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Design and Development of Electromagnetic Braking System

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Abstract – *The conventional braking systems works on the friction principle where the electromagnetic brakes are completely frictionless. By using electromagnetism and Eddy's current fundamentals the Electromagnetic Braking System is actuated. It uses magnetic force to carry out its purpose and the power required for breaking is transmitted manually. This system is formed by combining Electrical and Mechanical concepts. The purpose of introducing this system is to achieve efficient braking and reduce the frequency of automobile accidents as well as the maintenance of this braking system is less as compared to conventional braking systems. This dissertation concentrates on supplying electricity to the coil so the magnetic field can be developed across the armature. The current flowing across the coil results in attraction of armature towards the coil which develops the torque and the vehicle come to rest.*

Key Words: conventional braking system, electromagnetism, electromagnetic braking system, electricity, armature, coil, torque.

1. INTRODUCTION

A device for slowing or stopping a vehicle or other moving mechanism by absorption of the energy or transfer of momentum is called as brake. Electromagnetic brakes reduces the speed or stop motion using electromagnetic force to apply mechanical resistance. Initially they were called as Electro-Mechanical Brakes, but over the years the name changed to Electromagnetic Brakes, due to their method of actuation. These Electromagnetic Brakes are used as supplementary retardation equipment in addition to the regular friction brakes in heavy vehicles and machineries.

The Electromagnetic Brakes works on Electromagnetism Principles which clearly displays the source of name of these brakes. Electromagnetism is a branch of physics under which the systematic study of electromagnetic force and a type of physical interaction that occurs between electrically charged particles is done.

Electromagnetic Force is a fundamental force related to the electric and magnetic fields. The electromagnetic force is carried by the photon and is responsible for chemical reactions, atomic structure, the attractive and repulsive forces connected with electrical charge as well as magnetism, and all other electromagnetic phenomena.

When a conductor is placed in a magnetic field and current flows in the conductor, the magnetic field and the current interacts with each other to produce force and this force is called as Electromagnetic Force.

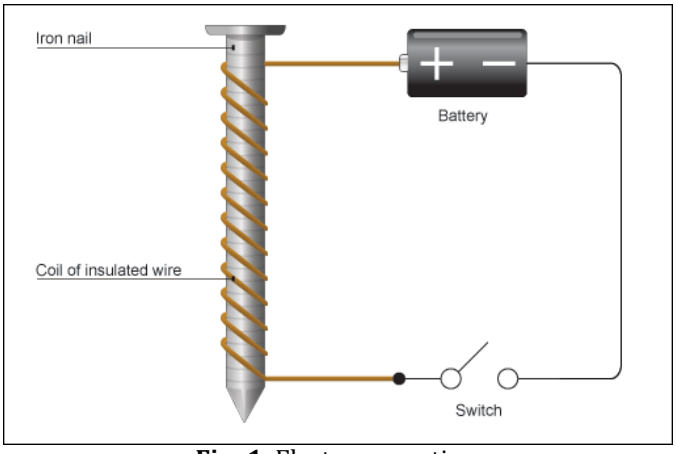

Fig -1: Electromagnetism

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. It aims to minimize the brake failure and steer clear of road accidents.

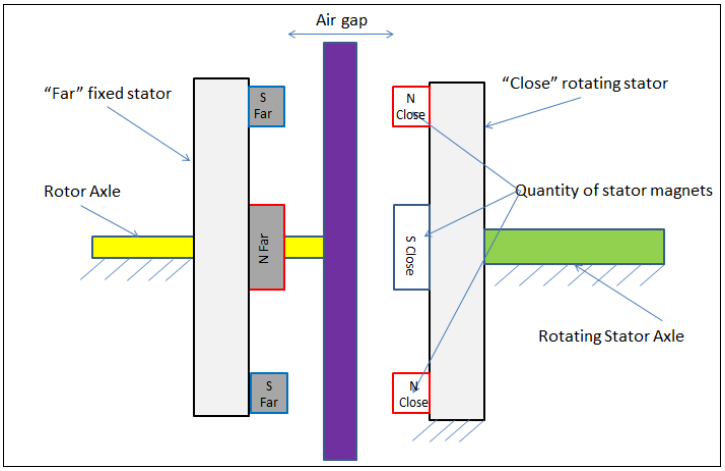

Fig -2: Eddy Current Brake Design

2. OBJECTIVE

The focus of this study is to achieve maximum possible efficiency while stopping the vehicle by controlling the vehicle speed quickly. The reaction time of braking can be reduced by using electromagnetic braking system. The Airplanes are always equipped with extra safety measures. This Electromagnetic Braking Unit can be installed in the Airplanes as add on kits in this extra safety measure units. On priority, this system can be automated and then installed on the automobiles for the safety measures. In the industries

there are number of large and heavy machineries. It is really difficult to achieve control over these heavy machineries by using conventional methods. Electromagnetic brakes can be introduced with these machineries to achieve efficient braking.

3. WORKING

When electricity flows in a long straight wire it creates a circular or cylindrical magnetic field around the wire according to the right-hand rule. If the fingers of the right hand are curled in the direction of the circular component of the current, the right thumb points to the North Pole.

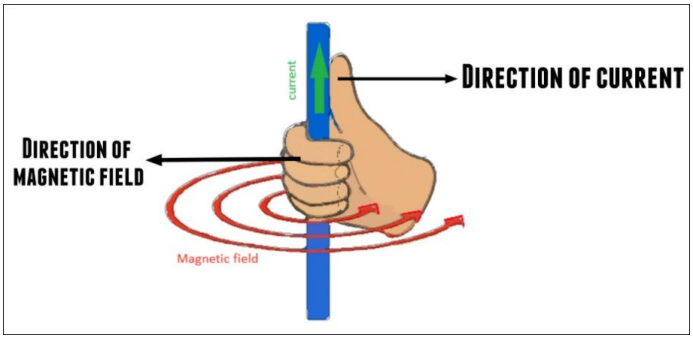

Fig -3: Right Hand Thumb Rule

If we wound a piece of copper wire around a metal conductor and connect it to the battery, it will turn that metal conductor into an Electromagnet. Whenever the current carrying conductor cuts the magnetic field, it results in generation of Electromagnetic Force.

The electromagnetic braking system is based on the creation of eddy current within a metal disc rotating between two electromagnets as shown in Fig. 2 which set up a force opposing the rotation of the disc.

The rotation of the disc is free when the electromagnet is not energized and the disc accelerates uniformly under the action of the weight to which its shaft is connected. The rotation of the disc is retarded when the electromagnet is energized and the disc gets heated as the result of absorption of energy.

The problems that occur in the conventional braking system can be eliminated by using the updated electromagnetic braking system.

4. CALCULATIONS

Area of the Electromagnet = 12.4 m

Current & Voltage supplied (I/V) = 7 amp / 230 volts

Length of electromagnet (L) =90 mm

Let the maximum weight of plate & wheel assembly to be approximately 2kg which is 19.62 N so that;

F = [(B^2)*A]/2μ

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);

μ = 4π*(10^-7)*H*m^-1

19.62 = (B^2)*(12.4)/2*4π*10^-7

B = 0.00199 wb/m sq.

Total magnetic flux in core;

Ø = B*A
= 0.00199*12.4
= 0.0246 wb

Magnetizing Force

H = B/μ
= 0.00199/4π*10^-7
= 1583.59 AT/m

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

AT = H*L
= 1583.59*90*10^-3
= 142.52

To find the power of electromagnet that is manually constructed;

Assuming;

N = Number of turns in the electromagnetic coil = 800
F = (N*I)^2μa/(2*g)
g = air gap between electromagnet & plate

F = [(8*1) ^2]*4π*10^-7*0.00199/ (2*0.5) ^2
F = 16.045 N for each electromagnet

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

For Single phase AC motor,

Power = 12v/5A = 60 watt
Speed = 0-8600 rpm (variable)
P = 2πNT/60
T = 60*60/2π*8600
= 0.066 N-m

At constant speed 2000 rpm;

r = radius of wheel
V = r ώ
= 0.9*2πn/60
= 0.9*2π*2000/60
= 188.4 m/s

According to Newton's Law of Motion;

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

Initial velocity of the wheel (u) = 188.4 m/s
Final velocity of the wheel (v) = 0 m/s
a = (0-188.4)/1 = -188.4 m/s sq
a = (0-188.4)/3 = -62.8 m/s sq

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

5. APPLICATION

1. It is really difficult to achieve immediate reduction in speed and stop the high speed electric trains by using conventional braking systems. Electromagnetic braking can be used in such cases to achieve quick and efficient braking.
2. At global level, there are numbers of car or bike race competitions. Here these vehicles have to run at higher speeds and Electromagnetic Braking is the option which can help racing drivers to achieve the control over the respected vehicles efficiently.
3. Electromagnetic braking is not limited to the vehicles only but it can be used in heavy machineries in the industries as well.
4. The Pick and Place robots, Conveyers and lifts can also be equipped with the Electromagnetic Braking Units.

6. CONCLUSIONS

From the above study, conclusions drawn are;

1. The frequency of accidents is minimized by using Electromagnetic brakes as it is used as supplementary retardation equipment in addition to regular function of braking.
2. The Electromagnetic Braking System is more reliable than the conventional braking systems.
3. The conventional brakes may create a danger situation when used beyond their capabilities to dissipate heat and this problem can be resolved by using Electromagnetic Braking System.
4. The cost of these brakes is less than the other available substitutes as well as this system can work in wet conditions as well which helps to avoid the problem of skidding.

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