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Innovative Electro Magnetic Braking System

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ABSTRACT: An Electromagnetic Braking system uses Magnetic force to engage the brake, but the power required for braking is transmitted manually. The disc is connected to a shaft and the electromagnet is mounted on the frame .When electricity is applied to the coil a magnetic field is developed across the armature because of the current flowing across the coil and causes armature to get attracted towards the coil. As a result it develops a torque and eventually the vehicle comes to rest. In this project the advantage of using the electromagnetic braking system in automobile is studied. These brakes can be incorporated in heavy vehicles as an auxiliary brake. The electromagnetic brakes can be used in commercial vehicles by controlling the current supplied to produce the magnetic flux. Making some improvements in the brakes it can be used in automobiles in future

KEYWORDS: Peak Force, Fade, Drag, Flux, Electro Magnet

I. Introduction

A brake is a device which inhibits motion. Its opposite component is a clutch.Most commonly brakes use friction to convert kinetic energy into heat, though other methods of energy conversion may be employed. For example regenerative braking converts much of the energy to electrical energy, which may be stored for later use.

II. Principle of Braking System

The principle of braking in road vehicles involves the conversion of kinetic energy into thermal energy (heat). When stepping on the brakes, the driver commands a stopping force several times as powerful as the force that puts the car in motion and dissipates the associated kinetic energy as heat. Brakes must be able to arrest the speed of a vehicle in short periods of time regardless how fast the speed is. As a result, the brakes are required to have the ability to generating high torque and absorbing energy at extremely high rates for short periods of time.

III.Existing Condition

A. Types of Braking System

Brakes may be broadly described as using friction, pumping, or electromagnetic. One brake may use several principles: for example, a pump may pass fluid through an orifice to create friction.

B. Conventional Friction Brake

The conventional friction brake system is composed of the following basic components: 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.

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C. Characteristics

Brakes are often described according to several characteristics including:

- **Peak force** is the maximum decelerating effect that can be obtained. The peak force is often greater than the traction limit of the tires, in which case the brake can cause a wheel skid.
- **Continuous power dissipation** Brakes typically get hot in use, and fail when the temperature gets too high. The greatest amount of power (energy per unit time) that can be dissipated through the brake without failure is the continuous power dissipation. Continuous power dissipation often depends on e.g., the temperature and speed of ambient cooling air.
- **Fade** As a brake heats, it may become less effective, called brake fade. Some designs are inherently prone to fade, while other designs are relatively immune. Further, use considerations, such as cooling, often have a big effect on fade.

IV. EXISTING CONDITION

A. Brake fading effect:

The conventional friction brake can absorb and convert enormous energy values (25h.p. without self-destruction for a 5-axle truck, Reverdin1974), but only if the temperature rise of the friction contact materials is controlled. This high energy conversion therefore demands an appropriate rate of heat dissipation if a reasonable temperature and performance stability are to be maintained.

B. Brake fluid leakage

If your vehicle has worn brake pads or brake shoes, the fluid level in your brake fluid reservoir will be low. But let's say you have relatively new brake pads and you recently topped-off your brake reservoir only to notice a few days later that the fluid level has dropped noticeably. If that's the case, it's a good bet you have a leak somewhere in your brake system -- which means that you likely have bigger brake issues than something as simple as worn brake pads.

C. Other major problems

And other problems include the brake fluid vaporization and brake fluid freezing though vaporization occurs only in rare cases. Freezing is quite common in colder places like Scandinavian countries and Russia etc…… where the temperature reaches as low as -50°C to–65°C, in such cases there is a need for some anti-freezing agents and increases the complexity and cost of the system.

V. WORKING PRINCIPLE

A. Electromagnetism

Electromagnetism is one of the four fundamental interactions in nature. The other three are the strong interaction, the weak interaction and gravitation. Electromagnetism is the force that causes the interaction between electrically charged particles; the areas in which this happens are called electromagnetic fields

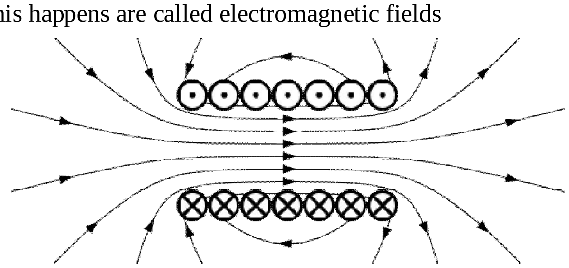

Fig. 1 Magnetic Field Lines

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B. Magnetic Effect of Current

The term "Magnetic effect of current" means that "a current flowing in a wire produces a magnetic field around it". The magnetic effect of current was discovered by Oersted in 1820. Oersted found that a wire carrying a current was able to deflect a magnetic needle

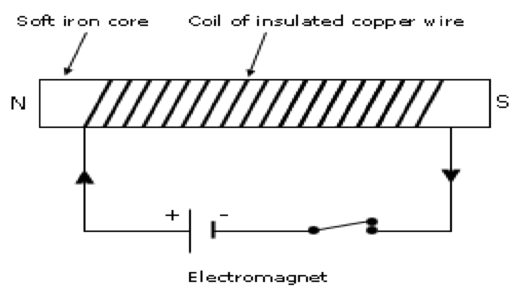

Fig. 2 Magnetic Field Lines

C. Electromagnet

An electric current can be used for making temporary magnets known as electromagnets. An electromagnet works on the magnetic effect of current. It has been found that if a soft iron rod called core is placed inside a solenoid, then the strength of the magnetic field becomes very large because the iron ore is magnetized by induction

D. Factors affecting strength of an Electromagnet

The strength of an electromagnet is:

- Directly proportional to the number of turns in the coil.
- Directly proportional to the current flowing in the coil.
- Inversely proportional to the length of air gap between the poles.

In general, an electromagnet is often considered better than a permanent magnet because it can produce very strong magnetic fields and its strength can be controlled by varying the number of turns in its coil or by changing the current flowing through the coil.

VI. ELECTROMAGNETIC BRAKES

Electromagnetic brakes operate electrically, but transmit torque mechanically. This is why they used to be referred to as electro-mechanical brakes. Over the years, EM brakes became known as electromagnetic, referring to their actuation method. The variety of applications and brake designs has increased dramatically, but the basic operation remains the same. Single face electromagnetic brakes make up approximately 80% of all of the power applied brake applications

A. Characteristics of Electromagnetic Brakes

It was found that electromagnetic brakes can develop a negative power which represents nearly twice the maximum power output of a typical engine, and at least three times the braking power of an exhaust brake. These performances of electromagnetic brakes make them much more competitive candidate for alternative retardation equipment’s compared with other retarders. The brake linings would last considerably longer before requiring maintenance, and the potentially “brake fade” problem could be avoided. In research conducted by a truck manufacturer, it was proved that the electromagnetic brake assumed 80 percentage of the duty which would otherwise have been demanded of the regular service brake. Furthermore, the electromagnetic brake prevents the dangers that can arise from the prolonged use of brakes beyond their capability to dissipate heat. This is most likely to occur while a vehicle descending a long gradient at high speed.

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VII. CONSTRUCTION

The parts of Electromagnetic Disc Brake are:

- AC Motor
- Disc
- Frame
- Electromagnet
- Pulleys & Belt
- Shaft

A. AC Motor

An AC motor is an electric motor driven by an alternating current. It commonly consists of two basic parts, an outside stationary stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft that is given a torque by the rotating field. Where speed stability is important, some AC motors (such as some past motors) have the stator on the inside and the rotor on the outside to optimize inertia and cooling

Fig.3 Photographic View of an AC Motor

B. Disc

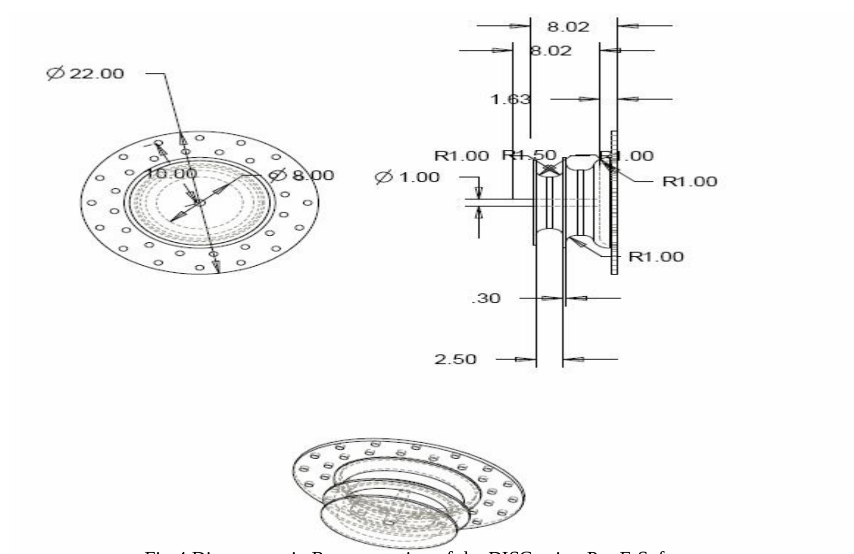

Fig.4 Diagrammatic Representation of the DISC using Pro E Software

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C. Frame

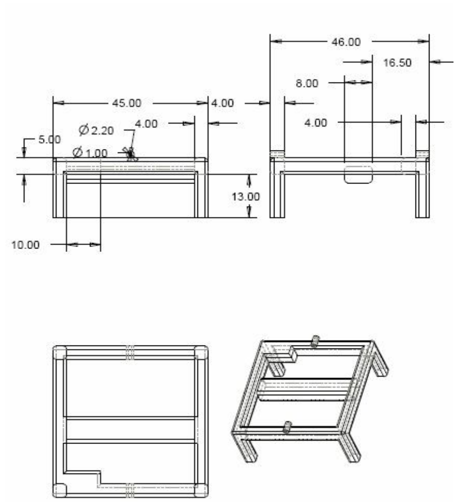

Fig.5 Diagrammatic Representation of the Frame using Pro E Software

D. Electromagnet

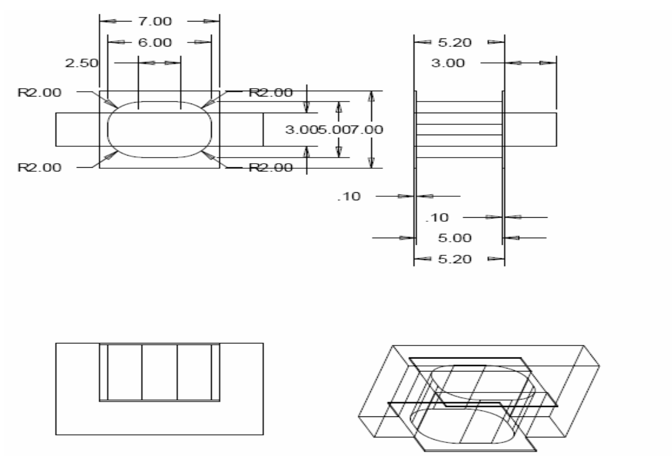

Fig.6 Diagrammatic Representation of the Electro Magnet using Pro E Software

VIII. ASSEMBLED – 3 DIMENSIONAL MODEL

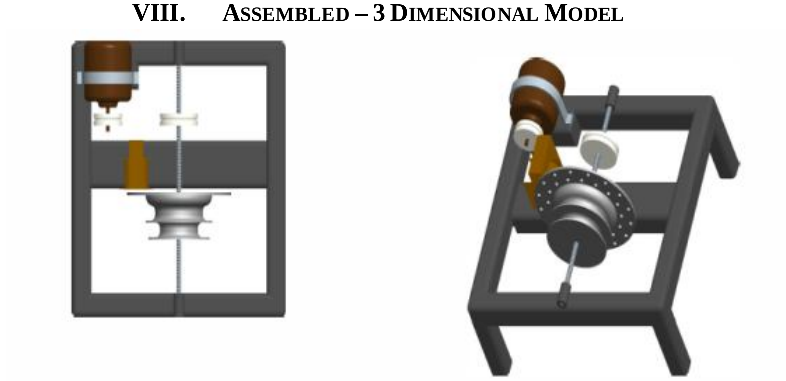

Fig.7 Assembled View of the Electro Magnetic Braking System using Pro E Software

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IX. DESIGN CALCULATIONS

Centre distance between the pulleys= .24 m=C
Diameter of the driving pulley = .085 m=d
Diameter of the driven pulley = .05 m=D
Speed of the driving pulley = 1800 rpm=N1
Material of the belt = fabric
Material of the pulley = plastic

A. Determination of speed of the driven pulley

$n_1d=n_2D$

$$i = \frac{n1}{n2} = \frac{D}{d}$$

$$N2 = \frac{D}{d} * N1$$

$$N2 = \frac{.085}{.05} * 1800$$

$$= 3060 \text{ rpm}$$

B. Checking for centre distance:

"The centre distance between the two pulleys must be greater than the average value of the diameters of both the pulleys."

$$C \geq \frac{D+d}{2}$$

$$\frac{D+d}{2} = \frac{.085+.05}{2} = .07\text{m}$$

C= .24 m

Therefore $C \geq \frac{D+d}{2}$

C. Arc of Contact:

$$\text{Arc of contact} = 180^0 - \frac{D-d}{C} \text{ X } 60^o$$

$$= 180^0 - \frac{.085-.05}{.24} \text{ X } 60^o$$

$$= 172^0$$

D. Length of the Belt:

$$L_o = 2C + \frac{\pi}{2}(D+d) + \frac{(D-d)^2}{4C} \text{ (opendrive)}$$

$$= 2 * .24 + \frac{\pi}{2}(.085 + .05) + \frac{(.085 - .05)^2}{4 * .24}$$

=.6933 m/s

E. Actual Length of the Belt:

= L – [1% of L]
= .6933 – [.01*.6933] =.6240 m

X. THERMAL DYNAMICS

Thermal stability of the electromagnetic brakes is achieved by means of the convection and radiation of the heat energy at high temperature. The value of the energy dissipated by the fan can be calculated by the following expression:

***Q MCp*= Dq**

Where M = Mass of air circulated;
Cp = Calorific value of air;
Dq = Difference in temperature between the air entering and the air leaving the fan;

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XI. WORKING OF ELECTROMAGNETIC DISC BRAKE

The electromagnet is energized by the AC supply where the magnetic field produced is used to provide the braking mechanism. When the electromagnet is not energized, the rotation of the disc is free and accelerates uniformly under the action of weight to which the shaft is connected. When the electromagnet is energized, magnetic field is produced thereby applying brake by retarding the rotation of the disc and the energy absorbed is appeared as heating of the disc. So when the armature is attracted to the field the stopping torque is transferred into the field housing and into the machine frame decelerating the load. The AC motor makes the disc to rotate through the shaft by means of pulleys connected to the shaft.

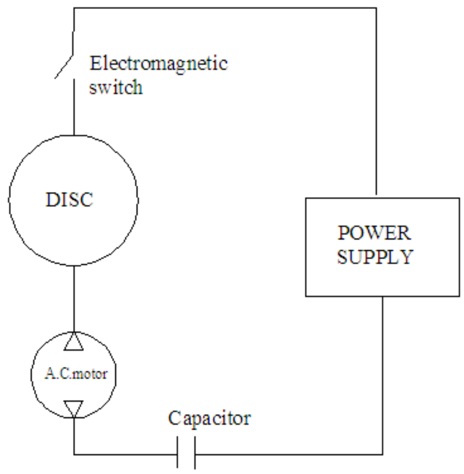

Fig.8 Working of Electro Magnetic Disc Brake

A. Engagement Time

There are actually two engagement times to consider in an electromagnetic brake. The first one is the time it takes for a coil to develop a magnetic field, strong enough to pull in an armature. The second one is air gap, which is the space between the armature and the coil shell. CAD systems can automatically calculate component inertia, but the key to sizing a brake is calculating how much inertia is reflected back to the brake. To do this, engineers use the formula: $T = (WK2 \times \Delta N) / (308 \times t)$ Where T = required torque in lb-ft, WK2 = total inertia in lb-ft2, ΔN = change in the rotational speed in rpm, and t = time during which the acceleration or deceleration must take place.

XII. ASSEMBLED MODEL

Fig 10. Front View of the Fabricated Brake System

Fig 11 .Top view of the Fabricated Brake System

XIII. ADVANTAGES

- Problems of drum distortion at widely varying temperatures. Which is common for friction-brake drums to exceed 500 °C surface temperatures when subject to heavy braking demands, and at temperatures of this order, a reduction in the coefficient of friction (‘brake fade’) suddenly occurs.
- This is reduced significantly in electromagnetic disk brake systems.
- Potential hazard of tire deterioration and bursts due to friction is eliminated.
- There is no need to change brake oils regularly.
- There is no oil leakage.
- The practical location of the retarder within the vehicle prevents the direct impingement of air on the retarder caused by the motion of the vehicle.
- The retarders help to extend the life span of the regular brakes and keep the regular brakes cool for emergency situation.
- The electromagnetic brakes have excellent heat dissipation efficiency owing to the high temperature of the surface of the disc which is being cooled.
- Due to its special mounting location and heat dissipation mechanism, electromagnetic brakes have better thermal dynamic performance than regular friction brakes.
- Burnishing is the wearing or mating of opposing surfaces .This is reduced significantly here.
- In the future, there may be shortage of crude oil, hence by-products such as brake oils will be in much demand. EMBs will overcome this problem.
- Electromagnetic brake systems will reduce maintenance cost
- The problem of brake fluid vaporization and freezing is eliminated

XIV. DISADVANTAGES

- Dependence on battery power to energize the brake system drains down the battery much faster.
- Due to residual magnetism present in electromagnets, the brake shoe takes time to come back to its original position.
- A special spring mechanism needs to be provided for the quick return of the brake shoe.

XV. CONCLUSION

With all the advantages of electromagnetic brakes over friction brakes, they have been widely used on heavy vehicles where the ‘brake fading’ problem exists. The same concept is being developed for application on lighter vehicles. The concept designed by us is just a prototype and needs to be developed more because of the above mentioned disadvantages. These electromagnetic brakes can be used as an auxiliary braking system along with the friction braking system to avoid overheating and brake failure. ABS usage can be neglected by simply using a micro controlled electromagnetic disk brake system .These find vast applications in heavy vehicles where high heat dissipation is required.

In rail coaches it can used in combination of disc brake to bring the trains moving in high speed. When these brakes are combined it increases the life of brake and act like fully loaded brakes. These electromagnetic brakes can be used in wet conditions which eliminate the anti-skidding equipment, and cost of these brake are cheaper than the other types. Hence the braking force produced in this is less than the disc brakes if can be used as a secondary or emergency braking system in the automobiles.

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