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Experimental Investigations to Study the Influence of Thickness and Speed of Aluminum Discs on Brake Parameters with Neodymium – Iron – Boron Magnets

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Abstract

In the existing friction brakes there are several problems such as squealing, judder, thermal and mechanical failures, disc distortions etc. Hence, in the current work an effort is made to develop contactless braking system using eddy current principles. Aluminum disc along with Neodymium – Iron – Boron (NdFeB) permanent magnets are used for investigations. Thickness of discs considered are 4, 6 and 8 mm. Speeds of disc rotation are equivalent of 75.39 Km/hr, 113 Km/hr, 150.8 Km/hr and 188.5 Km/hr. Considered brake parameters are percentage of reduction in speed, negative acceleration and time consumed. In lone magnet situation with gradual application, higher percentage of reduction in speed, good negative acceleration and less time consumed were observed in 4 mm disc thickness. Hence is suitable for faster train applications. In lone magnet with rapid application situation, superior negative acceleration and lesser time consumed were found in 4 mm disc thickness. This situation is beneficial for high speed automobile applications.

Keywords: *Eddy current; Permanent magnets; NdFeB magnets; Aluminum; percentage of reduction in speed; Negative acceleration; time consumed*

1.0 Introduction

A vehicle in motion develops kinetic energy given by ½ mV2. Currently friction brakes are used for bringing the vehicle to rest. Many problems exist in existing friction brakes such as squealing sound, crack propagation due to temperature and failure of parts due to heat, recovery property after fading of friction material, brake judder, brake grabbing, disc distortion etc.

Contact less brakes that works on eddy current law could be an option because of innumerable problems of friction brakes.

2.0 Literature Survey

Once the eddy current brake is switched on [1] the brakes that works with electromagnets has a potential to obstruct with signals and control systems of train and damage the systems. Electromagnetic braking is quite expensive as well.

Elevated braking torque is generated if lesser is the air gap, larger the electromagnetic turns, higher electrical conductivity and thicker the disc thickness [2].

The Piecewise constant magnetic fields and section wise guide rail with a constant magnetic field have passable negative acceleration [3].

In this work, to eliminate the problem of inadequate braking torque production at lesser speeds, [4] investigations were carried out with alternating current magnetic fields. These fields have preset and changeable frequencies in diverse wave forms at lower and higher speeds.

A size replica fixture to test diverse passive brakes using Neodymium – Iron – Boron (NdFeB) magnets was used [5]. It is found that the main material price is for the permanent magnet.

Based on the literature survey, it is observed that a braking system using permanent magnets would eliminate the problems faced by friction brakes and electromagnetic brakes with electromagnets.

In the present work, influence of various parameters of NdFeB magnets on brakes is investigated.

The conducting material chosen is Aluminum since it is a good conductor and has good permeability that are necessary properties for a brake which works on eddy current principle.

3.0 Methodology

The investigations are carried out on a special purpose test fixture (Fig.1). The base is made of Aluminum on which a DC motor is mounted. Stainless steel shaft is attached to motor where discs are attached. The diameter of the discs is 200 mm. The speeds at which experiments were conducted are 2000 rpm, 3000 rpm, 4000 rpm and 5000 rpm to simulate speeds of 75 km/hr, 113 km/hr, 150.8 km/hr and 188.5 km/hr respectively.

Investigations were done with two changed locations of magnets like lone magnet with gradual application and lone magnet with rapid application situations [6]. The experimental set up is as shown in Figure 1.

The magnets made of NdFeB material that has thickness of 12.5 mm and diameter of 50 mm is selected for experiments. The measurables of experimentation are speed of disc, flux density of magnet used, distance of

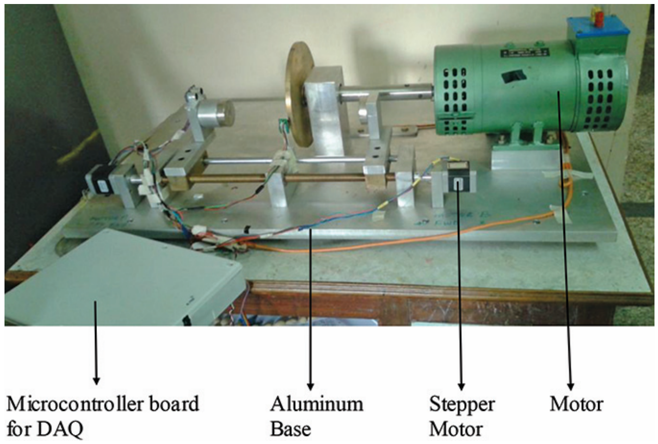

Figure 1. Developed test equipment

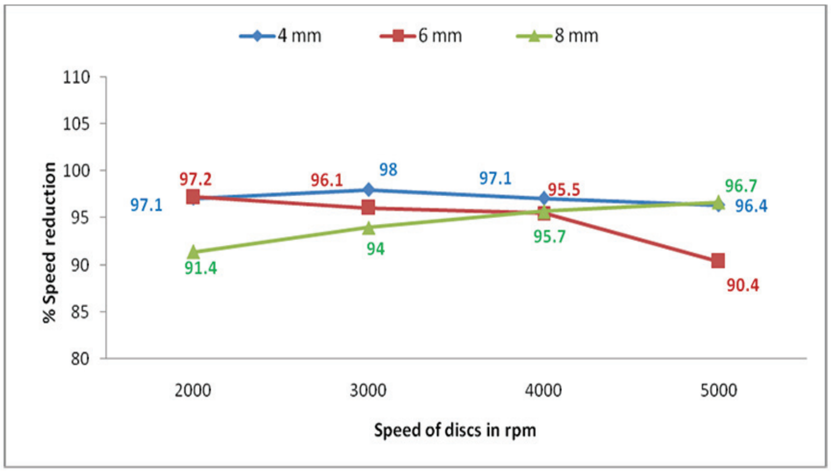

Figure 2.Comparison of percentage reduction in speed in discs of Aluminum in lone magnet in gradual application situation

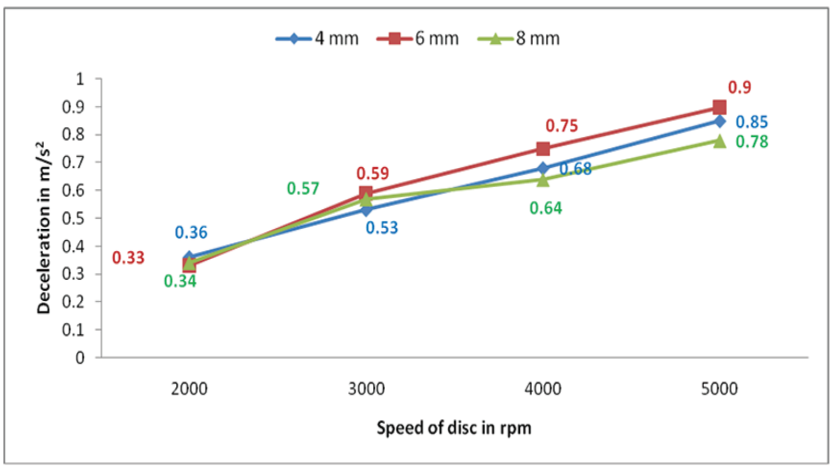

Figure 3.Comparison of negative acceleration in discs of Aluminum in lone magnet in gradual application situation

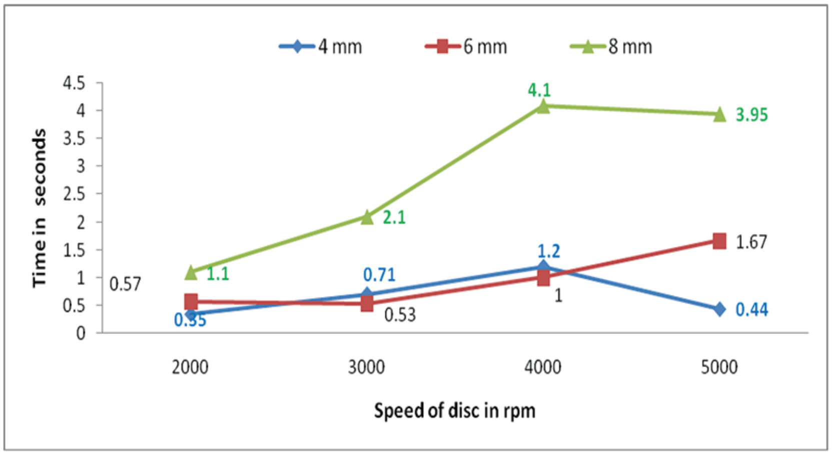

Figure 4.Comparison of time consume d in discs of Aluminum in lone magnet in gradual application situation

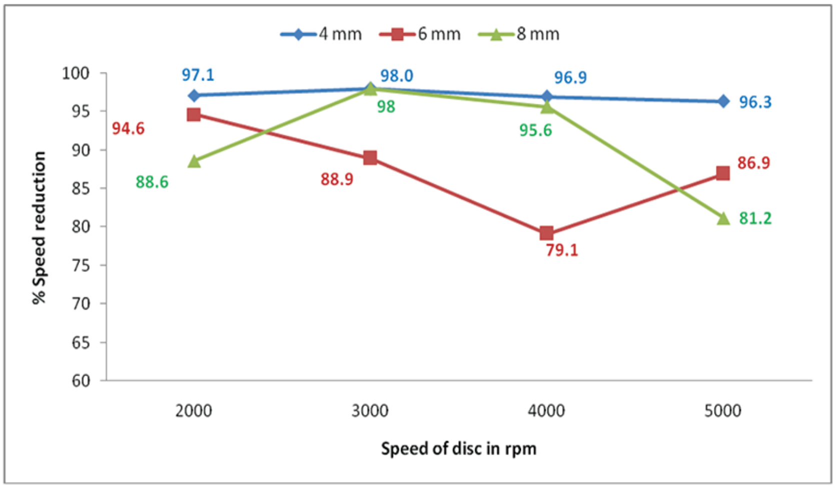

Figure 5.Comparison of percentage reduction in speed in discs of Aluminum in lone magnet in rapid application situation

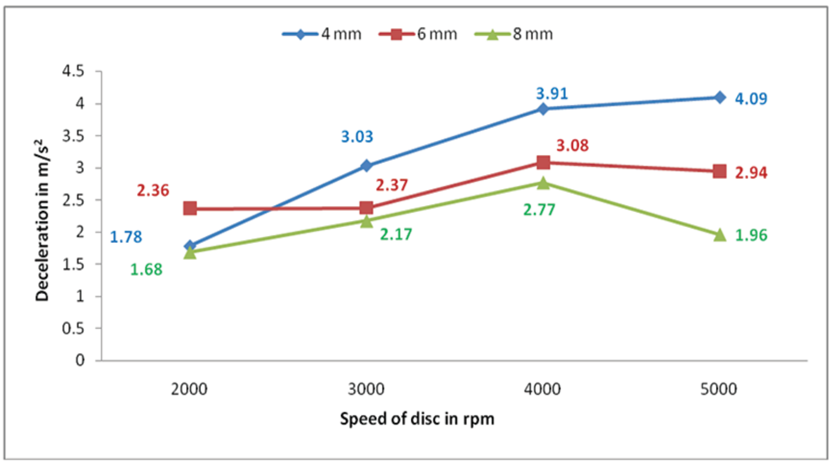

Figure 6.Comparison of negative acceleration in discs of Aluminum in lone magnet in rapid application situation

magnets from disc. The time consumed for reduction in speed and negative acceleration is acquired by data acquisition system.

4.0 Results and Discussions

Brake parameters considered are percentage reduction in speed, negative acceleration and time consumed for reduction in speed Negative acceleration considered is the maximum value recorded during experimentation.

4.1 Lone Magne t with Gradual Application Situation

In this method of conducting tests, a magnet will travel towards rotating disc at 4 mm per second velocity.

Referring to Figure 2, the percentage reduction in speed is high and even at all speeds in 4 mm disc thickness. This is owed to skin effect where in a fast varying magnetic fields, the magnetic field doesn't enter fully inside the material.

Referring to Figure 3, it can be observed that the negative acceleration in 4 mm disc is found to be as good as other two discs.

From Figure 4, we can see that in 4 mm disc, the time consumed is very less when compared to other two thickness discs.

Hence, from observations disc of 4 mm thickness Aluminum disc will be a superior option in the said situation.

4.2 Lone Magne t in Rapid Application Situation

In this situation of experimentation, a magnet will travel towards disc at a high speed to imitate actual braking in practice.

Referring to Figure 5 and Figure 6 it is seen that in percentage reduction in speeds and negative acceleration in 4 mm disc are higher compared to other discs.

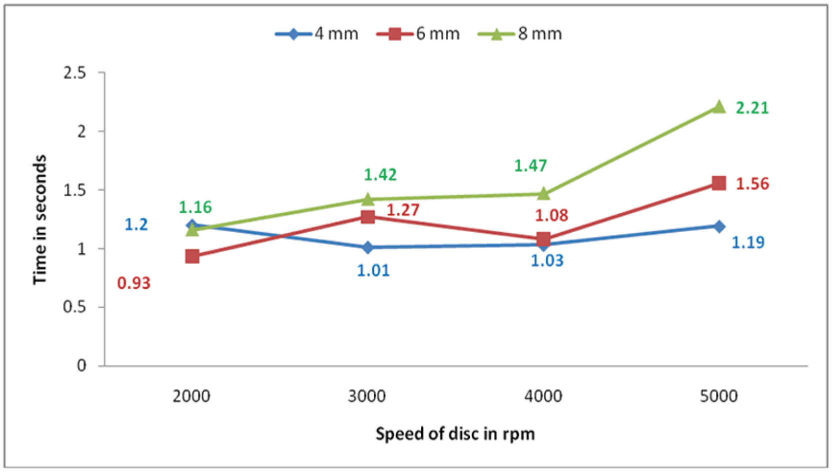

Figure 7.Comparison of time consume d in discs of Aluminum in lone magnet in rapid application situation

With reference to Figure 7, the time consumed for reduction in speeds in 4 mm disc thickness is less. This is because of enhanced interaction among Aluminum and induced magnetization.

From molecular theory of induced magnetism, the magnetic phenomena apparently depends on the inertia of molecules. Here, a known force causes higher magnetic induction for rapid application than if applied gradually. This phenomenon leads to less left over magnetism when quickly isolated. Hence, induced magnetization in rapidly applied situation is more and hence higher percentage reduction in speed and higher negative acceleration.

5.0 Conclusions

Taking into consideration the outcomes of experimental analysis it is found that brake characteristics considered with 4 mm Aluminum disc are superior in lone magnet with gradual application situation as well as in rapid application situation in comparison with those of discs of 6 mm and 8 mm thickness.

Because of higher negative accelerations and lower time consumed for reduction in speed, 4 mm disc can be used for soaring pace automobile and trains.

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