A Review Paper on Electromagnetic Breaking System

J. Manikandan and Ajay Yadav

Abstract--- We had develop In this paper the electromagnetic braking system. Braking System should ensure the safety and comfort of the passenger, driver and other road user. The brake must be strong enough to stop the vehicle during emergency within shortest distance. The convential braking system are bulky and power to weight ratio is low. Electromagnetic braking system is high-tech braking system find its use in small & heavy vehicle like car, jeep, truck, busses etc. It also reduces the maintenance of braking system. The effectiveness of brake should remain constant. The proper cooling of brake gives anti fade character and efficient operation of brake. Proper lubrication and maintenance must be done to operate brake safe, effective and progressive with minimum fatigue to driver. This system provides better response time for emergency situations and in general keeps the friction brake working longer and safer.

Keywords--- Brake, Electromagnetism, Brake Power, Torque.

I. INTRODUCTION

Electromagnetic brakes have been used as supplementary retardation equipment in addition to the regular friction brakes on heavy vehicles. We outline the general principles of regular brakes and several alternative retardation techniques in this section. The working principle and characteristics of electromagnetic brakes are then highlighted. 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. 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 prolonged periods of time in some applications such as a heavy vehicle descending a long gradient at high speed. Brakes have to have the mechanism to keep the heat absorption capability for prolonged periods of time. In the electromagnetic brake, the coil or solenoid attracts a steel disc. The steel disc presses a brake disc made of sintered or asbestos material between itself and a stationary steel disc. The torque is thus 'grounded' and braking action takes place. This type of brake is used in machines like lathes, presses etc. In electro-magnetic braking system electro-magnetic property is used due to this action of braking will be done. In this system, electromagnet iron plate, liners, tension spring, stud, disc brake plate are used. The brake liners are attached with electromagnet and iron plate individually and both plate insert the disc plate and this plate rigidly attached with wheels. When current is passed through the coil, it produces a magnetic field which magnetizes the core into the bar magnet with the polarities. Strong magnetic field is obtained by high currents of large self-induction.
High currents are not always feasible, which is why a high self-induction is obtained by making a loop of wire in the shape of a coil, a so-called solenoid. More current and more turns produce a stronger magnetic field which results in stronger electromagnet. 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.

II. LITERATURE REVIEW

A number of theories have been proposed in the literature to explain the brake squeal phenomenon. An early experimental investigation found that variation in coefficient in the contact interface was the cause for brake to squeal. In Mills (1938) hypothesised that squeal was associated with the negative gradient characteristics of dynamic friction coefficient against the sliding velocity. He attempted to examine various drum brakes and brake linings and thought that such mechanism was a necessary condition for a brake to squeal. Sinclair (1955) through his mathematical model showed that the presence of such mechanism led to unstable oscillations and gave rise to self-excited vibration in the system. Later, Fosberry and Holubecki (1955, 1961) suggested that the disc brake tended to squeal when either a static coefficient of friction was higher than the dynamic coefficient or a dynamic coefficient decreases with increase of speed present in the contact interface. The above mechanisms are also referred to as “stick-slip” and “negative damping” respectively in current terminology. The stick-slip theory has not received much attention recently except for explaining some low frequency brake vibration problems such as creep-groan whilst negative damping theory still has its place in brakes squeal studies. (1961-1962) seemed to be a first researcher who turns away from the above theories. He proposed a new theory of brake squeal by which the unstable oscillation in the system could also occur even with constant friction coefficient. In describing this mechanism, he developed a model that consisted of a rigid, massless rod (pivoted at one end, O and free to another end with an angle theta) in contact with a rigid moving plane as shown in figure 2.0. An external force, L was loaded to its free end. He found that the instability of the system depended upon the friction coefficient, the magnitude of the friction force, the normal force, N. These two forces then generated a resultant force that formed an angle theta (physically the angle of free end cantilever) which crucial to the stability of the system. When the friction coefficient reached the cotangent of the angle theta, the free end cantilever woupragld ‘s’ or lock and the surface motion become impossible. Due to the flexibility (stiffness) within the system, it allowed the cantilever free itself from the spragging condition. Once the spragging has been relieved, the original contact situation re-established. This process continued and could lead to a sprag-slip limit cycle. In 1971 he attempted to confirm the sprag-slip mechanism through experimental investigation. He observed that squeal was associated with the position of the contact area between the pad and the disc and the nature of the between the cylinder and back contact

Nomenclature

V=Initial velocity

U=Final velocity
A=Deceleration of rotating mass
F=Braking force
T=Braking torque
H=magnetic field length
N= No. of turns/ length of solenoid
P=average power
K.E=kinetic energy

Assume Data

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<th>Notation</th>
<th>Value</th>
<th>Meaning</th>
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<td>Rotating mass</td>
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<tr>
<td>2</td>
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<td>Braking time</td>
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<td>4</td>
<td>N</td>
<td>150rpm</td>
<td>Wheel rotational speed</td>
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<tr>
<td>5</td>
<td>R</td>
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<td>6</td>
<td>Rd</td>
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<td>Disc radius</td>
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<td>Effective disc radius</td>
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<tr>
<td>10</td>
<td>I</td>
<td>8 Amp-hr</td>
<td>Current through coil</td>
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<tr>
<td>11</td>
<td>L</td>
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<tr>
<td>12</td>
<td>Σ</td>
<td>59.6×10⁶ S/m</td>
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<td>R</td>
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<td>14</td>
<td>V</td>
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<td>Battery Voltage</td>
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<td>8 Amp-Hr</td>
<td>Battery Current</td>
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<td>16</td>
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<td>465 J/Kg°C</td>
<td>Sp. Heat capacity of disc</td>
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<td>Disc volume</td>
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<td>20</td>
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<tr>
<td>21</td>
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<td>2000</td>
<td>Permeability of steel</td>
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Braking Force

Brake force also known as brake power is a measure of braking power of a vehicle In the case of railways, it is important that staff are aware of the brake force of a Locomotive so sufficient brake power will be available on trains, particularly heavy Freight trains.

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

\[ V = \pi \times d \times N / 60 = (\pi \times 0.276 \times 150) / 60 = 2.1666 \text{ m/sec} \]

\[ A = (v-u)/t = (2.1666-0)/2.5 = 0.86664 \text{ m/sec}^2 \]
F = m*A = 12 x 0.867 = 10.40 N

**Braking force**

\[ T = \frac{Fx 0.5d}{R} \]
\[ = \frac{10.40 \times 0.5 \times 0.276}{1.725} = 0.832 \text{Nm} \]

Clamp force

\[ C = \frac{T}{(\mu \times Re)} \]
\[ = \frac{0.832}{(0.25 \times 0.06)} = 55.46 \text{N} \]

**Brake Power**

Vehicle braking system fade, or brake fade, is the reduction in stopping power that can occur after repeated or sustained application of the brakes, especially in high load or high speed conditions. Brake fade can be a factor in any vehicle that utilizes a friction braking system, including automobiles, trucks, motorcycles, airplanes, and bicycles.

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

\[ KE = \frac{0.5 m x v^2}{2} \]
\[ = 0.5 x 12 x 2.1666^2 = 28.149336 \text{Joules} \]

**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:

\[ P = \frac{E}{t} = \frac{29.0}{2.5} = \frac{11.61}{\text{watt}} \]

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

**Brake Heating**

Braking fade is caused by a buildup of heat in the braking surface and the subsequent changes and reaction in the brake system component and can be experienced with both Drum brakes. Loss of stopping power, or fade can be caused by friction fade, mechanical fade or fluid fade.

The flux density is the number of magnetic line of flux that pass through a certain point on a surface. The SI unit is T (tesla), which is weber per square metre (Wb/m²)

\[ T = \frac{1}{2} \pi R^2 \sum m^2 B^2 \times \left( \frac{\delta}{1-} \right) \]
\[ = (0.5 x 59.6 x 106 x 0.003 x 5 x 2 x 0.0152 x 0.0072 x B^2) x (1-(0.035/0.996)) = 18.01 \text{Wb/m²} \]
B = (µs x µo x n x I)/L

18.01 = (2000 x 4Π x 10^-7 x n x 8)/0.048

N= 43 turns/m

**Magnetic Field Strength (H)**

Magnetic field strength is one of two ways that intensity of a magnetic field can be expressed. Technically, a distinction is made between magnetic field strength H, measured in amperes per meter (A/m), and magnetic flux density B, measured in Newton-meter per ampere (Nm/A), also called tesla (T).

\[ H = N \times I/L \]

\[ = (43 \times 8)/0.048 = 7166.66 \text{ A/m} \]

**III. RESULT**

By using the electromagnetic brake as supplementary retardation equipment, the friction 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. In research conducted by a truck manufacturer, it was proved that the electromagnetic brake assumed 80 percent of the duty which would otherwise have been demanded of the regular service brake (Reverdin 1974). 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. The installation of an electromagnetic brake is not very difficult. It does not need a subsidiary cooling system. It does not affect the efficiency of the engine. Electromagnetic brake also has better controllability. Thermal stability of the electromagnetic brakes is achieved by means of the convection and radiation of the heat energy at high temperature. The electromagnetic brakes have excellent heat dissipation efficiency. Electromagnetic brakes have better thermal dynamic performance than regular friction brakes.

**IV. CONCLUSION**

As we discussed about the limitations of drum brakes, hydraulic brakes and pneumatic brakes electromagnetic brake is a better and reliable solution. Electromagnetic brake control system is an electric switching system which gives it superior controllability. The installation of an electromagnetic brake is not very difficult. From the foregoing, it is apparent that the electromagnetic brake is an attractive complement to the safe braking of heavy vehicles. Good results with current design, a larger budget would improve performance.

**REFERENCES**


