helps in transmitting motion from motor to wheel.

Types

They are mainly classified into two types.

• Transmission shafts are used to transmit power between the source and the machine absorbing power; e.g. counter shafts and line shafts.

• Machine shafts are the integral part of the machine itself; e.g. crankshaft.

Materials

• The material used for ordinary shafts is mild steel. When high strength is required, an alloy steel such as nickel, nickel-chromium or chromium-vanadium steel is used.

• Shafts are generally formed by hot rolling and finished to size by cold drawing or turning and grinding.

Standard sizes Machine shafts

• Up to 25 mm steps of 0.5 mm

Transmission shafts

• 25 mm to 60 mm with 5 mm steps

• 60 mm to 110 mm with 10 mm steps

• 110 mm to 140 mm with 15 mm steps

• 140 mm to 500 mm with 20 mm steps

• The standard lengths of the shafts are 5 m, 6 m and 7 m

Stresses

The following stresses are induced in the shafts.

• Shear stresses due to the transmission of torque (due to torsional load).

• Bending stresses (tensile or compressive) due to the forces acting upon the machine elements like gears and pulleys as well as the self-weight of the shaft.

• Stresses due to combined torsional and bending loads.

Fig 3.2 shafts

3.2.3 Belt and Pulleys

A **pulley** is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or transfer of power between the shaft and cable or belt.

A belt and pulley system is characterized by two or more pulleys in common to a belt. This allows for mechanical power, torque, and speed to be transmitted across axles. If the pulleys are of differing diameters are used different speeds can be obtained.

Fig 3.3 Belt and Pulleys

3.2.4 DC-Motor

A **DC motor** is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. 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.

DC motors were the first type widely used, since they could be powered from existing direct- current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

Power ratings are 160-24 volts, maximum current is 2.0A and the speed is 01425 rpm.

Fig 3.4 DC-Motor

3.2.5 Braking Unit

The braking unit consists of a permanent magnet and a stator which has 3 spokes made of iron having copper wires windings. The stator may consist of 2 to 18 spokes depending upon the application. The copper wires may be of different gauges. On increasing the no. of turnsof copper windings the braking effect can be increased due to passage of more current through the coils.

Fig 3.5 Braking Unit

3.2.6 Tire (or) Wheel

A **wheel** is a circular block of a hard and durable material at whose center has been bored a circular hole through which is placed an axle bearing about which the wheel rotates when a moment is applied by gravity or torque to the wheel about its axis, thereby making together one of the six simple machines.

Fig 3.6 Wheel

3.2.7 Bearings

A **bearing** is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The simplest form of bearing, the plain bearing, consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.

The purpose of Bearing is to reduce rotational friction and support radial and axial loads.

Types of bearings:

There are at least 6 common types of bearing, each of which operates on different principles:

- Plain bearing, consisting of a shaft rotating in a hole. There are several specific styles bushing, journal bearing, sleeve bearing, rifle bearing, and composite bearing.
- Rolling-element bearing, in which rolling elements placed between the turning and stationary races prevent sliding friction. There are two main types
- Ball bearing, in which the rolling elements are spherical balls
- Roller bearing, in which the rolling elements are cylindrical, taper and spherical rollers
- Jewel bearing, a plain bearing in which one of the bearing surfaces is made of an ultra-hard glassy jewel material such as sapphire to reduce friction and wear
- Fluid bearing, a noncontact bearing in which the load is supported by a gas or liquid,

• Magnetic bearing, in which the load is supported by a magnetic field

• Flexure bearing, in which the motion is supported by a load element which bends.

Fig 3.7 Types of bearings

Fig 3.8 Bearing

3.2.8 Adapter

An (electrical) **adapter** is a device that converts attributes of one electrical device or system to those of an otherwise incompatible device or system. Some modify power or signal attributes, while others merely adapt the physical form of one electrical connector to another. Power ratings are 12 volts and maximum current 10A.

Fig 3.9 Adapter

3.3 Construction of Electro-Magnetic Braking System:

The motor is placed on the bottom of the frame and the motion transmission from motor to shaft is done with the help of pulleys and belt i.e. one end of the shaft is connected to a pulley and the shaft pulley is connected is to the motor pulley with the help of belt so that when motor pulley rotates due to the power supply the shaft pulley rotates and the shaft pulley rotates and the shaft rotates which is mounted on the frame with the help of bearings. Here the other end of the shaft is connected to one side of the wheel so that when shaft rotates wheel also rotates. The braking unit consists of permanent magnet, stator which has 3 spokes of iron winded with copper wires. The permanent magnet is attached to the other side of the wheel and the stator outer frame is welded to the base frame.

3.4 Working of Electro-Magnetic Braking System

There are two methods of operations of the braking system.

Braking system with EMF generation effect:

In this type an alternator of bikes is used as a braking unit. The braking unit consists of permanent magnet and stator which has three spokes of iron material winded with copper wires or magnetic wires. The permanent magnet and stator are connected to the equipment as mentioned in the construction above.

When magnet which is attached to the wheel rotates an EMF is generated in the coils according to Faraday's Law of Electromagnetic Induction, this generated EMF can be used to charge batteries with the help of rectifier and regulator because the output EMF is in AC form. So, this process of generating EMF when wheel is freely rotating is known as EMF generating effect. In order to apply brakes a reverse current is supplied from the adaptor which should be more than the produced EMF so that the electromagnetic poles get interchanged and creates an opposing torque to the rotating wheel and tries to stop the wheel.

But in this method of operation the EMF generated is more than the reverse current which we are supplying from adaptor. So, the brakes are not making the wheel stop. To avoid this either we have to increase the adaptor specifications (current and voltage) or to stop the EMF generating effect. If we change the adaptor specifications i.e. increasing current and voltage the coils in the electromagnet gets damaged due to coils gauge and less no. of turns. So, we have done this experiment in second method of operation which is to eliminate EMF generating effect is as follows.

Braking system without EMF generation:

The construction details are same as the first method. But only difference is the magnetic replaced by circular steel plate in the braking unit. So, when electromagnet is energized by supplying current from adaptor it creates a magnetic field which attracts the rotating circular steel plate creating an opposing torque to stop the rotation of the wheel. In this there is a gap of 2mm between the steel plate and electromagnet so this is frictionless braking system which is major advantage. As the rotating circular plate does not produce any EMF, so the brakes are applied without any EMF generation.

So, we used 2nd method of operation to apply brakes in order to overcome the difficulties obtained in the first method.

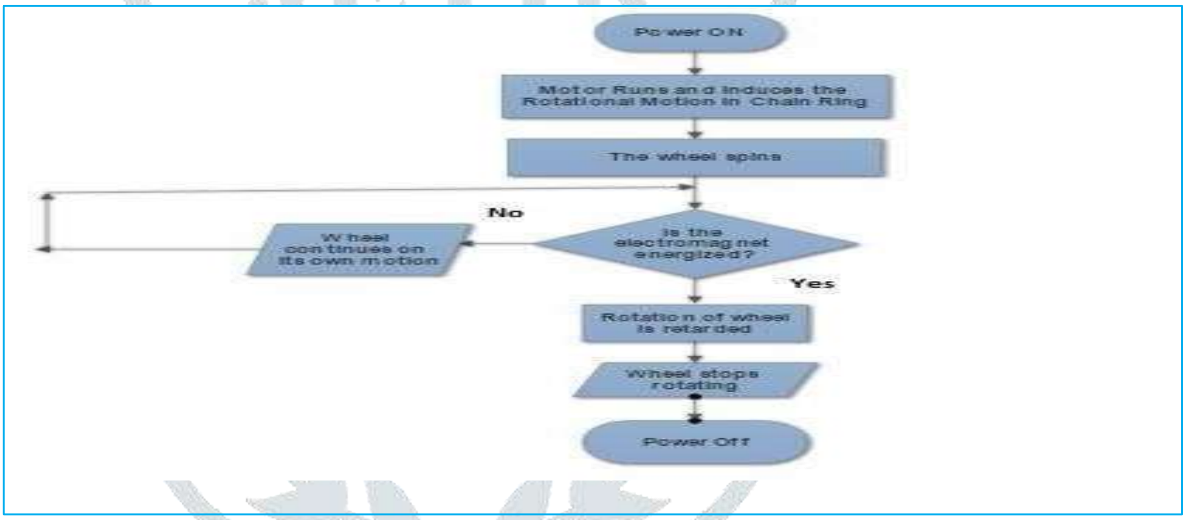


Fig 3.10 Flowchart of working

3.5 Advantages of Electro-Magnetic Braking System

• We can use these brakes to charge batteries with the help of rectifiers and regulators Problems of drum distortion at widely varying temperatures.

• Which is common for friction-brake drums to exceed 500 °C

• surface temperatures when subject to heavy braking

• demands, and at temperatures of this order, a reduction in the

• coefficient of friction ("brake fade") suddenly occurs

• 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

• 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 here. 11)

• 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.

• Electromagnetic brake systems will reduce maintenance cost.

• The problem of brake fluid vaporization and freezing is eliminated.

• Electric actuation, no fluid.

• Easy individual wheel braking control

3.6 Disadvantages of Electro-Magnetic Braking System

• Failure to act as a holding device

• Usage of electric power for braking

• Less effective under very low velocities.

• It cannot use grease or oil.

• Dependence on battery power to energize the brake system drains down the battery much faster.

• Due to residual magnetism present in electromagnets, the brake shoe takes time to come back to its original position.

• The installation of an electromagnetic brake is very difficult if there is not enough space between the gearbox and the rear axle.

3.7 Applications

• Already in use under some railway system

• Can be used for any road vehicles

• Equally applicable to heavy and light vehicles

• Can be used as additional retarder for aircrafts

• May also find application in virtually any rotating system which have metallic parts

• This brake system can be use in two-wheeler.

• Electromagnetic braking system can be used as a modern technology of braking in automobile.

Chapter-4: Calculations

The specifications of the components selected for the model are listed in the below table:

Sl. No	Parts	Specifications
1.	Base Frame	
2.	DC Motor	• Voltage:160-240 Volts • Current: 2A • HP:0.25 • Power: 180W • Maximum Speed: 1425 RPM • No. of Poles: 2 • Frequency: 50HZ
3.	Adapter	• Power Ratings: • Voltage: 12V • Current: 10A
4.	Braking Unit	• Stator having 3 poles with copper winding • No of turns in the copper winding • Diameter of circular plate
5.	Pulleys	• Motor Pulley Diameter: 3.3cm • Shaft Pulley Diameter: 10.5 cm • Center to center distance between pulleys = 37cm
6.	Shaft	• Diameter:2cm • Material: Mild Steel
7.	Bike Tire (or) Wheel	• Mass :7kg • Diameter :60.94cm
8.	Bearings	• 2cm Diameter • Plain Bearing

4.1 STANDARD CALCULATIONS

Base frame:

Dimensions are:

- Length
- Width
- Height

Dc motor:

- Used to rotate the wheel by using belt and pulley arrangement when power supply is given
- Voltage = 160-240 Volts
- Current = 2A
- HP = 0.25
- Power = 180W
- Maximum Speed = 1425 RPM

Braking Unit

- Stator having 3 poles with copper winding
- No of turns in the copper winding
- Diameter of circular plate

4.2 Design Calculations Max speed

N x D = n x d

1425 x 3.3 = n x 10.5

N = (1425 x 3.3) / 10.5 N = 457.85 RPM

Checking the center-to-center distance between pulley

$C \geq (D + d) / 2$

37 > (10.5+3.3) / 2

37cm > 6.79cm

Arc of contact between belt and pulley

$A = 180 - \frac{(D - d)}{C} \times 60^0$

$A = 180 - \frac{(10.5 - 3.3)}{37} \times 60^0$

$A = 168.32^0$

Length of the belt

$L = 2C + \pi \frac{(D + d)}{2} + \frac{(D-d)^2}{4C}$

$L = (2 \times 37) + \pi \frac{(10.5 + 3.3)}{2} + \frac{(10.5 - 3.3)^2}{4 \times 37}$

L = 74 + 21.67 + 0.3502 L = 96.02cm

Actual length

$L_a = L - (1\% \text{ of } L)$ $L_a = 96.02 - 0.96$ $L_a = 95.059$cm

4.3 Braking torque and braking time

Formula for Braking Torque

We know that

Power = Force x distance per minute --------- (1)

$Force = \frac{Torque}{Radius}$ -------- (2)

Now distance per revolution = Radius x 2 π Distance per minute = Radius x 2 π x RPM (3)

Substituting equation (2) & (3) in (1) then we get

$Power = \frac{Torque \times \cancel{Radius} \times 2 \pi \times RPM}{\cancel{Radius}}$

= Torque x 2 π x RPM

Divide both sides by 33000 to find HP in Pb then we get

$$HP = \frac{Torque \times RPM \times 2\pi}{33000}$$

$$HP = \frac{Torque \times RPM \times 6.2831}{33000}$$

$$HP = \frac{Torque \times RPM \times 1}{5252}$$

$$Torque = \frac{HP \times 5252}{RPM}$$

Formula for Braking Time in Imperial Units

T = I α

T = W x R^2 x α

T = M x R^2 x α (Since W = Mg) gand α = ω/ t

T = M x R^2 x ω

ere g is in m/ec^2

32.2 t and 1m = 3.2208 ft then 10m = 32.2 ft g in ft / sec2 is

ω = 2πN 10 m/sec^2 = 32.2 ft /sec^2 60

T = M x R^2 x 2 π x N 60 x t

$$T = \frac{M \times R^2 \times N}{308 \times t}$$

$$t = \frac{M \times R^2 \times N}{308 \times T}$$

Theoretical calculations:

1. At speed N = 150 rpm

$$T = \frac{5252 \times 0.25}{150}$$

T = 8.753 ft-pb

Here M = 7 kg

R = 0.3047 m MR^2 = 7 x 0.3047^2

= 0.6498 kg- m^2 1 kg-m^2 = 23.73 Pb Ft^2

Then 0.6498 kg-m^2 = 15.422 PbFt^2

$$t = \frac{15.422 \times 150}{308 \times 8.753}$$

t = 0.857 sec

2. At speed N = 200 rpm T = 5252 x 0.25
200

T = 6.565 ft-pb t = 15.422 x 200
308x 6.565

t = 1.52 sec

3. At speed N = 250 rpm T = 5252 x 0.25
250

T = 5.252 ft-pb t = 15.422 x 250
308x 5.252

t = 2.38sec

4. At speed N = 300 rpm T = 5252 x 0.25
300
T = 4.3767 ft-pb

t = 15.422 x 300
308 x 4.3767
t = 3.5 sec

5. At speed N = 350 rpm T = 5252 x 0.25
350

T = 3.751 ft-pb

t = 15.422 x 350
308x 3.751

t = 4.671 sec

6. At speed N = 400 rpm T = 5252 x 0.25
400

T= 3.28 ft-pb

t = 15.422 x 400
308x 3.28

t = 6.1 sec

7. At speed N = 450 rpm T = 5252 x 0.25
450
T = 2.917ft-pb

t = 15.422 x 450
308x 2.917

t = 7.772 sec Assumptions

- The wheel is considered as solid disc for calculating the moment of inertia of wheel above central axis
- Assuming the Torque produced by the brake is equal to Torque given by the motor for calculation purpose. Since the torque from the brake is difficult to calculate experimentally.

Chapter-5: Comparisons & Results

5.1 Comparisons of drum, disc and Electromagnetic brakes

Braking systems play a critical role in ensuring vehicle safety by enabling controlled deceleration and stopping. The comparison of disc brakes, drum brakes, and electromagnetic brakes highlights the advantages and limitations of each system, providing valuable insights into their suitability for various applications. The primary factors influencing braking performance include braking efficiency, heat dissipation, maintenance requirements, response time, cost, and applicability to different vehicle types. Each braking system has distinct characteristics that make it suitable for specific use cases, ranging from conventional passenger vehicles to high-performance and heavy- duty applications.

Disc brakes are widely used in modern vehicles due to their high braking efficiency, superior heat dissipation, and relatively fast response time. These brakes operate by using calipers to squeeze brake pads against a rotating disc (rotor), generating friction to slow down or stop the vehicle. One of the primary advantages of disc brakes is their ability to dissipate heat effectively, reducing the risk of brake fade during prolonged braking. This makes them ideal for high-speed applications, including sports cars and motorcycles, where rapid deceleration is necessary. Additionally, disc brakes are less prone to water retention, providing consistent performance in wet conditions. However, they tend to be more expensive than drum brakes and require regular maintenance to replace worn-out brake pads.

In contrast, drum brakes are a more traditional braking system that uses brake shoes to press against the inner surface of a rotating drum. While drum brakes are more cost-effective and offer higher braking force for the same applied pedal effort, they have significant drawbacks, particularly in terms of heat dissipation and response time. Since the braking components are enclosed within a drum, heat buildup is a common issue, leading to reduced braking efficiency over extended use. This phenomenon, known as brake fade, makes drum brakes less reliable for high-speed or performance-oriented vehicles. Additionally, the enclosed design makes it difficult for heat and moisture to escape, which can lead to corrosion and reduced braking effectiveness in wet conditions. Despite these limitations, drum brakes are still widely used in heavy-duty and budget- friendly vehicles due to their affordability and durability. They are particularly beneficial for rear- wheel braking applications, where braking force requirements are lower compared to the front wheels.

Electromagnetic brakes, on the other hand, offer a completely different approach to braking by utilizing magnetic forces instead of friction. These brakes generate a magnetic field that opposes the rotation of the braking surface, allowing for smooth and contactless braking. One of the major advantages of electromagnetic brakes is their ability to provide highly efficient braking without generating excessive heat. Since there is no direct contact between braking components, wear and tear are significantly reduced, leading to lower maintenance costs and longer service life. Electromagnetic braking systems also offer rapid response times, making them suitable for applications that require precise and immediate braking, such as high-speed rail systems, industrial machinery, and electric vehicles. However, a key limitation of electromagnetic brakes is their dependence on electrical power. In the event of a power failure, braking performance can be compromised, making them less reliable as standalone braking systems in conventional automobiles. To overcome this limitation, electromagnetic brakes are often used as auxiliary braking systems in conjunction with traditional friction brakes, enhancing overall braking efficiency and safety.

A detailed comparison of these braking systems reveals that each type has its own set of advantages and limitations. Disc brakes excel in high-speed applications due to their superior heat dissipation and consistent performance. However, they require more frequent maintenance and are costlier than drum brakes. Drum brakes, while affordable and effective in low-speed applications, suffer from issues related to heat retention and brake fade. Electromagnetic brakes provide a promising alternative by eliminating friction-related wear and tear, but their reliance on electrical power restricts their widespread use in conventional vehicles. To maximize the benefits of each braking system, hybrid braking solutions that integrate electromagnetic brakes with traditional disc or drum brakes can be developed to enhance vehicle safety and performance.

5.2 Results

The results of this study indicate that electromagnetic brakes have significant potential for future braking technologies, especially in electric and hybrid vehicles. As the automotive industry shifts toward electrification, the demand for advanced braking systems that reduce energy loss and improve efficiency will continue to grow. Electromagnetic brakes can be integrated with regenerative braking systems to recover kinetic energy and convert it into electrical energy, further enhancing fuel efficiency and sustainability. This makes them an attractive option for the next generation of automobiles, particularly in urban transportation and high-performance electric vehicles.

In the context of heavy vehicles such as buses, trucks, and trains, electromagnetic brakes offer substantial advantages as supplementary braking systems. When combined with conventional friction brakes, electromagnetic brakes help distribute braking force more effectively, reducing wear on traditional braking components and preventing brake overheating during extended downhill descents. This application is particularly beneficial in commercial and industrial vehicles, where safety and durability are paramount. The aviation industry also stands to benefit from electromagnetic braking systems, as they can provide additional stopping power for aircraft during landing, improving overall safety and reliability.

Despite their advantages, electromagnetic brakes still face several challenges that must be addressed for broader adoption. One of the primary concerns is their dependency on electrical power, which raises questions about reliability in case of battery depletion or electrical failures. To mitigate this issue, backup power sources and fail-safe mechanisms should be integrated into electromagnetic braking systems to ensure consistent performance under all conditions. Additionally, the initial cost of implementing electromagnetic braking systems remains relatively high compared to traditional braking technologies. However, as advancements in materials and power electronics continue to drive down costs, electromagnetic brakes are expected to become more affordable and widely accessible in the near future.

In conclusion, the comparison of disc, drum, and electromagnetic brakes highlights the unique strengths and weaknesses of each system. While disc and drum brakes continue to dominate the automotive industry due to their established reliability and cost-effectiveness, electromagnetic brakes present a compelling alternative for specific applications requiring high efficiency, rapid response, and minimal maintenance. As technology continues to evolve, the integration of electromagnetic braking systems with conventional braking mechanisms is likely to become more prevalent, leading to safer, more efficient, and environmentally friendly braking solutions. Future research and development efforts should focus on optimizing electromagnetic brake designs, improving energy efficiency, and expanding their application across various transportation and industrial sectors. With continued innovation, electromagnetic brakes have the potential to revolutionize braking technology and play a crucial role in the advancement of modern transportation systems.

Chapter-6: CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

Electromagnetic brakes are important supplementary retardation equipment in addition to the regular friction brakes. They have been used in heavy vehicles such as coaches, buses, trucks under conditions such as reducing speed in motorways and trunk roads and braking for prolonged periods during down slope operations. New types of electromagnetic brakes have been under development for lighter vehicles as well. Regular friction brakes have an outstanding and vital load absorbing capability if kept cool. Electromagnetic brakes help friction brakes to retain this capability under all conditions by absorbing energy at a separate location based on a totally different working principle. This report presents the performance of an electromagnetic braking system which includes various components with its cost effectiveness and efficient methodologies to utilize the supplied energy. With the application of the effective and strong electromagnet we can have greater efficient braking system. The concept designed by us is just a prototype and needs to be developed more because of the above-mentioned disadvantages. These electromagnetic brakes can be used as an auxiliary braking system along with the friction braking system to avoid overheating and brake failure. ABS usage can be neglected by simply using a micro controlled electromagnetic disk brake system. These find vast applications in heavy vehicles where high heat dissipation is required. In rail coaches it can used in combination of disc brake to bring the trains moving in high speed. When these brakes are combined it increases the life of brake and act like fully.

6.2 FUTURE SCOPE

The future scope of the Electromagnetic Braking System (EMBS) is vast, with significant advancements expected in multiple industries. In the automotive sector, the growing adoption of electric and hybrid vehicles is driving interest in EMBS due to its frictionless operation, reduced wear and tear, and improved efficiency. The integration of electromagnetic brakes with regenerative braking systems could enhance energy recovery, making vehicles more sustainable. Moreover, as autonomous vehicles become more prevalent, EMBS can provide precise and reliable braking solutions. In the railway industry, high-speed trains and metro systems can benefit from electromagnetic brakes, offering smoother operation and reduced maintenance costs. Aerospace applications may also evolve, with EMBS improving braking performance in aircraft landing systems. Additionally, industrial machinery and robotics will likely adopt EMBS for precise motion control and safety. With continuous advancements in materials, power electronics, and automation, the future of electromagnetic braking looks promising, paving the way for safer.

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