DESIGN AND FABRICATION OF AUTOMATIC EDDY CURRENT BRAKING

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Abstract - This study has been undertaken to investigate the determinants of Eddy current braking, majority of braking system works on the friction of kinetic energy with heat energy. this method has its own drawbacks and must be replaced with a more reliable braking system that is quick in response, doesn't heat up and is maintenance free. In this project the design an eddy current braking system and optimization for various operational parameters has been done. These parameters have been previously iterated in cited projects and papers and also in the simulation models and are to be cross-checked with the experimental setup. If suppose mechanical braking has been failure automatically electromagnetic braking induced by electrical circuit board connections and sensor.

IndexTerms **– Eddy current Braking, Aluminium Disc, Electro Magnet, Arduino Board**

I. INDRODUCTION

Electrical brakes make use of opposing tendency of eddy currents. In an eddy current brake the magnetic field may be created by a permanent magnet, or an electromagnet so the braking force can be turned on and off or varied by varying the electric current in the electromagnet's windings.

The principle of braking in road vehicles involves the conversion of kinetic energy into thermal energy (heat). In the electromagnetic brake, the coil or solenoid attracts a Aluminium disc. This ability of an electromagnet provides a strong magnetic force of attraction. Shape geometry and material used in construction of electromagnet decide the shape and strength of magnetic field produced by it. In the operation of any machinery the most primary safety system is the braking system. The most basic designs of the braking system involve the conversion of kinetic energy to heat energy by friction. This is accomplished by friction between two rubbing surfaces. These brakes pose several problems i.e. significant wear, fading, complex and slow actuation, lack of fail-safe features, increased fuel consumption due to power assistance, and requirement for anti-lock controls. To solve these problems, a contactless magnetic brake has been developed. This concept includes a metals disk which will conduct eddy currents generated by magnets. This brake is wear-free, less-sensitive to temperature than friction brakes, has fast and simple actuation, and has a reduced sensitivity to wheel lock. This is achieved by the generation of braking torque by a magnetic field across a moving conductor which creates a perpendicular magnetic field by induced eddy currents. Contactless brakes can be applied to any machinery like automobiles, locomotives, roller coasters, hydraulic and turbo machinery, machine tools, elevators, etc. The wide range applicability of these brakes strongly imply the effectiveness and ease of operation. The braking force can be adjusted to control higher torque loads by varying the coil turns or by increasing the voltage. This gives flexibility of operation of the system and makes it reliable even in changing loading patterns. A study of eddy current braking system is performed to find out the practical limit of using an electromagnetic braking system.

2. METHODOLOGY

Modelling of designed experimental setup is done in Solid works. it can be said that with increase in air gap and disc thickness, the torque generated by the electromagnets is decreased. This relation can be verified by noting the stoppage time after varying the air gap. As per the model the stoppage time must reduce with increase in air gap.

Following parameters are selected after literature survey

2.1. Aluminium Disc

Undoubtedly, aluminum disc, aluminum alloy in the future will be more widely used, aluminum metal ranked second in the current global metal usage, second only to steel, has become the second largest metal people application. The reason why it is widely used is that aluminum has characteristics that other metals do not have.

Figure – 1: Aluminium Disc

2.2. Electro Magnet

Electromagnets are DC type that can be powered by battery. Electromagnets are selected instead of permanent magnet as electrical actuation is faster than mechanical actuation with lower losses.

Figure – 2: Electro magnet

Electro magnet is a device. It will get magnetize when current flow on copper wire (Gauge 26) winded over iron rod.

2.3 Inductive Sensor

An **i**nductive sensor is an electronic proximity sensor, which detects metallic objects without touching them.

The sensor consists of an induction loop. Electric current generates a magnetic field, which collapses generating a current that falls asymptotically toward zero from its initial level when the input electricity ceases. The inductance of the loop changes according to the material inside it and since metals are much more effective inductors than other materials the presence of metal increases the current flowing through the loop. This change can be detected by sensing circuitry, which can signal to some other device whenever metal is detected.

The inductive sensor detects the presence of the metallic cable wire by generating the magnetic field around the object if any change occurs in the metallic object it leads to the change in the magnetic field, this variation in the magnetic helps to detect the brake failure in the system and the signal is send to the control unit which controls other major working of the system.

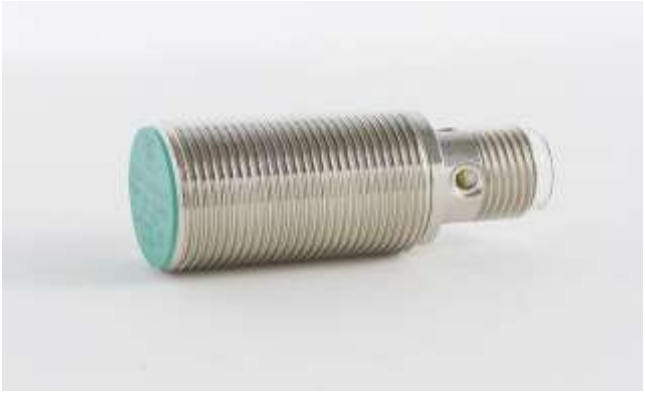

Figure – 3: Inductive Sensor

2.4. Arduino Board

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers for building digital devices and interactive objects that can sense and control objects in the physical and digital world.

The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or Breadboards and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers.

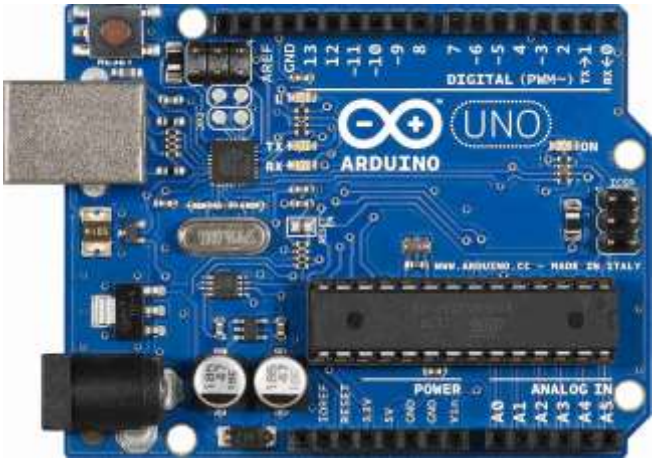

Figure – 4: Arduino Board

The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

3. CONSTRUCTION

An eddy current brake, like a conventional friction brake, is a device used to slow or stop a moving object by dissipating its kinetic energy as heat. However, unlike friction brakes, in which the drag force that stops the moving object is provided by friction between two surfaces pressed together, the drag force in an eddy current brake is an electromagnetic force between a magnet and a nearby conductive object in relative motion, due to eddy currents induced in the conductor through electromagnetic induction.

A conductive surface moving past a stationary magnet will have circular electric currents called eddy currents induced in it by the magnetic field, as described by Faraday's law of induction. By Lenz's law, the circulating currents will create their own magnetic field which opposes the field of the magnet. Thus the moving conductor will experience a drag force from the magnet that opposes its motion, proportional to its velocity. The kinetic energy of the moving object is dissipated as heat generated by the current flowing through the electrical resistance of the conductor.

In an eddy current brake the magnetic field may be created by a permanent magnet, or an electromagnet so the braking force can be turned on and off or varied by varying the electric current in the electromagnet's windings. Another advantage is that since the brake does not work by friction, there are no brake shoe surfaces to wear out, necessitating replacement, as with friction brakes. A disadvantage is that since the braking force is proportional to relative velocity of the brake, the brake has no holding force when the moving object is stationary, as is provided by static friction in a friction brake, so in vehicles it must be supplemented by a friction brake.

Eddy current brakes are used to slow high-speed trains and roller coasters, to stop powered tools quickly when power is turned off, and in electric meters used by electric utilities.

4. PRINCIPLE OF OPERATION

Eddy current brake works according to Faraday's law of electromagnetic induction. According to this law, whenever a conductor cuts magnetic lines of forces, an emf is induced in the conductor, the magnitude of which is proportional to the strength of magnetic field and the speed of the conductor. If the conductor is a disc, there will be circulatory currents i.e. eddy

currents in the disc. According to Lenz's law, the direction of the current is in such a way as to oppose the cause, i.e. movement of the disc.

Essentially the eddy current brake consists of two parts, a stationary magnetic field system and a solid rotating part, which include a metal disc. During braking, the metal disc is exposed to a magnetic field from an electromagnet, generating eddy currents in the disc. The magnetic interaction between the applied field and the eddy currents slow down the rotating disc. Thus the wheels of the vehicle also slow down since the wheels are directly coupled to the disc of the eddy current brake, thus producing smooth stopping motion.

Since researches are going on to eliminate some of the disadvantages of this system, we can accept it to be the norm one in a few years of time.

5. WORKING

5.1. Mechanical Braking System

The master cylinder which is located under the hood is directly connected to the brake pedal, and converts the drivers foot pressure into hydraulic pressure. Steel brake hoses connect the master cylinder to the slave cylinders located at each wheel. Brake fluid, specially designed to work in extreme temperature conditions, fills the system. Shoes or pads are pushed by the slave cylinders to contact the drums or rotors, thus causing drag, which slows the car. Two major kinds of friction brakes are disc brakes and drum brakes.

Disc brakes use a clamping action to produce friction between the rotors and the pads mounted in the caliper attached to the suspension members. Disc brakes work using the same basic principle as the brakes on a bicycle: as the caliper pinches the wheel with pads on both sides, it slows the vehicle. Drum brakes consist of a heavy flat-topped cylinder, which is sandwiched between the wheel rim and the wheel hub. The inside surface of the drum is acted upon by the linings of the brake shoes. When the brakes are applied, the brake shoes are forced into contact with the inside surface of the brake drum to slow the rotation of the wheels. Air brakes use standard hydraulic brake system components such as braking lines, wheel cylinders and a slave cylinder similar to a master cylinder to transmit the air-pressure-produced braking energy to the wheel brakes. Air brakes are used frequently when greater braking capacity is required.

5.2. Eddy Current Braking System

They're electric currents generated inside a conductor by a magnetic field that can't flow away so they swirl around instead, dissipating their energy as heat.

One of the interesting things about eddy currents is that they're not completely random: they flow in a particular way to try to stop whatever it is that causes them. This is an example of another bit of electromagnetism called Lenz's law (it follows on from another law called the conservation of energy, and it's built into the four equations summarizing electromagnetism that were set out by James Clerk Maxwell).

Here's an example. Suppose you drop a coin-shaped magnet down the inside of a plastic pipe. It might take a half second to get to the bottom. Now repeat the same experiment with a copper pipe and you'll find your magnet takes much longer (maybe three or four seconds) to make exactly the same journey. Eddy currents are the reason. When the magnet falls through the pipe, you have a magnetic field moving through a stationary conductor (which is exactly the same as a conductor moving through a stationary magnetic field). That creates electric currents in the conductor—eddy currents, in fact. Now we know from the laws of electromagnetism that when a current flows in a conductor, it produces a magnetic field. So the eddy currents generate their own magnetic field. Lenz's law tells us that this magnetic field will try to oppose its cause, which is the falling magnet. So the eddy currents and the second magnetic field produce an upward force on the magnet that tries to stop it from falling. That's why it falls more slowly. In other words, the eddy currents produce a braking effect on the falling magnet. It's because eddy currents always oppose whatever causes them that we can use them as brakes in vehicles, engines, and other machines.

Mechanical braking system is failure in vehicle the micro processor sense and then energize the electromagnet and brake will be applied.

6. MERITS

The device should be used in heavy automobiles as an accessory. Safety of the vehicle is assured. Accident rate is reduced. It act as a secondary braking system. No contact therefore no wear or tear. High brake force at high speed. No noise. It is highly suitable at high speed. It works on electricity and consumes very small amount of power for a tiny time period. Can be easily controlled and resettable. Very light weight and low maintenance. Consumes small space therefore installation is easy. Running cost is small.

7. CONCLUSION

The eddy current brakes can be used as an accessory in heavy automobiles with conventional friction brakes; because it is the remedy of problems faced by conventional brakes like fading, skidding, high maintenance requirement, low reliability, requirement of servo mechanisms, breaking, higher weights etc.

This device is easy to install an cost incurred is small so can be used in the automobiles manufactured.

8. REFERENCE

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