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Selection of Mechanism and Fabrication of Eddy Current Braking System for High Speed Automobiles

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Abstract: All vehicles need a braking system, therefore it has been there in the automobile since its invention. However, the technology of the components and design of braking system have involved throughout the years. In the present work of eddy current brake system we are using eddy current force to retard the rotating aluminum disc. This is achieved with the help of permanent magnets which is attached to the aluminum supports on either side of the disc. These magnets are made to slide to the required position with the help of screw and nuts. This type of braking system is used as internal retards in the real time applications such as high speed trains and roller coasters. To stop the motion of the vehicle completely a regenerative braking system is used hence eddy current braking system cannot be used for passenger car vehicles.

All the components of our project are made up of aluminum because of its light weight and it is avery good conductor of electricity. A total of 25 experiments are conducted with five different distances and different speed of disc which helped us to obtain optimal distance and the speed.

Keywords: Aluminum Disc, Aluminum parts, Coupling, Motor (1/4 HP, <15000 rpm), Permanent Magnets (18 kg/mm), Roller Bearings.

1. INTRODUCTION

Most of the braking systems utilize friction forces to transform the kinetic energy of a moving body into heat that is dissipated by the braking pads. The overuse of friction-type braking systems causes the temperature of the braking pads to rise, reducing the effectiveness of the system. The relative motion between the magnet and the metal (or alloy) conductor produces an eddy current that induces a reverse magnetic field and results in deceleration. Without using friction, an eddy-current braking system transforms the kinetic energy of the moving body into heat energy that is dissipated through the eddy current in the conductor. Eddy currents are one of the most outstanding of electromagnetic induction phenomena. They appear in many technical problems and in a variety of everyday life situations. Sometimes they are undesirable because of their dissipative nature (e.g. transformer cores, metallic parts of generators and motors etc.).

In many other cases, however, eddy currents are valuable (metal detectors, coin recognition systems in vending machines, electricity meters, induction ovens, etc.).However, little attention is paid to eddy currents in many of the textbooks commonly used in introductory physics courses they are often dealt with only from a phenomenological point of view, and they are considered in some cases only as a topic for optional reading. Furthermore, most of the commercially available experimental setups concerning eddy currents treat only their qualitative aspects. This paper presents a set of laboratory experiments intended to help students better understand the phenomenon from a quantitative point of view. The experiments may be helpful to physics and electromagnetism students in first-year undergraduate courses.

2. LITTERATURE SURVEY

In this paper[1] the author is trying to introduce a simple and low-cost experimental setup that can be used to study the eddy current brake, which considers the motion of a sliding magnet on an inclined conducting plane in terms of basic physical principles. We present a set of quantitative experiments performed to study the influence of the geometrical and electromagnetic properties of the magnet on the magnetic drag force. This video-based experiment is ideal for the study of kinematic graphs and the application of Newton's laws. Video motion analysis software enables student's to make precise measurements of the magnet's position at incremental times during its motion, thus allowing them to quantify electromagnetic induction phenomena.

In this paper [2] the author is investigating and suggesting the best material and system for Eddy current braking. It is found that Aluminium is the best material as conductor compared to Copper and Zinc. It is found that a brake built up from permanent magnet pieces that combine both magnetic rail brake and eddy current brake permits the most profitable braking action through the whole range of acceptable speeds. Permanent magnet eddy current brake uses Neodymium - Iron - Boron (NdFeB) magnets. The analysis of permanent magnet eddy current shows that the parallel magnetized eddy current topology has the superior braking torque capability. In electrically controlled eddy current braking system subjected to time varying fields in different wave forms, the triangular wave field application resulted in highest braking torque. Electromagnetic brakes were found to interfere with the signaling and train control system. Permanent magnet eddy current brakes are a simple and reliable alternative to mechanical or electromagnetic brakes in transportation applications. Greater the speed greater is the eddy current

In this paper [3]the author simulates and checks the efficiency ofEddy Current braking technique. Eddy Current braking technique is a classical example of how effective and efficient braking be obtained from application of magnetic field. Eddy current braking is based on the principle of relative motion between a magnetic source and a metal. In this paper, eddy current braking system is modeled in SIMULINK and effects of various parameters are observed over the overall braking. This would provide a comparative study between the various parameters involved and understand the braking system.

In this paper [4] the author presents design of eddy current brakes. Eddy current brakes provide non-contact means to produce braking forces required to decelerate the motion of a moving object. In this study, four systematic engineering design scenarios to design a braking system are presented: a constant magnetic field, an optimal magnetic field distribution, piecewise-constant magnetic fields and a section-wise guide rail with a constant magnetic field. Although the simulation results show that the optimal magnetic field is better than the constant magnetic field, a deceler. Further, the sudden increase in current could cause wire overload. The piecewise constant magnetic field has the advantages of a preset terminal speed and predictable wire current but it produces a higher speed. Alternatively, it is much easier to keep the magnetic field constant and select the proper conductor materials. The advantages of these last two designs using different materials along the guide rail are tolerable deceleration; and easy manufacturing. A nearly maintenance-free system can be achieved if permanent magnet is utilized to establish the magnetic field.

In this paper [5] the author discusses how the eddy current braking system can be implemented in automobiles. The eddy-current principle states that a no stationary magnetic field induces swirl like electric currents in a conductive body subjected to its influence. Theseeddy-currents occur either when a moving conductive body crosses a magnetic field or by imposing a varying magnetic field upon a stationary conductor. The eddy-currents generate a magnetic field whose flux is opposite to the applied one, in an attempt to reduce the net magnetic flux to zero. This magnetic interaction generates the force necessary to cause a deceleration of the conductor body. This idea can then be implemented in a car braking system.

In this paper[6]the author and his team designed and analyzed an Eddy current braking system that will create a differential torque for the activation of a Honeywell Aerospace Generator Disconnect. They have also analyzed how eddy current braking system can be used effectively.This document will state the problem with the current Honeywell disconnect system and how we have taken the voice of the customer into consideration in coming up with a Final Design that will analytically produce the necessary torque for disconnect activation, thereby fulfilling the requirements set by Honeywell Corporation. Upon establishing a Final Design we will explain how the design works and why this particular design is ideal for application for disconnect activation.

3. APPLICATIONS FOR EDDY CURRENT BRAKING SYSTEM

In mountain areas where continuous braking force is needed, for a long time, the eddy current braking is very much useful for working without overheating. It can also be used to slow down the trolleys of faster roller coasters.Eddy current brakes are very much useful for high-speed passengers and good vehicles. It is used as a stopping mechanism in trains. Ex- Japanese Shinkansen trains

4. SCOPE OF THE WORK

From the detailed literature survey it can be seen that use of eddy current breaking system is a current state of the art used for braking. In this study we study we have fabricated a test rig for ECBS, where we have mounted an aluminum disc on a mild steel shaft. The shaft is made to run with bearings mounted on either side permanent magnets(18kg/mm) are mounted on both side of the disc.For the braking action to take place the magnets have to be brought close to the disc when the magnets are brought closer, because of the eddy current forces it reduces the speed of the disc.

In the present work we test the braking effects at various speeds of the disc and check the speed deduction for the various distances of the magnets from the rotating disc. The details are reported in this work.

5. ECBS FABRICATION MODEL

PARTS REQIRED:

- Shaft (MS),
- Roller Bearings,
- Base Plate(Al),
- Motor,
- Permanent Magnets
- T-Bolts & Supports Blocks
- Bearing Supports(Al),
- Disc(Al),
- Fastener

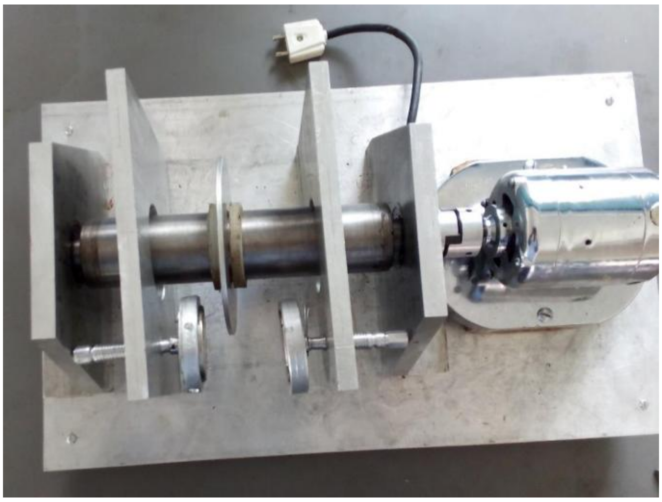

Figure 4.1: Eddy Current Braking System(ECBS) Fabrication Model

i) Mild steel shaft:

Shaft is made of mild steel of length 250mm with 50mm diameter and mild steel is used in 85% of all steel products. The calculated average industry grade mild steel density is 7861.093kg/ m3.Its young's modules, a measure of its stiffness is around 210,000MPa.

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Figure 4.1: Mild Steel Shaft (hollow)

ii) Motor

Capacity of the motor is 1/8 HP and it is used to run the shaft with speed of 15000 RPM .Motor works on the principle of Flemings left hand rule. An electric motor is an electrical machine that converts electrical energy into mechanical energy.

iii) **Aluminum disc:**

Figure 4.2: Aluminum disc

iv) T-Bolts & Support Blocks

It is used for tightening and fitting of magnets in either side of bearing supports. T-bolt is used to threading purpose and threaded part is inserted into the magnetic support blocks and it is used for moving magnets close to the aluminum disc.

Figure 4.3: Support Bearings

v) Permanent Magnets:

The capacity of permanent magnet is around 18 kg/mm, permanent magnets with the diameter of 50mm and size of 10mm. A magnet is an object made from a material that is a magnetized and creates its own magnetic field; this magnetic fieldis invisible but responsible for the mostnotable property of a magnet,forces that pulls on other ferromagnetic material, such as iron and attract or repels other magnets. Permanent magnets are used for reducing speed of the aluminum disc

Figure 4.4: Permanent Magnets

vi) Base Plate

Base plate is made of aluminum, because of its low cost, light weight. Base plate is made with dimensions 550x310x68mm.It is support for whole setup and it is fixed with wooden block. It is with stand with any load conditions and the setup is fixed with T-bolts and hexagonal and square nuts with in base plate only and it is rigid structure. As shown in Figure 4.5.

vii) Fastener:

A fastener is a hardware device that mechanically joins or affixes two or more objects together. Fasteners can also be used to close containers such as a bag, a box, or an envelope or they may involve keeping together the sides of an opening of flexible material, attaching lid to a container, etc.

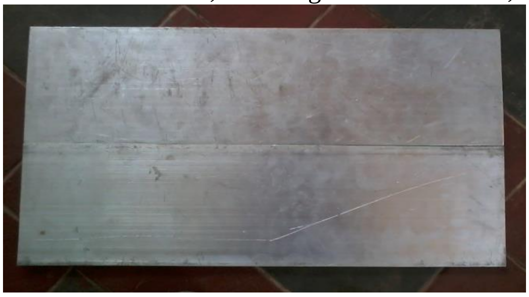

Figure 4.5: Base Plate

viii) Coupling:

Coupling is made of aluminum and it is used for transmission of torque from motor to shaft with the speed of 14000 rpm and it is cylindrical in shape and it is with stand with any running speeds.

Figure 4.6: Coupling

6. Experimental Procedure

Once set up is ready, we have conducted a total 25 experiments at different distances and different speeds of the disc. At first the motor was made to run at 1000 rpm with the distance between the magnets being varied from 1mm to 5mm.Percentage retardation in speed for the above variation was recorded. Now the motor is made to run at 2000, 3000,4000and 5000 rpm and above procedure is repeated.

The experimental results along with the graphs are shown in the below.

TABLE5.1: SPEEDFOR 1000RPM

Sl.No	Distance(mm)	Reduction in Speed(rpm)	% Reductioninspeed
1	1	250	75
2	2	330	67
3	3	450	55
4	4	495	50.5
5	5	505	49.5

From the Table 5.1 it can be seen that percentage reduction of 75% is obtained for the disc rotation of 1000 rpm at a gap of 1mm between magnets and disc. As the gap between these two is increased it is observed that percentage reduction is reduce to 49.5%.

TABLE5.2: SPEEDFOR 2000RPM

Sl.No	Distance(mm)	Reduction in Speed(rpm)	% Reductioninspeed
1	1	400	80
2	2	495	75.25
3	3	500	75
4	4	800	60
5	5	904	54.8

From the Table 5.2 it can be seen that percentage reduction of 80% is obtained for the disc rotation of 2000 rpm at a gap of 1mm between magnets and disc. As the gap between these two is increased it is observed that percentage reduction is reduce to 54.8%.

TABLE5.3: SPEEDFOR 3000RPM

Sl.No	Distance(mm)	Reduction in Speed(rpm)	% Reductioninspeed
1	1	725	75.8
2	2	940	68.6
3	3	985	67.16
4	4	1295	56.8
5	5	1564	47.8

From the Table 5.3 it can be seen that percentage reduction of 75.8% is obtained for the disc rotation of 3000 rpm at a gap of 1mm between magnets and disc. As the gap between these two is increased it is observed that percentage reduction is reduce to 47.8%.

TABLE5.4: SPEEDFOR 4000RPM

Sl.No	Distance(mm)	Reduction in Speed(rpm)	% Reductioninspeed
1	1	750	81.25
2	2	986	75.35
3	3	1072	73.2
4	4	1222	69.45
5	5	1456	63.6

From the Table 5.4 it can be seen that percentage reduction of 81.25% is obtained for the disc rotation of 4000 rpm at a gap of 1mm between magnets and disc. As the gap between these two is increased it is observed that percentage reduction is to 63.6%.

TABLE5.5: SPEEDFOR 5000RPM

Sl.No	Distance(mm)	Reduction in Speed(rpm)	% Reductioninspeed
1	1	1035	79.3
2	2	1350	73
3	3	1375	72.5
4	4	2019	59.62
5	5	2521	49.58

From the Table 5.5 it can be seen that percentage reduction of 79.3% is obtained for the disc rotation of 5000 rpm at a gap of 1mm between magnets and disc. As the gap between these two is increased it is observed that percentage reduction is reduce to 49.58%.

7. RESULTS & DISCUSSION

A total 25 experiments were conducted with 5 different distances and 5 different speeds of the disc. It is seen from our study; at 4000 rpm a percentage reduction of 81.25% is achieved. Also the percentage speed reduction reduces with increase in gap between magnet and disc. This observation can be effectively used in current city plying vehicles as it is not always required to bring the vehicles to a complete stop.

8. CONCLUSION & FUTURE SCOPE

From the study it was observed that a higher percentage reduction in speed is achieved with increase in speed of the disc. This is in accordance with the principle of eddy current. According to this law the permanent magnet induces the line of magnetic flux of a nonferrous conducting object(aluminum) is moved in a perpendicular to the lines of magnetic flux, then the current induced is proportional to the velocity of the object assuming that the magnetic flux and the dimensions of the body remain constant

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From this work we arrived at the conclusion that with increasing velocity (speed) the amount of braking force developed also increases which is in accordance with the principle of eddy current. Hence this type of braking is suitable for high speed transportations.

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