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Enhancement of Braking System in Automobile Using Electromagnetic Braking

Akshyakumar S.Puttewar[1], Nagnath U. Kakde[2], Huzaifa A. Fidvi[3], Bhushan Nandeshwar[4]

1Asstt. Professor, Mechanical Department, Dr.Babasaheb Ambedkar College of Engineering & Research, Wanadongri, Nagpur
2Asstt. Professor, Mechanical Department, Dr.Babasaheb Ambedkar College of Engineering & Research, Wanadongri,Nagpur
3Asstt. Professor, Mechanical Department, Anjuman College of Engineering and Technology,Sadar,Nagpur
4Asstt. Professor,Mechanical Department, Dr.Babasaheb Ambedkar College of Engineering & Research, Wanadongri,Nagpur

ABSTRACT: *An electromagnetic brake is a new and revolutionary concept. Electromagnetic braking system is a modern technology braking system used in light motor & heavy motor vehicles like car, jeep, truck, busses etc. This system is a combination of electro-mechanical concepts. The frequency of accidents is now-a-days increasing due to inefficient braking system. In this research work, with a view to enhance to the braking system in automobile, a prototype model is fabricated and analyzed. 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.*

Keywords: *Accidents, Electromagnetic braking, Eddy current braking system , Hydraulics, Energy Flow*

I. INTRODUCTION

With the technological enhancement a lot of new technologies are arriving in the world. Many industries got their faces due to the arrival of these technologies. An automobile technology is one of them. As a part of automobile, there are also innovations in brake. The commonly used types of brakes used in automobiles are drum and disc brakes[1]. Various types of braking system used are hydraulic [2] ,pneumatic etc. Magnetic braking forms the basis of growing technology [3]. Braking system is generally classified based upon the principle of operation. The two major type of brake are frictional and electromagnetic retarder [4]. 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. Ineffective braking results in a lot of accidents. Brakes must be able to arrest the speed of a vehicle in a short period 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. Brakes may be applied for a prolonged periods of time in some applications such as a heavy vehicle descending a long gradient at high speed. Brakes must have the mechanism to keep the heat absorption capability for prolonged periods of time. The frequency of accidents is now-a-days increasing due to inefficient braking system. Hence braking system needs to be enhanced for effective and efficient braking. Electromagnetic brake is as new revolutionary concept [5]. 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. These performance of electromagnetic brakes make them much more competitive candidate for alternative retardation equipments compared with other retarders.

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 BRAKING

2.1 Introduction

Electromagnetic brakes operate electrically, but transmit torque mechanically[6]. This is why they used to be referred to as electro-mechanical brakes[7]. 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. Single face 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 brakes on heavy vehicles. Various Other types of Electromagnetic Braking System are: Electromagnetic Braking System With Brake Pads, Eddy-Current Braking System[8].

2.2. Construction

There are three parts to an electromagnetic brake: field, armature, and hub (which is the input on a brake)[9]. Usually the magnetic field is bolted to the machine frame (or uses a torque arm that can handle the torque of the brake). So when the armature is attracted to the field the stopping torque is transferred into the field housing and into the machine frame decelerating the load. This can happen very fast (1-3sec).Disengagement is very simple. Once the field starts to degrade flux falls rapidly and the armature separates. A spring(s) hold the armature away from its corresponding contact surface at a predetermined air gap.

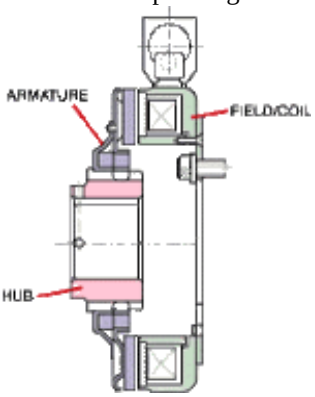

Fig.1 Electromagnetic brake

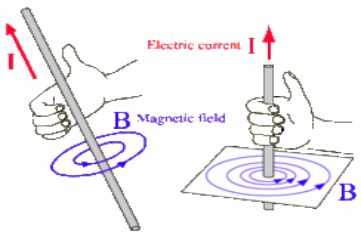

Fig.2 Voltage/Current - And the Magnetic Field

The working principle of the electromagnetic brake is based on Right hand thumb rule [10]

2.3. 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". The strength of the magnetic field can be changed by changing both wire size and the amount of wire (turns). The fields of EM brakes can be made to operate at almost any DC voltage and the torque produced by the brake will be the same as long as the correct operating voltage and current is used with the correct brake. A constant current power supply is ideal for accurate and maximum torque from a brake. If a non regulated power supply is used the magnetic flux will degrade as the resistance of the coil goes up. Basically, the hotter the coil gets the lower the torque will be produced by about an average of 8% for every 20°C. If the temperature is fairly constant, and there is a question of enough service factor in the design for minor temperature fluctuation, by slightly over sizing the brake can compensate for degradation. This will allow the use of a rectified power supply, which is far less expensive than a constant current supply.

Based on $V = I \times R$, as resistance increases available current falls. An increase in resistance, often results from rising temperature as the coil heats up, according to:

$R_f = R_i \times [1 + \alpha Cu \times (T_f - T_i)]$

Where Rf = final resistance, Ri = initial resistance, αCu = copper wire's temperature coefficient of resistance, 0.0039 °C-1, Tf = final temperature, and Ti = initial temperature.

2.4 Installation Location

Electromagnetic brakes work in a relatively cool condition and satisfy all the energy requirements of braking at high speeds, completely without the use of friction. Due to its specific installation location (transmission line of rigid vehicles), electromagnetic brakes have better heat dissipation capability to avoid problems that friction brakes face as mentioned before. Typically, electromagnetic brakes have been mounted in the transmission line of vehicles. The propeller shaft is divided and fitted with a sliding universal joint and is connected to the coupling flange on the brake. The brake is fitted into the chassis of the vehicle by means of anti-vibration mounting.

Details Of Components Used

The various components used include Disc brake plate, Disc liner, breaking coil, Tension spring, Battery, Alloy wheel & Electro-magnet. The arrangement of all these components can be best explained using the following block diagram:

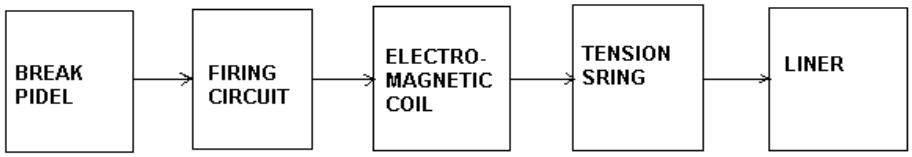

Fig. 3 Diagram of electromagnetic breaking system

1. Disc brake plate

Fig. 1 Disc brake plate

Fig. 2 Disc liner

Fig. 3 Tension spring

Disc liner

The lining is the portion of the braking system which converts the vehicle's kinetic energy into heat. The lining must be capable of surviving high temperatures without excessive wear (leading to frequent replacement) or out gassing (which causes brake fade, a decrease in the stopping power of the brake). Brake linings are composed of a relatively soft but tough and heat-resistant material with a high coefficient of dynamic friction (and ideally an identical coefficient of static friction) typically mounted to a solid metal backing using high-temperature adhesives or rivets.

Braking coil

An electromagnetic coil (or simply a "coil") is formed when a conductor (usually an insulated solid copper wire) is wound around a core or form to create an inductor or electromagnet. When electricity is passed through a coil, it generates a magnetic field. One loop of wire is usually referred to as a turn or a winding, and a coil consists of one or more turns. For use in an electronic circuit, electrical connection terminals called taps are often connected to a coil. Coils are often coated with varnish or wrapped with insulating tape to provide additional insulation and secure them in place. A completed coil assembly with one or more set of coils and taps is often called windings.

Tension Spring

A spring is an elastic object used to store mechanical energy. Depending on the design and required operating environment, any material can be used to construct a spring .When a spring is compressed or stretched, the force it exerts is proportional to its change in length. The rate or spring constant of a spring is the change in the force it exerts, divided by the change in deflection of the spring. That is, it is the gradient of the force versus deflection curve. An extension or compression spring has units of force divided by distance, for example lbf/in or N/m.

Battery

A battery is a device that converts chemical energy directly to electrical energy. 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. One half-cell includes electrolyte and the electrode to which anions (negatively charged ions) migrate, i.e., the anode or negative electrode; the other half-cell includes electrolyte and the electrode to which cations (positively charged ions) migrate, i.e., the cathode or positive electrode. In the redox reaction that powers the battery, reduction (addition of electrons) occurs to cations at the cathode, while oxidation (removal of electrons) occurs to anions at the anode.

The electrodes do not touch each other but are electrically connected by the electrolyte. Some cells use two half-cells with different electrolytes. A separator between half cells allows ions to flow, but prevents mixing

of the electrolytes. Each half cell has an electromotive force (or emf), determined by its ability to drive electric current from the interior to the exterior of the cell. The net emf of the cell is the difference between the emf of its half-cells, as first recognized by Volta. Therefore, if the electrodes have emf and, then the net emf is in other words, the net emf is the difference between the reduction potentials of the half-reactions.

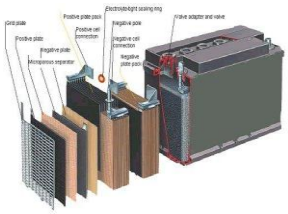

Fig. 4 Exploded view of a 12v battery

Fig. 5 Alloy wheel

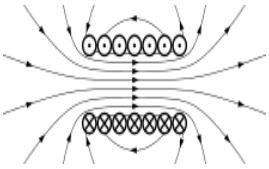

Fig. 6 Electromagnetic field

Fig. 7 Electromagnetic coil

6. Alloy wheel

Alloy wheels have become considerably more common since 2000. Alloy wheels are automobile (car, motorcycle and truck) wheels which are made from an alloy of aluminum or magnesium. They are typically lighter for the same strength and provide better heat conduction and improved cosmetic appearance over steel wheels. The earliest light alloy wheels were made of magnesium alloys. Alloy wheels have long been included as standard equipment on higher-priced luxury or sports cars, with larger-sized or "exclusive" alloy wheels being options. The high cost of alloy wheels makes them attractive to thieves; to counter this, automakers and dealers often use locking wheel nuts which require a special key to remove. Most alloy wheels are manufactured using casting, but some are forged.

7.Electro-magnet

An electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current. An electric current flowing in a wire creates a magnetic field around the wire. To concentrate the magnetic field, in an electromagnet the wire is wound into a coil with many turns of wire lying side by side. The magnetic field of all the turns of wire passes through the center of the coil, creating a strong magnetic field there. The direction of the magnetic field through a coil of wire can be found from a form of the right-hand rule. The main advantage of an electromagnet over a permanent magnet is that the magnetic field can be rapidly manipulated over a wide range by controlling the amount of electric current.

II. FABRICATION OF MODEL

In electro-magnetic braking system we use electro-magnetic property due to which action of braking will be done. In this system we used electro magnet iron plate, liners, tension spring, Disc brake plate. The brake liners are attached with electro-magnet and iron plate individually and both plates insert the disc plate as shown in figure and this plate is fixed with wheels. The battery of minimum 12 volts is used for external power supply.

In electro-magnetic braking system we use silicon control rectifier (SCR). The gate pulse of SCR is fired and the output of SCR is given to electro-magnet for braking the wheels. This SCR provides high current to our electro-magnetic braking system, electro-magnet and attracts the iron plate towards itself. This method opposes the motion of wheels. Here we have designed electro-magnetic coil and liner system.

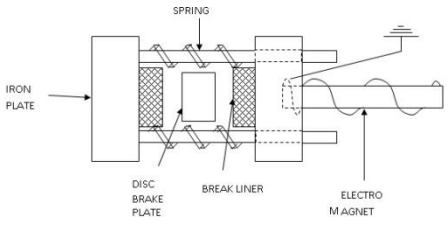

Fig. 8 Constructional diagram

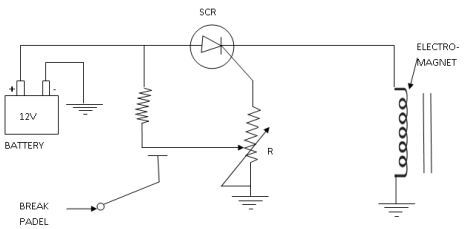

Fig. 9 Firing Circuit Diagram

Fabrication Stages

The various stages of fabrication of the prototype model is as follows:

Fabrication of frame

Attachment of wheel to frame

Coil with braking plate & chain drive along with motor is added to the frame

Finally, control circuit box with battery is assembled and connected to the limit switches.

Final assembly

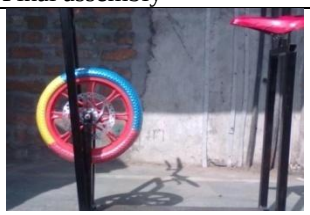

Fig. 10 Fabrication Of Frame

Fig. 11 Addition of solenoid coil & chain drive to frame

Fig. 12 Addition of control circuit box

Fig. 13 Final assembly

Cost Estimation

Sr. No.	Componetns	Nos.	Cost
1	Limit Switches	2	200
2	DC motor (12v)	1	700
3	Electromagnetic solenoid	1	3500
4	Battery (12v,7.5Ah)	1	1200
5	Control Relay	1	500
6	Firing Circuit	1	800
7	Battery Charger	1	700
8	Disc Plate	1	1200
9	Wheel	1	350
10	Free Wheel	2	200
11	Frame & Machining	1	3000
Total			12350

III. CONCLUSION

Electromagnetic braking system is found to be more reliable as compared to other braking systems. In oil braking system or air braking system even a small leakage may lead to complete failure of brakes. While in electromagnetic braking system as four disc plates, coils and firing circuits are attached individually on each wheel, even any coil fails the brake does not completely fails remaining three coil works properly. And this system needs very little of maintenance. 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 brakes on heavy vehicles. The frictions 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. 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.

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