Safety Brake using Eddy Current

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Abstract— Road and rail vehicles and aircraft rely mainly or solely on friction brakes. These brakes pose several problems, especially in hybrid vehicles: 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 proposed. This concept includes a novel flux-shunting structure to control the excitation flux generated by permanent 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.A simple theory is proposed using Faraday's law and the Lorentz force. With this theory, magnetic braking on Aluminum disc, rotating through a magnetic field is explained.In this work an attempt is made to show that the braking of an electric drives in industries and automobiles using permanent magnets which produce energy while braking and it is a similar one to that of the existing electric regenerative braking. Also to show permanent magnetic system is a better one than existing electromagnetic brake, eddy current brake and electric brakes, etc.

Key words: Permanent magnet, Faradays law, Lorentz force, Magnetic field, Eddy current

I. Introduction

Magnetic brakes are a relatively new technology that is beginning to gain popularity due to their high degree of safety. Rather than slowing a train via friction (such as fin or skid brakes), which can often be affected by various elements such as rain, magnetic brakes rely completely on certain magnetic properties and resistance. In fact, magnetic brakes never come in contact with the train.

Magnetic brakes are made up of one or two rows of neodymium magnets. When a metal fin (typically copper or a copper/aluminium alloy) passes between the rows of magnets, eddy currents are generated in the fin, which creates a magnetic field opposing the fin's motion. The resultant braking force is directly proportional to the speed at which the fin is moving through the brake element.

Towards green technology, which focuses on the importance of environment conservation, a transition to a new braking system is needed i.e. a new braking system to replace the conventional braking system.

II. Concept

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 (Electromotive Force) 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.

As the rotating disc enters the magnetic field a series of eddy currents will be produced (as explained by Lenz’s law). This produces a magnetic field that will oppose the change brought about by the rotating disc. If the magnetic field of the permanent magnet is coming out of the page then the induced magnetic field will be into the page. The induced current will be in a clockwise direction to produce this field. This will bring the disc to a halt very quickly and will result in a small amount of heat being produced by the eddy currents.

III. Construction

SR. NO.	PART NAME	MATERIAL	QUANTITY
1	MOTOR	STD	1
2	PULLEY	CI	2
3	BELT	RUBBER CANVAS	1
4	SHAFT	MS	1
5	PEDESTAL BEARING	CI	2
6	MAGNET PLATE	MS	1
7	ALLUMINUM PLATE	AL	1
8	FRAME	MS	1
9	MAGNETS	REAR EARTH	12
10	NUT & BOLT	MS	8

Table 1:

A. Motor

Speed of the motor N = 1350 rpm and transmission ratio of about I = 3 so as to match the speed of normal car.

Angular speed $\omega = \frac{2\,\pi \times N}{60}$ = 141.37 rad/sec

Torque $T = F \times R = 12\times 0.1 = 1.2$ Nm

Power $P = T\times \omega = 1.2 \times 141.37 = 169.644$ W = 0.227 hp Hence selecting 3-ϕ Motor of 0.25 hp @ 1350 rpm.

B. Selection Of Pulley And Belt

For P = 0.25 KW N = 1350 rpm
Reduction ratio i = 2.7
Centre distance C =180 mm
Select “A” Cross-section of V-belt.
Input pulley dia. D1 = 76 mm & Output pulley dia. D2 = 28 mm

Belt Length $L = 2C + \frac{\pi}{2} \times (D1 + D2) + \frac{(D2-D1)^2}{4C}$

L = 526.56 mm
Selecting Standard Rubber Canvas Belt of Length L = 580 mm.
Calculating exact centre distance C = 192 mm.
Since diameter of both pulleys D < 280 mm
Hence taking solid construction for both the pulleys.

C. Shaft Design

Taking both Bending and Torsion consideration in design of shaft.
Shaft diameter ds = 20mm.

Total length L_s = 558 mm

D. *Magnet Plate Design*

Neodymium magnets are placed in such a way that magnets adjacent to each other has reverse polarity (N-S-N-S-N-S) at a radial distance of 100 mm.
Diameter of magnet plate D = 240mm.
Thickness t = 5mm.
Diameter of hub. D_h = 2D = 40mm.
Length of hub. L_h = 1.5D = 30mm

E. *Aluminum Plate Design*

Diameter d =240mm
Thickness t =5mm
Diameter of hub D_h = 2D = 40mm
Length of hub L_h = 1.5D = 30mm

IV. WORKING OF MODEL

We have used 3-ϕ motor to rotate the shaft along with steel plate. The power from the motor is transmitted through pulley and belt with transmission ratio of 2.7. Magnets are mounted on steel plate at a radial distance of 10 cm. Steel plate rotates along with the shaft due to which varying magnetic field is obtained .When aluminum plate is brought near to rotating steel plate , it cuts varying magnetic field . Hence as per Faraday's law an emf induced in the aluminum plate. The induced emf generates eddy current in the aluminum plate. According to Lenz's law, the direction of the current is in such a way as to oppose the cause, i.e. rotation of the disc.

Fig. 1:

V. OBSERVATION

Motor power P = 0.25 hp = 186.425 W ,
N =1350 rpm
Transmission ratio i = 2.71
At shaft P = 186.425 W, N = 3600 rpm
Torque T = P /ω = 186.425 / 377= 0.495 Nm

Distance Between Plates , D (mm)	Speed Of Steel Plate ,N (rpm)
1	00
2	240
3	520
4	1100
5	1900
6	2400
7	2600

Table 2:

VI. CALCULATION

As we move Al plate near rotating magnets speed of steel plate decreases and torque increases (since constant power from motor). The increase in torque is the braking torque
At d = 1 mm , N = 450 rpm , ω = 47.124 r/s
Since power of the motor is constant
Power = T *ω
T = 186.425 / 47.124 = 3.95 Nm
Braking Torque T = increase in torque
= Final torque – Initial Torque
= 3.95 – 0.495
= 3.455 Nm

D (mm)	N (rpm)	Torque T (Nm)
1	450	3.455
2	520	2.925
3	770	1.820
4	1160	1.040
5	1800	0.494
6	2600	0.190
7	2800	0.141

Table 3:

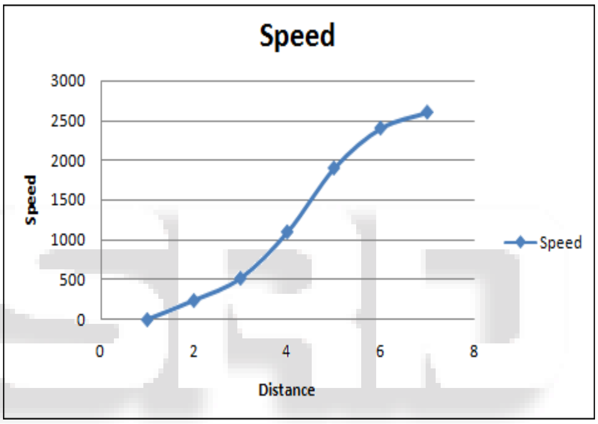

Fig. 2:

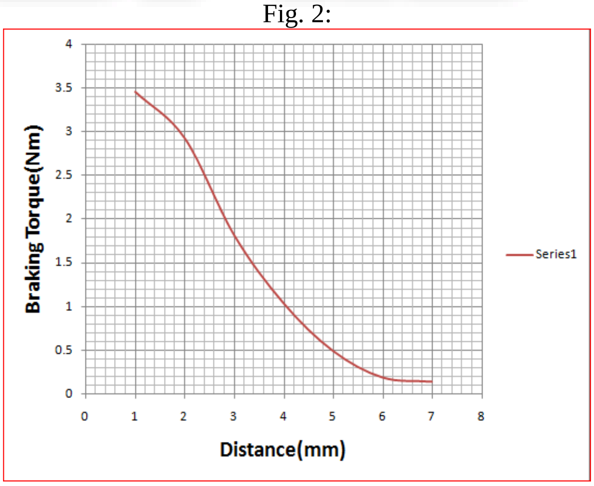

Fig. 3:

VII. ADVANTAGES

1) Magnetic brakes are friction-less and wear free.
2) Less maintenance cost.
3) Good performance at High speed.
4) Reduction of overall wastage of energy.
5) Regenerative braking even supplies back the energy it consumes back to the system for future use.

VIII. Disadvantages

1) Braking force diminishes as speed diminishes with no ability to hold the load in position at standstill
2) That could be considered to be a safety issue, but it really means that friction braking may need to be used as well
3) Magnetic brakes can only be used where the infrastructure has been modified to accept them

IX. Applications

1) For additional safety on long decants in mountain area.
2) For high speed passenger and goods vehicles.
3) It can also be used to slow down the trolleys of faster roller coaster.
4) It can be used in train and road vehicles because of jerk free operation.

X. Conclusion

As we have seen, our experimental setup allows us to investigate one of the most outstanding aspects of eddy current, namely their reduction in speed with respect to decrease in distance between the plates. The results show a reasonable but not indisputable agreement with theoretical prediction.

Nevertheless the we believes that the experiments deals with concepts, instruments and measurement techniques with high didactic value for us, regardless of whether the agreement between theory and experiments is good or poor.

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