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Title of Ph.D. Thesis: Soft Computing Techniques for Modeling Simulation and Analysis of Eddy Current Braking System

ABSTRACT

In the proposed work a hardware model of ECBS has been developed. The most important feature of the proposed ECBS model is being multidisc type it offers greater operational flexibility and usage. A mathematical model of the proposed ECBS has also been developed. Simulation of ECBS was performed using various soft computing techniques such as fuzzy logic controller (FLC), artificial neural network (ANN) and particle swarm optimization (PSO). The main objective of using the controllers based on above soft computing techniques was to improve the overall performance of ECBS. It was observed that performance of ECBS was significantly improved after using these techniques.

In mathematical modeling, a mathematical relation between braking torque of ECBS and various parameters of ECBS has been derived. Using basic equations of magnetism, the expression of power developed due to eddy currents was obtained. Expression of braking torque of eddy current brakes (ECB) was obtained by dividing the power developed due to eddy currents by angular speed of the disc. The braking torque produced by ECB was considered to be equivalent to the load torque of dc motor. Mathematical model of complete ECBS was obtained by replacing load torque by the braking torque of ECB in the final expression of angular velocity of dc motor. State space model of ECBS was also obtained using same concept. It was observed from the mathematical model of ECBS that the braking torque of ECB was directly proportional to the electrical conductivity of material of disc, thickness of disc, angular speed of disc and square of electromagnet (EM) coil current.

Hardware model of ECBS was developed using discs made up of two different alloys namely EN31 cast iron alloy and LM6 aluminium alloy. A multidisc structure was developed using vertical flange type dc motor. Four discs of LM6 aluminium alloy and EN31 cast iron alloy each were used for experimentation work. Using one type of disc at a time, they were placed equidistantly on the extended vertical shaft of the dc motor with the help of supporters. Around each disc, two U-shaped electromagnets were placed in such a way that some part of disc passes through the U-shape EM. Therefore, the disc cuts the magnetic flux produced by U-shape EM and eddy currents are induced in the disc. These eddy currents act in such a way that they oppose the cause of their origin which is the relative motion between EM and disc. Hence, a braking torque is produced which opposes the rotation of disc or motor, thereby producing eddy current braking. In order to measure the speed of the disc or the motor, RPM sensor was placed near the motor shaft such that it senses the motor speed and displays it on the RPM display meter placed on the control panel. All the electrical connections of EM coil and the motor were taken on the top of multidisc structure, in order to make the connections easily and safely. Electrical power supply connections to the motor and EM coils were also made on the top of multidisc structure.

The parameter analysis of ECBS was performed using the developed hardware model. Effect of different design parameters on the performance of ECBS was analyzed. Design parameters are type of power supply to EM coil, material of disc, thickness of disc, air gap length, distance between center of disc and center of pole, number of electromagnets and number of discs. Controllers were designed using fuzzy logic, artificial neural network (ANN) and particle swarm optimization (PSO) techniques to improve the performance of ECBS.