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Magnetic Braking and Speed Stabilization

H.E. Güner*, M. Ambarkutuk*, L. Bilginer*, C.Oysu*

**Kocaeli University, Dept. of Mechatronics Engr. Umuttepe Campus, Kocaeli, Turkey, 41380, E–mail:emre.guner@kocaeli.edu.tr*

Abstract

The speed and braking control of moving systems are vital engineering problem. The goal of this study, is to solve this problem by using magnetic braking and speed stabilization with eddy currents. In this study, magnetic circuit was designed to control the speed and brake of the dc motor. Maxwell which is the analysis software of magnetic circuits was used to design this circuit. Firstly, computations and analysis were done by Maxwell software. Then, magnetic circuit was designed depending on the Maxwell analysis results. A setup mechanism was developed for experiments. According to experimental results on this setup, it was shown that the magnetic circuit was correctly designed. Due to usage of this model, it was aimed to prevent energy loses caused by friction.

KEY WORDS: *Magnetic braking, speed stabilization, eddy current brake.*

1. Introduction

The braking systems of the heavy vehicles are common problem in the industry. Besides using the magnetic braking systems has increased in recent years because of the their advantages. In this paper, experimental model of the eddy current braking system is clearly examined. The term of the Eddy Current was found by Focault Bau J. S, he explained that when the magnetic flux linked a metallic conductor changes, induced currents are set up in the conductor in the form of the closed loops [1]. Fig. 1 shows that a sketch of the eddy currents in a rotating disc. The crosses represent a steady magnetic field perpendicular to the plane of the disc. According to Faraday's law, eddy currents appear in those points of the disc where the magnetic field increases or decreases [2]. This current produces a counter-opposing flux and Lorentz force to slow the moving object. By means of this Magnetic braking works because of induced currents and Lenz's law [3].

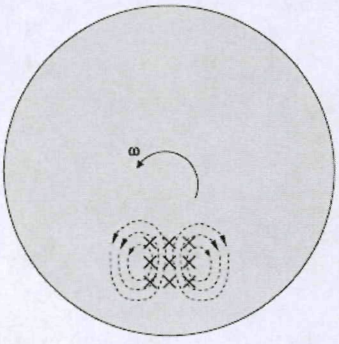

Fig. 1 Sketch of the Eddy Current in rotating disc

This system is used to eddy currents to brake and stop the disc. The working principle of the electric retarder is based on the creation of eddy currents within a metal disc rotating between two electromagnets, which sets up a force opposing the rotation of the disc. An eddy current brake, like a conventional friction brake, is responsible for slowing an object, such as a train or a roller coaster etc [1].

Moreover, eddy current brake is different than the frictional brake. When the eddy current brakes compared with the friction brakes that has some advantages to reduce the wear of the brake pad, and vibration. In this paper magnetic braking system that with using the eddy currents is clearly examined. It consists of a rotating metallic disc, which is subjected to the magnetic field present at the gap of an electromagnet. Eddy currents appear inside the disc and brake its rotation. This is the foundation of the electromagnetic braking systems used by heavy vehicles such as trains, buses or lorries [4].

In this Fig. 2 shows that; working principles of the eddy current brake mechanism that can be analyzed by Maxwell 3D transient solver. Maxwell model shows the eddy currents of the system. In this system was modeled for one electromagnet. Due to the red colors of the Fig. 2, one electromagnet occurred the high eddy currents of the disc plate. The results of the Maxwell model, a real physical system which has four electromagnets was designed using the Solidworks program.

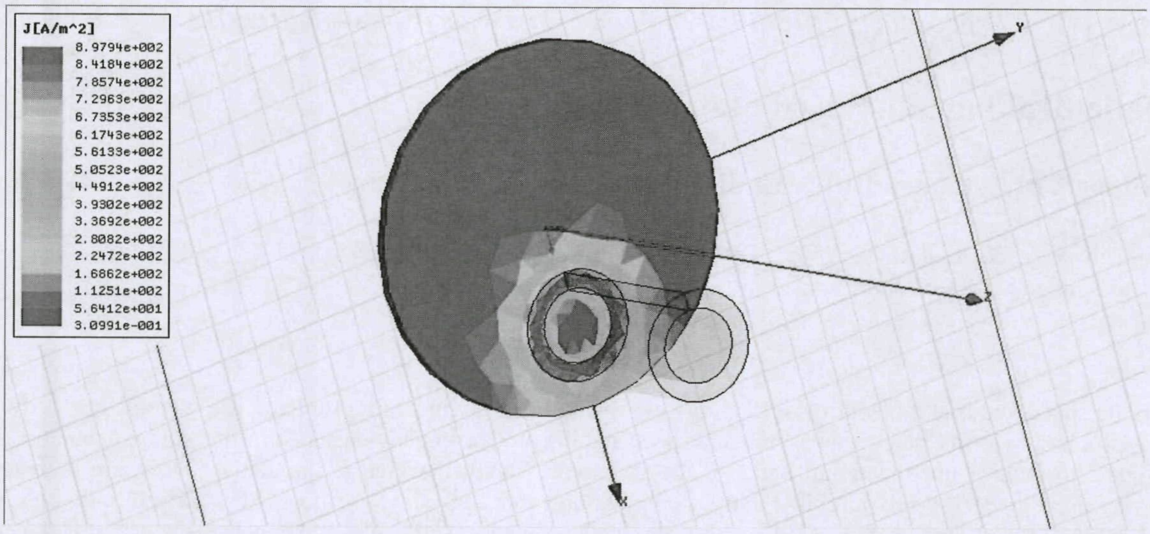

Fig. 2 Maxwell model of the system

2. Experimental setup

In this Part, the experimental model of the system was examined. In real physical model consist of the 4 electromagnets, dc motor, rotary encoder, Arduino Board, and adjustable power supply. Fig. 3 shows the 3-D model of the experimental set up using the Solidworks. After the 3-D model and Maxwell results, a real eddy current braking model was designed as shown in Fig. 4. This system consists of a 24V 6.72 W dc motor and its angular speed is 300 Rpm at 24V when the motor is unloaded. Firstly, optical tachometer is used to measure the speed of the Dc motor then a rotary encoder is connected to opposite side of the Dc motor. Arduino Board which is used to read rotary encoder values from its serial port, is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software [5].

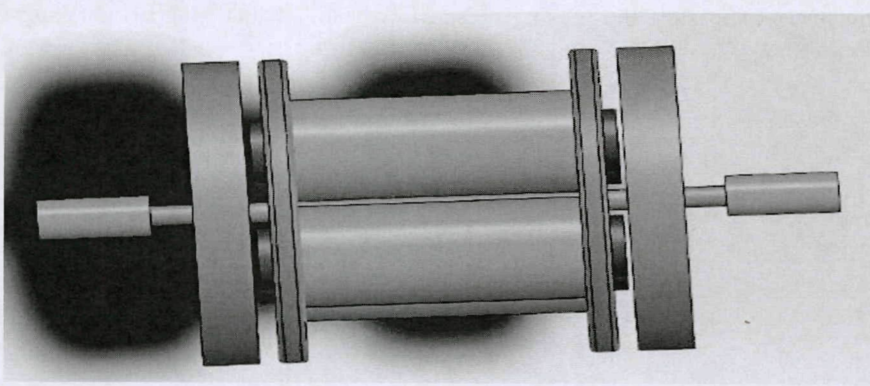

Fig. 3 3-D Solidworks model of the magnetic braking system

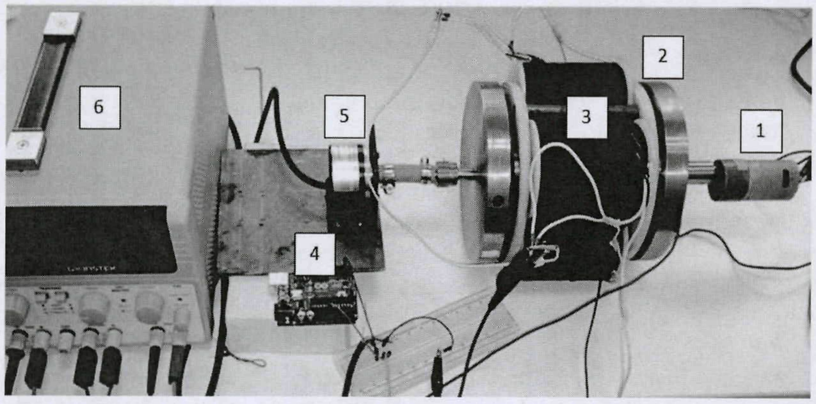

Fig. 4 The whole experimental setup. 1: dc motor 2: Disc 3 Electromagnets. 4 Arduino Board 5. Rotary Encoder 6: dc power source

2.1 Experimental procedure. Results and discussion

This part mention about the several kinds of measurements that can be carried out with the proposed experimental setup. There are several measurements were done for one Magnet in different kind of Dc motor currents. In this model 3 scenario was tested for efficiency of the eddy current braking system. All tests were done in The experiments were done with 2 mm air gap between the disc and the magnets. Moreover 3mm air gap between the rotary encoder and magnets. The air gap between the magnets and disc is selected 2 mm because the smaller the air-gap, the larger of electromagnet turns and this will generate higher braking torque to stop rotational motion of disc [6].

Moreover all the magnets worked at maximum 24 V and 2Ampere. In the first scenario was developed for one magnet with the following limited currents 0.28A-0.48A-0.68A. In this Figure 5 shows that the results of the electromagnetic braking system for one magnet(N=1). Firstly, The motor current is limited to 0.28 Ampere, also this ampere value is the unloaded position of the Dc motor. The motor is stopped at the one magnet works at 15.8 Volt and 1.28 Ampere. When the motor is limited to 0.48 Ampere the braking of the disc is saw but the motor could not be stopped. In this position magnet is worked full performance and reached 24 Volt and 1. 86 Ampere. The final ampere limit of the Dc motor is 0.68 Ampere. The motor works with like a loaded position. Disks can be braked however one magnet could not stopped the disc. The system could not be stopped when the one magnet works under the condition of the Dc motor current at 0.48 A and 0.68 A because of the poor eddy currents.

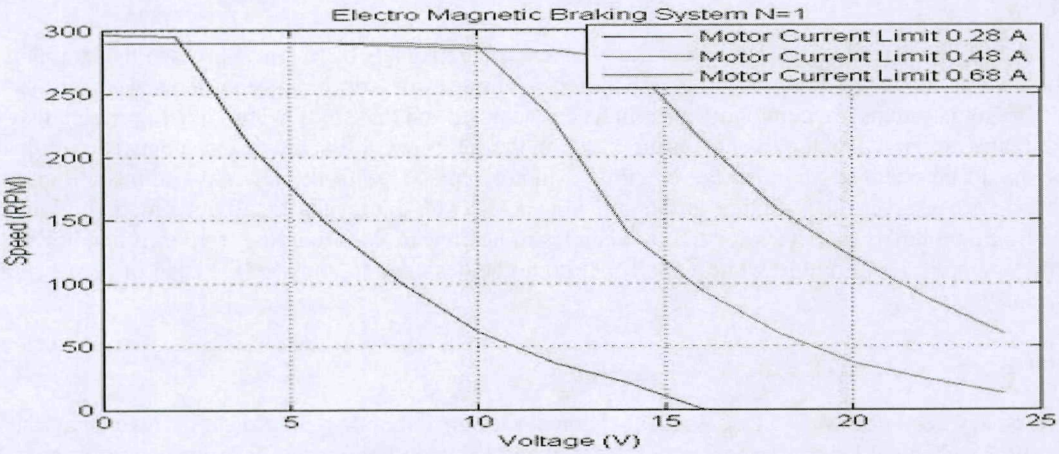

Fig. 5 Electromagnetic braking system when one magnet is active

When the number of the active magnets are increased two, the same limited current measurement were done. The magnets of the system is selected of the bottom and upper side of the system. When the motor is unloaded position that the motor is limited to 0.28 Ampere, stops the 13.2 Volt and 1.91 Ampere in the 0.48 ampere and 0 68 ampere respectively the disc was stopped at 16 Volt and 24 Volt at 2.5 Ampere and 3.7 Ampere.

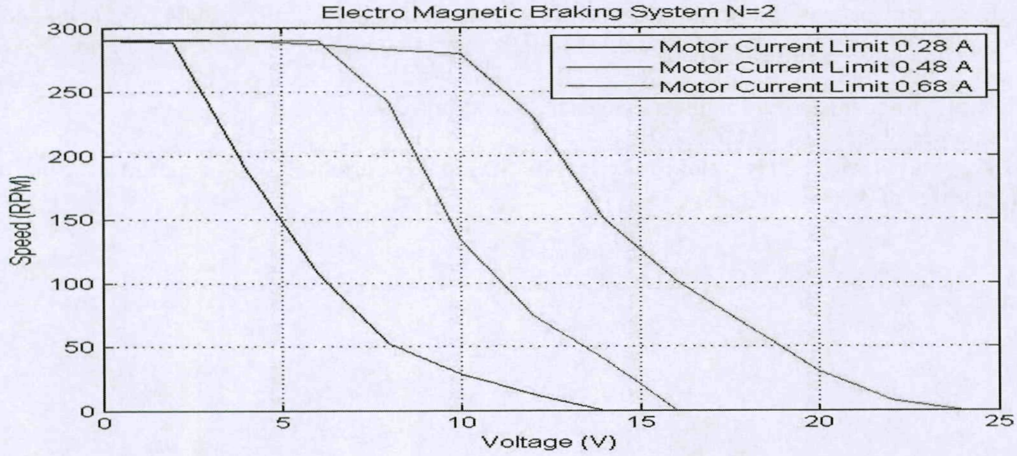

Fig. 6 When two magnets are active

All the magnets are actively worked and the results obtained in the Fig. 7. In the Fig. 7 expressed that the disc is the stopped in the shortest time when the dc motor is unloaded position. When the limited current is increased of the Dc motor, the stoppage time and stoppage voltage of the motor was increased at the 2mm air gap between the distance.

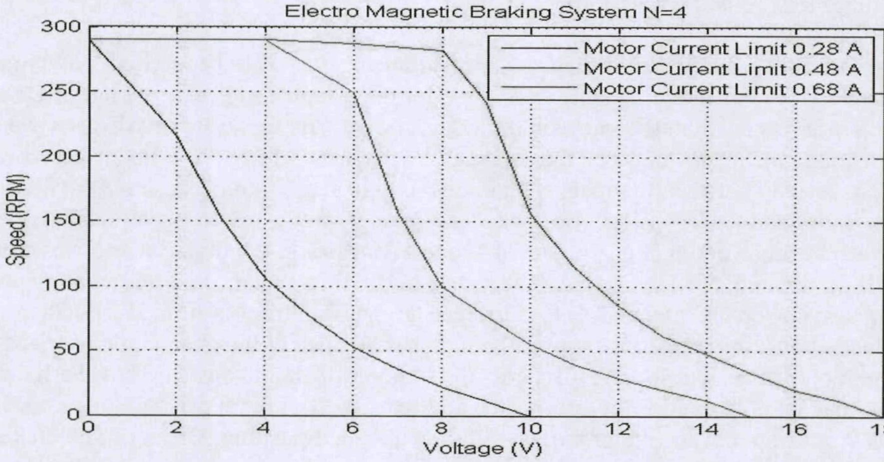

Fig. 7 When all the magnets are active

3. Conclusion

As a result of the experiments, to increase the number of the magnets from 1 to 4 provide the stopping voltage and time of the disc is decreased. The principles of the eddy current law and braking systems were discussed. The electromagnetic braking systems are commonly used in heavy vehicles and this study would like to provide that systems may be applied lighter systems than the trucks. Furthermore, in the future work that the distance between of the disc and electromagnets should be changed and also the electric dc motor replaced with the internal combustion engine. This study shows us experimental results is similar to theoretical and Maxwell 3D results Finally, magnetic braking systems can be replaced frictional braking systems for lighter vehicles in nearby. In this study the rpm of the motor is adjusted by using the power supply. In the future work a controller could be designed to adjusted the sped of the dc motor with respect to electromagnets.

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