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Electromagnetic Braking

An Innovative Approach

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Abstract: This paper focuses on use of electromagnetic force to stop vehicle. An Electromagnetic Braking system uses Magnetic force as well as eddy current to engage the brake, but the power required for braking is transmitted through current source. The disc (rotor) is connected to a shaft and the electromagnet is mounted on the caliper and permanent magnet is fused or mounted on disc at an angle. 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 of attraction between magnets in calipers as well as disc, it develops a torque which opposes the motion of rotor and eventually the vehicle comes to rest and also, eddy current is developed on the disc when highly strength magnet is placed near the moving disc. Eddy current produced in the disc develop their own magnetic field which opposes the applied magnetic field. Thus, rotor or disc comes to rest by torque produced due to opposition of magnetic field i.e. (of supplied and eddy current`s magnetic field). So, this brake uses both magnetic force as well as eddy current to engage brake. These brakes can be incorporated in heavy vehicles and car 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: Electromagnet , auxillary brake , friction-less braking

1. INTRODUCTION

New technologies are arriving in this world. Many industries got benefited due to the arrival of these new technologies. An automobile industry is one of them. As brake is an important part of automobile technology, there are innovations in brakes too. The commonly used brakes in automobiles are drum and disc brakes. Various types of braking system used are hydraulic, pneumatic etc. Electromagnetic braking is an innovative technology and also forms the basis of growing technology. Braking system is generally classified according to their method of operation. The two major types of brake are frictional and electromagnetic retarder. The brake is a mechanical device which involves the conversion of kinetic energy into thermal energy (heat) by stopping vehicle in a motion. When braking force is applied by brake to inhibit the motion of vehicle lots of kinetic energy is dissipated in the form of heat energy. Primary function of Brakes is to slow the speed of a vehicle in a short time irrespective of speed. 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. Brakes may be applied for a longer periods of time in some applications such as a heavy vehicle descending in a slope at high speed. Brakes must be able to keep the heat absorption for prolonged periods of time. The frequency of accidents is now-a-days increasing due to inefficient braking system. Hence braking system needs to be enhanced for effective and efficient braking. Electromagnetic brake is as new concept. It is found that electromagnetic brakes can develop a power which is nearly twice the maximum power output of a typical engine, and at least three times the braking power of an exhaust brake to stop vehicle. These performances of electromagnetic brakes make them much more competitive candidate for alternative retardation equipment's compared with other retarders. This research work aims to minimize the brake failure to avoid the road accidents. It also reduces the maintenance of braking system. An advantage of this system is that it can be used on any vehicle and is friction-less mode of braking.

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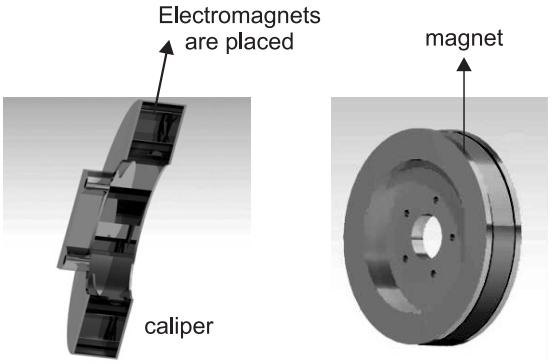
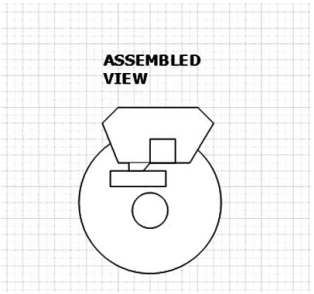
2. CONSTRUCTION

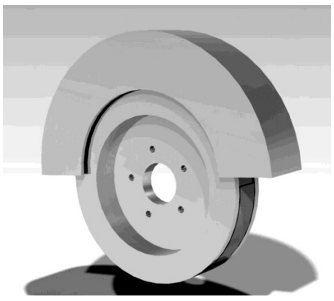
The electromagnet brake has two parts mainly; they are caliper and custom designed rotor made of aluminum. Electromagnet and neodymium permanent magnets are placed on calipers and rotor respectively. Current is provided to electromagnet through current source. Electromagnets in caliper and rotor can be fixed by bolting, riveting or by high strength glues (cyanoacrylates, polyurethane). In rotor permanent magnet are fitted in its peripheral surface at an angle. The electromagnets in caliper which are facing perpendicular to electromagnets in rotor. There is also one more very strong electromagnet which is used for developing eddy current in aluminum rotor.



3. WORKING

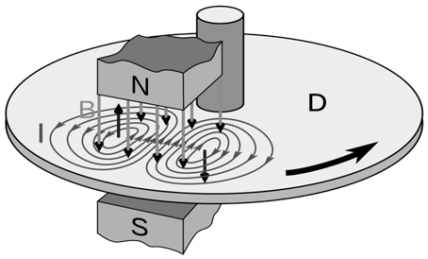
Electromagnetic brake works on the principle of electromagnetism. They are totally friction-less. Due to this they have longer life-span and durable. Less maintenance is required in these brakes. It can be used as supplementary brakes and can also use to stops rotating shafts of high-grade machines in industries.





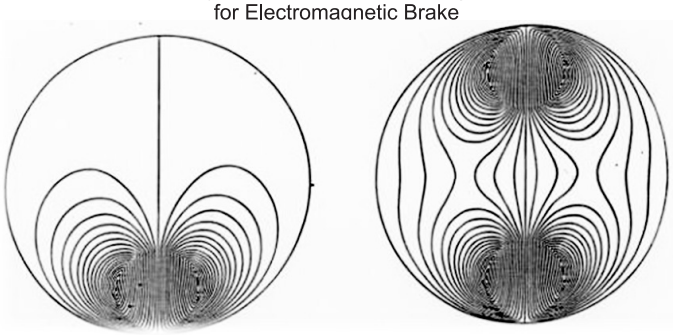
This brake uses both eddy current and attraction force of magnet to stop vehicle. Eddy current is used to retard the vehicle while magnetic force is used to bring vehicle to rest. This braking is based on attraction property of magnets. So when the rotor moves between the caliper, the electromagnets in the caliper attract the permanent magnet in rotor. Since, electromagnets in caliper are fixed; they try to rotate the rotor in opposite direction i.e. decelerating it. The deceleration is done by increasing magnetic field by increasing current supply to the electromagnets. The current supply for electromagnets in caliper is done by wiring through caliper to battery. The middle portion of rotor has structure like circular thick plate and strong electromagnet is placed in front of it. The clearance between rotor middle part and electromagnet is less. While driving a car, strong electromagnet positioned in front of rotor middle portion is turned on, thus forming a magnetic flux. This magnetic flux is perpendicularly introduced into rotor. An eddy current is thus induced in the customized rotor due to the Faraday's law. A Lorentz force is generated by the relative action between the eddy current and the magnetic flux, thus forming a braking torque. Eddy current does

not decelerate vehicle at low speed. That`s why projected brake is combination of both magnetic force and eddy current.



Eddy current retarding wheel

Eddy Currents Distribution Diagram
for Electromagnetic Brake



4. CALCULATIONS

1. Maximum braking force or force at wheel lock can be calculated by formula:

$$\mathbf{F_L = M_{DAL} \times g \times u_r}$$

F_L = possible braking force on axle

M_{DAL} = Dynamic axle load

g = acceleration due to gravity

u_r = coefficient of friction between road and tire

2. Braking torque require to stop wheel

$$\mathbf{T = B_F \times R/r}$$

B_F = Braking force

T = brake torque

R = radius of tire

r = speed ratio between the wheel and brake

3. Braking force obtained by eddy current

$$\mathbf{F_e = pie \times D^2 \times d \times B_0^2 \times c \times v/4\rho}$$

$$\mathbf{c = ½\ [1 - (1/4) * 1/(1 + r/A)^2\ (A - r/D)^2]}$$

F_e = braking force (N)

D = diameter of soft iron pole (m)

d = disk thickness

B_0 = air gap induction at 0 speed (T)

A = disk radius (m)

c = proportionality factor, ratio of total disk contour (outward curve) resistance to resistance of disk contour (outward curve) part under pole.

ν = tangential speed of the rotating disk

ρ = specific resistance of disc material

5. ADVANTAGES

- No friction loss.
- Less heat loss.
- Less wear of components.
- Fully electronically controlled.
- Great braking efficiency potential to regain energy lost in braking.
- Potential to regain energy lost in braking.
- Potential hazard of tire deterioration and bursts due to friction is eliminated.
- No need to change brake oils regularly.
- No oil leakage.
- Problem of brake fluid vaporization and freezing is eliminated.
- Less maintenance cost.
- Longer life span compared to conventional brakes.
- Can be used in industry to stop or decelerate rotating parts.
- No need of abs

6. CONCLUSION

Electromagnetic brakes have many advantages over frictional braking system. The combination of eddy current and magnetic forces makes this brake more effective. This brake can be used as auxiliary brake system in vehicle. The usage of abs can be neglected by using a micro controlled electromagnetic system. it can be used in rail coaches to decelerate the train moving in high-speed. Combination of these brakes increases the brake life and act like fully loaded brakes. These brakes can be used in wet condition, so there is no use of anti-skidding instrument. it is fully electrically controlled which results in less accidents. The braking force produced in this brake is less than the disc brakes. Hence, it can be used as a secondary or emergency braking system in the automobiles.

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