Electromagnetic Braking System in Automobile

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Abstract— This paper elaborates Electromagnetic Braking system and its impact on other conventional Braking system. Braking System should ensure safety and comfort to the driver while driving the vehicle on road. There are various types of Conventional systems of Braking such as Drum Brake, Disc Brake, Hydraulic brakes, Pneumatic brakes etc. This Braking System produce higher amount of friction which produces heat wear and tear of braking parts and eventually reduces efficiency of braking system. Therefore Electromagnetic Braking System is used which is efficient way of braking with high power to torque ratio and also provide less amount of friction.

Keywords: *Electromagnetic Braking; Conventional Braking; Friction; Heat;*

I. INTRODUCTION

A Braking System should provide retardation. Ineffective way of braking leads to accidents most of the accidents are due to faulty way of braking and due to their inefficient mechanism to control vehicle during the mischance. Electromagnetic braking system consist of solenoid coil which is uses principle of electromagnetic effect of electrical current for Braking. This is combination of Electrical and Mechanical components here Electrical energy is used to apply braking torque or retardation. It produces negative power which is twice of the power of machine in a rapid and efficient way.

II. EXISTING BRAKING SYSTEM

The braking system existing now are consist a brake pedal or a lever which is used to exert force pressed through foot and convert it to hydraulic, Mechanical Pressure etc. In this type of braking system due to Mechanical contacts friction is produced and more amount of heat is generated which decrease the life of Braking parts.

III. PRINCIPLE OF WORKING

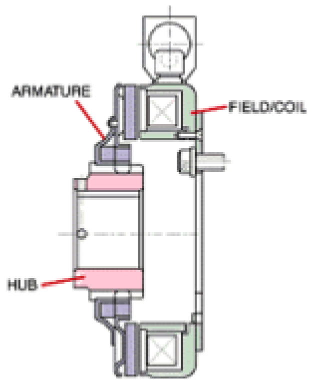
Principle of Electromagnetism is used in Electromagnetic Braking system. When certain amount of current is passed through a round conductor then it produces magnetic field which is uniform all over the conductor. The magnetic field strength depends on the current flowing through conductor and the no of turns more the no of turns and higher the current flowing through conductor higher the magnetic field gets created. Solenoid is the coil having more no of turns and it is used to produce high strength magnetic field which is used in this Electromagnetic Braking.

IV. CONSTRUCTION AND DESIGN OF BRAKING ELECTROMAGNETIC SYSTEM

There are three parts to an electromagnetic brake:

1) field
2) Armature
3) Hub (which is the input on a brake)

Usually the magnetic field is bolted to the machine frame (or uses a torque arm that can handle the torque of the brake). So when the armature is attracted towards the magnetic field the breaking torque is transferred into the field housing and into the machine frame decelerating the load. This can take place very fast in a seconds. Disengagement is very simple. Once the field starts to degrade flux falls rapidly and the armature separates. A spring is use to hold the armature away from its corresponding contact surface in a predetermined air gap.



Components used in Electromagnetic Braking system

Disc liner- The lining is the portion of the braking system which converts the kinetic energy into heat. The lining must be capable of its survival at high temperatures without excessive wear (leading to frequent replacements of machine parts) or out gassing (Decrease in power of Braking). Brake linings are composed of a relatively soft but tough and heat-resistant material with a high coefficient of dynamic friction (and ideally an identical coefficient of static friction) typically mounted to a solid metal backing using high-temperature adhesives or rivets.

Braking coil- An Solenoid coil is formed when a conductor is wound around a core or form to create an electromagnet. When electricity is passed through a coil, it generates a magnetic field. One loop of wire is usually referred to as a turn or a winding, and a coil consists of one or more turns. For use in an electronic circuit, electrical connection terminals called taps are often connected to a coil. Coils are often coated with varnish or wrapped with insulating tape to provide additional insulation and secure them in place. A completed coil assembly with one or more set of coils and taps is often called windings

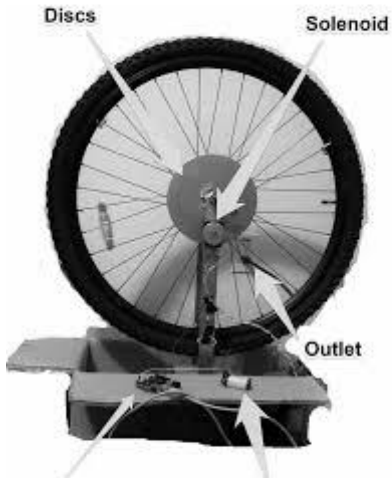
Tension Spring- A spring is an elastic component used to store mechanical energy. Depending on the design and required operating environment, any material can be used to construct a spring .When a spring is compressed or stretched, the force is exerted which is proportional to its change in length.

The rate or spring constant of a spring is the change in the force it exerts, divided by the change in deflection of the spring. That is, it is the gradient of the force versus deflection curve. An extension or compression spring has units of force divided by distance, for example N/m.

Battery- A battery is a device that converts chemical energy directly to electrical energy. It consists of a number of voltaic cells; each voltaic cell consists of two half cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the electrode to which anions migrate, i.e., the anode or negative electrode; the other half-cell includes electrolyte and the electrode to which cations migrate, i.e., the cathode or positive electrode. In the redox reaction that powers the battery, reduction occurs to cations at the cathode, while oxidation occurs to anions at the anode. The electrodes do not touch each other but they are electrically connected by the electrolyte. Some cells use two half-cells with different electrolytes. A separator between half cells allows ions to flow, but prevents mixing of the electrolytes. Each half cell has an electromotive force determined by its ability to drive electric current from the interior to the exterior of the cell. The net EMF of the cell is the difference between the EMF of its half-cells, as first recognized by Volta. Therefore, if the electrodes have EMF and, then the net EMF is in other words, the net EMF is the difference between the reduction potentials of the half-reactions.

Alloy wheel- Alloy wheels have become considerably more common since 2000. Alloy wheels are automobile wheels which are made from an alloy of aluminum or magnesium. They are typically lighter for the same strength and provide better heat conduction and improved cosmetic appearance over steel wheels. The earliest light alloy wheels were made of magnesium alloys. Alloy wheels have long been included as standard equipment on higher-priced luxury or sports cars, with larger-sized or "exclusive" alloy wheels being options. The high cost of alloy wheels makes them attractive to thieves; to counter this, automakers and dealers often use locking wheel nuts which require a special key to remove. Most alloy wheels are manufactured using casting, but some are forged.

Electro-magnet- An electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current. An electric current flowing in a wire creates a magnetic field around the wire. To concentrate the magnetic field, in an electromagnet the wire is wound into a coil with many turns of wire lying side by side. The magnetic field of all the turns of wire passes through the center of the coil, creating a strong magnetic field there. The direction of the magnetic field through a coil of wire can be found from a form of the right-hand rule. The main advantage of an electromagnet over a permanent magnet is that the magnetic field can be rapidly manipulated over a wide range by controlling the amount of electric current.



Assumed data

1) 12kg – M - Rotating mass
2) 2.5 sec - t -Braking time
3) 0.276m – d - Wheel diameter.
4) 150rpm – N- Wheel rotational speed
5) 1.725- R- Ratio of wheel / disc diameter
6) Rd -0.08m -Disc radius
7) μ -0.25- Coefficient of friction
8) Re - 0.06m- Effective disc radius
9) E - 29.0 joules - Total energy of rotating mass
10) I - 8 Amp-hr - Current through coil
11) L- 0.048m - Length of solenoid
12) P- 59.6 x 106 S/m –Electrical disc conductivity
13) R- 0.015m - Radius of electromagnet
14) V- 12- Battery Voltage
15) I- 8-Amp-Hr - Battery Current
16) C- 465 J/Kg0C - Sp. Heat capacity of disc
17) K- 54 watt/m0C - Thermal conductivity of disc

18) Volume-0 0.00003601m3 - Disc volume
19) P- 7850 kg/ m3 - Density of disc
20) μo -4π x 10-7- Permeability of air
21) μs- 2000- Permeability of steel

Finding Design Parameters assuming certain Parameters

Braking force

The total braking force required can simply be calculated using Newton's Second Law

V = Π *d*N/60
= (Π x 0.276 x150)/60
= 2.1666 m/sec .

A = (v-u)/t
= (2.1666-0)/2.5
= 0.86664 m/sec^2

F= m*A
= 12 x 0.867
= 10.40N

T = (Fx 0.5d)/R
= (10.40 x 0.5 x 0.276)/1.725
= 0.832Nm

Clamp force

C = T/ (μ x Re)
= 0.832/(0.25 x 0.06)
= 55.46 N

Brake power

Assuming the stop is from the test speed down to zero then the kinetic energy is given by:-

KE=0.5 x m x v^2
= 0.5x12x2.16662
= 28.149336 Joules

Rotational Energy:

The rotational energy is the energy needed to slow rotating parts. It varies for different vehicles and which gear is selected however taking 3% of the kinetic energy is a reasonable assumption. The power is then given by:

P = E/t
= 29.0/2.5
= 11.61watt

This is the average power. The peak power at the time of braking is double of this.

Brake heating

Fade Stop Temperature Rise

Δt = (P x t)/ (ρ x c x Volume)
= (11.61x2.5)/ (7850*465*3.601*10-5)
= 1.0190 ^{0}C

Magnetic flux density(B):

T=1/2*Σ*δ π*R2*m2*B*z2*[1]
= (0.5x59.6x106 x0.003x5π2 x 0.0152 x 0.0072 x B2) x (1-(0.035/0.996)) =18.01Wb/m2.
B = (μs x μo x n x I)/L
18.01 = (2000 x 4Π x 10-7 x n x 8)/0.048
N= 43turns/m
Magnetic field strength (H):

H = N x I/L
= (43 x 8)/ 0.048 =7166.66 A/m

CONCLUSION

Electromagnetic braking system is found to be more reliable as compared to other braking systems. In oil braking system or air braking system even a small leakage may lead to complete failure of brakes. While in electromagnetic braking coils and firing circuits are attached individually on each wheel, even any coil fails the brake does not completely fails remaining three coil works properly. And this system needs very little of maintenance. In addition, it is found that electromagnetic brakes make up approximately 80% of all of the power applied brake applications. Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles. The frictions brakes can be used less frequently and therefore practically never reach high temperatures. The brake linings would last considerably longer before requiring maintenance and the potentially "brake fade" problem could be avoided. This enhanced braking system not only helps in effective braking but also helps in avoiding the accidents and reducing the frequency of accidents to a minimum. Furthermore the electromagnetic brakes prevent the danger that can arise from the prolonged use of brake beyond their capability to dissipate heat.

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