

# DESIGN AND FABRICATION OF ELECTROMAGNETIC BRAKING SYSTEM

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**Abstract :** An electromagnetic brake is a new and revolutionary concept. These are totally friction less. Electromagnetic brakes are the brakes working on the electric power & magnetic power. An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. Electromagnetic braking system is a modern technology braking system used in light motor & heavy motor vehicles. This system is a combination of electro-mechanical concepts. The frequency of accidents is now-a-days increasing due to inefficient braking system. It is apparent that the electromagnetic brake is an essential complement to the safe braking of heavy vehicles. It aims to minimize the brake failure to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this system is that it can be used on any vehicle with minor modifications to the transmission and electrical systems. An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. The disc is connected to a shaft and the electromagnet is mounted on the frame. When electricity is applied to the coil a magnetic field is developed across the armature because of the current flowing across the coil and causes armature to get attracted towards the coil. As a result, it develops a torque and eventually the vehicle comes to rest. 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.

**IndexTerms -** Component, formatting, style, styling, insert.

## I. INTRODUCTION

A brake is a device, where it restricts motion. It is commonly known that the brakes use friction to convert kinetic energy into heat. But the Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles. They work on the principle of electromagnetism. The working principle of this system is that when the magnetic flux passes through and perpendicular to the rotating wheel the eddy current flows opposite to the rotating wheel/rotor direction. By using the electromagnetic brake as supplementary retardation equipment, the frictions brakes can be used less frequently and therefore practically never reach high temperatures. In this research work, with a view to enhance to the braking system in automobile, a prototype model is created and analyzed. It aims to minimize the brake failure to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this system is that it can be used on any vehicle with minor modifications to the transmission and electrical systems. Electromagnetic brakes operate electrically, but transmit torque mechanically. This is why they used to be referred to as electro-mechanical brakes. Over the years, EM brakes became known as electromagnetic, referring to their actuation method. Since the brakes started becoming popular over sixty years ago, the variety of applications and brake designs has increased dramatically, but the basic operation remains the same



fig 1.1

The electromagnetic brakes make up exactly 80% of all of the power applied brake applications. Electromagnetic brakes have been used as retardation equipment in addition to the regular friction brakes on heavy vehicles and in some cars.

## 1.1 OBJECTIVES

- The main objective of our project is to control the speed of the vehicle as well as to stop it when and where quickly and efficiently.
- By using electromagnetic braking, we can reduce the reaction time of braking
- By automating the system we can implement it on the automobiles for the safety measures on daily basis.
- We can minimize the time of the braking and bring to 3 seconds
- These systems can be used as an additional braking system in aircrafts which provides extra safety measures.
- By this method of system we can implement it in the industries where to control the speed of some bigger moving parts in the machines where the size is huge and powerful of those components which will be hard to control by the other conventional methods.

## II. WORKING

### 2.1 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.

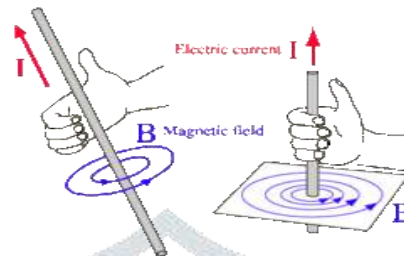


Fig 1.2

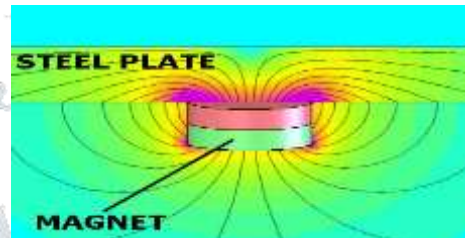


Fig 1.3

### 2.2 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 is been automated with a regulator, relay and a RF channel controller. Where 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 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 is then activates the circuit and then it directly activates the electromagnets where the electromagnets tends 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.

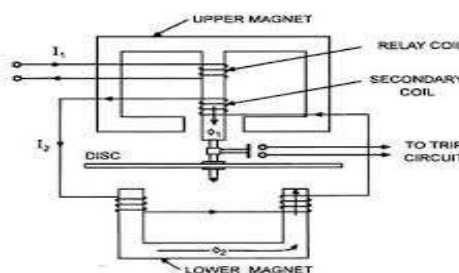


Fig 1.4

### 2.3. COMPONENTS USED

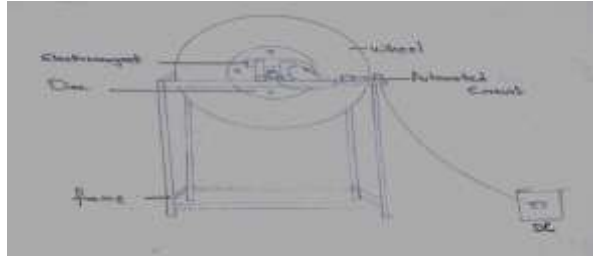


Fig 1.5

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

#### 2.3.1 Wheel:

The wheel is a circular component that rotates on an axle bearing where it is one of the key component of the braking system with a radius of 90cm.

#### 2.3.2 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.

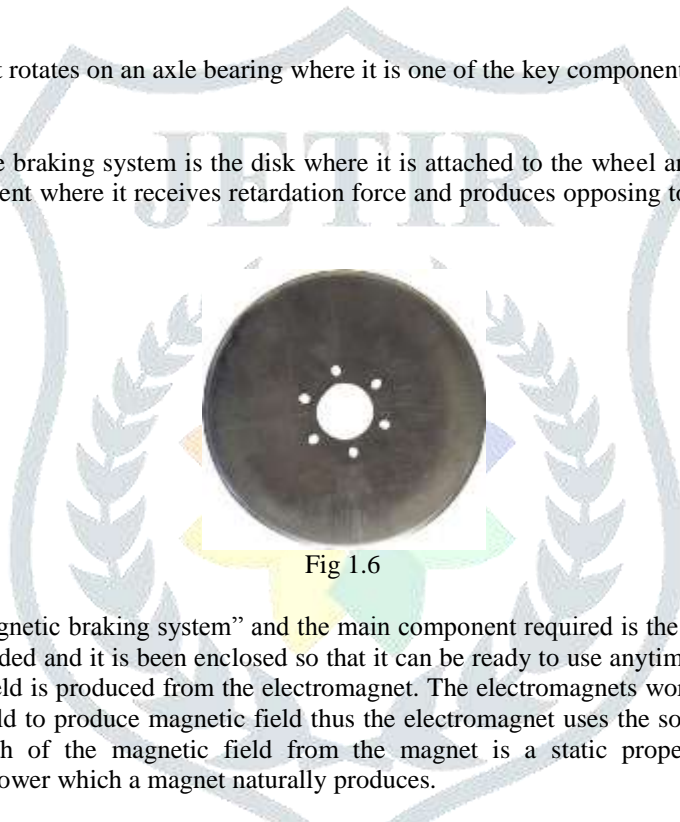


Fig 1.6

#### 2.3.3 Electromagnet:

Since the name itself says “Electromagnetic braking system” and the main component required is the electromagnet, whereas the e.m.f. rule states that the metal is completely wound 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 works by a source of power which a magnet naturally produces.



Fig 1.7

#### 2.3.4 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.

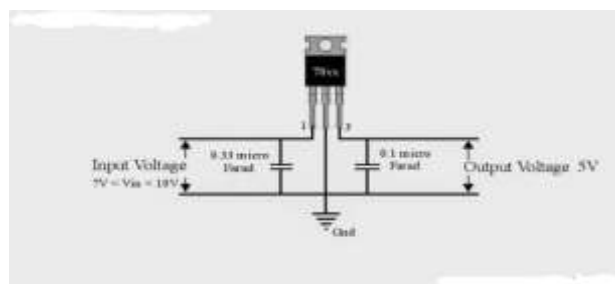


Fig 1.8

- **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 1.9

- **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 1.10

### 2.3.5 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.

### 2.3.6 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.

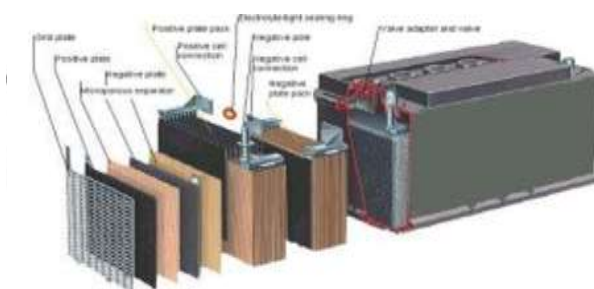


Fig 1.11



### III. 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 programs 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 to the design 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.

#### 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

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### IV. RESULT AND DISCUSSION

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

$$19.62 = \frac{B^2 (12.4)}{2 \times 4\pi \times 10^{-7}}$$

$$B = 0.00199 \text{ wb/m}^2$$

#### 4.1. TOTAL MAGNETIC FLUX IN CORE:

$$\Phi = B \times A$$

$$\Phi = 0.00199 \times 12.4$$

$$\Phi = 0.0246 \text{ wb.}$$

#### 4.2. THE MAGNETIZING FORCE:

$$H = B/\mu = 0.00199/4\pi \times 10^{-7}$$

$$= 1583.59 \text{ AT/m.}$$

For air gap of 0.5 mm magnetic force is given by between magnet & plate.

$$AT = H \times L = 1583.59 \times 90 \times 10^{-3}$$

$$= 142.52 \text{ AT}$$

To find the power of electromagnet which is manually constructed

Assuming N = number of turns in the electromagnetic = 800

$$F = (N \times I)^2 \mu_a / (2 \times g)$$

g = air gap between electromagnet & plate

$$F = (8 \times 1)^2 4\pi \times 10^{-7} \times 0.00199 / (2 \times 0.5)^2$$

$$F = 16.045 \text{ N for each electromagnet}$$

**TABLE .1 LIST OF ELECTROMAGNETS ACCORDING TO THEIR SIZE AND POWER**

NUMBER	SIZE(mm)			RATED POWER(W)	ADHESIVE FORCE(N)
4340105	25	25	100	7	600
4340110	35	40	100	9	850
4340120	35	40	150	11	1650
4342125	35	40	200	13	2300
4343135	35	40	300	19	4000
4344145	50	60	400	28	8400
4345155	35	40	500	40	6000
4346165	35	40	600	46	6600
4347175	35	40	700	54	7700

If the model is driven by the motor then the calculation will be as follows

Assuming,

Single phase AC motor.

$$\text{Power} = 12\text{V}/5\text{A} = 60 \text{ watt.}$$

$$\text{Speed} = 0-8600 \text{ rpm (variable).}$$

Motor Torque

$$P = 2 \pi N T / 60$$

$$T = 60 \times 60 / 2 \pi \times 8600$$

$$T = 0.066 \text{ N-m}$$

#### 4.4. PERFORMANCE TESTING

For constant speed at taking 2000 rpm

r= radius of wheel

$$V = r \dot{\omega}$$

$$= 0.9 \times 2\pi n / 60$$

$$= 0.9 \times 2\pi \times 2000 / 60$$

$$V = 188.4 \text{ m/s}$$

According to newton's law of motion

$$V = u + at$$

$$a = (v - u) / t$$

where the initial velocity of the wheel  $u = 188.4 \text{ m/s}$  and final velocity  $v = 0$

$$\text{therefore } a = (0 - 188.4) / 1 = -188.4 \text{ m/s}^2$$

$$a = (0 - 188.4) / 3 = -62.8 \text{ m/s}^2$$

#### RESULT:

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

#### 4.5. PERFORMANCE TESTING OF THE MODEL WHEN POWERED BY A MANUAL METHOD

For constant speed at taking 200 rpm

$r$  = radius of wheel

$$V = r \omega$$

$$= 0.9 \times 2\pi n / 60$$

$$= 0.9 \times 2\pi \times 200 / 60$$

$$V = 18.8 \text{ m/s}$$

According to Newton's law of motion

$$V = u + at$$

$$a = (v - u) / t$$

where the initial velocity of the wheel  $u = 188.4 \text{ m/s}$  and final velocity  $v = 0$

$$\text{therefore } a = (0 - 18.8) / 1 = -18.8 \text{ m/s}^2$$

$$a = (0 - 18.8) / 3 = -6.2 \text{ m/s}^2$$

#### RESULT:

Hence the deceleration of the electromagnetic braking system by using manual method takes place according to the braking time.

#### COST ESTIMATION

PARICULARS	COST (RS)
Electromagnets	2000
RF channel controller	600
Relay	300
7805 regulator	300
Disk	500
Wheel	500
Fixing clamps	200
Adaptor	400
Frame and machining of other materials	4000
Circuit board set up	200
<b>TOTAL</b>	<b>9000</b>

## V. APPLICATIONS

- 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.
- 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.
- 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
- 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.
- The electromagnetic braking system is even used in the industrial robotic applications where the requirement of pausing the actions.
- 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.

### 5.1 SCOPE

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.

#### 5.1.1 FUTURE APPLICATION



Fig 5.1.1 (a)



Fig 5.1.2(b)

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 automizing 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 from 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.

## VI CONCLUSION

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. 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. Furthermore the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat. 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. 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. It can not only be used in the field of automobiles but also in the field of aeronautics. Hence the electromagnetic braking system can be a better technological revolution in the future application

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