Study of Combined Braking System Using Eddy Current

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Abstract

The most efficient way of braking is to apply front and rear brakes simultaneously. But it is practice, most two - wheeler riders have not mastered. The combi brake system enables to use both brake with just one lever. It reduces braking distance and improves stability while braking. It prevents slipping of two – wheelers. In our project we are using combi brake technology in contactless braking system to avail frictionless braking with the advantage of Combi brake. 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 developed. 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. The present dissertation includes an introduction to friction braking, a theory of eddy-current braking, analytical and numerical models of the eddy-current brake, its excitation and power generation, record of experimental validation, investigation and simulation of the integration of the brake in conventional and hybrid vehicles.

I. INTRODUCTION

In the operation of any machinery, the most primary safety system is the braking system. The most basic designs of the braking system involve the conversion of kinetic energy to heat energy by friction. This is accomplished by friction between two rubbing surfaces. These brakes pose several problems i.e. significant wear, fading, complex and slow actuation, lack of fail-safe features, increased fuel consumption due to power assistance, and the requirement for anti-lock controls. To solve these problems, a contactless magnetic brake has been developed. This concept includes a metals disk which will conduct eddy currents generated by magnets.

This brake is wear-free, less-sensitive temperature than friction brakes, has fast and simple actuation, and has a reduced sensitivity to wheel lock. This is achieved by the generation of braking torque by a magnetic field across a moving conductor which creates a perpendicular magnetic field by induced eddy currents. Contactless brakes can be applied to any machinery like automobiles, locomotives, roller coasters, hydraulic and turbo machinery, machine tools, elevators, etc. The wide range applicability of these brakes strongly implies the effectiveness and ease of operation. The braking force can be adjusted to control higher torque loads by varying the coil turns or by increasing the voltage. This gives flexibility of operation of the system and makes it reliable even in changing loading patterns. A study of eddy current braking system is performed to find out the practical limit of using an electromagnetic braking system.
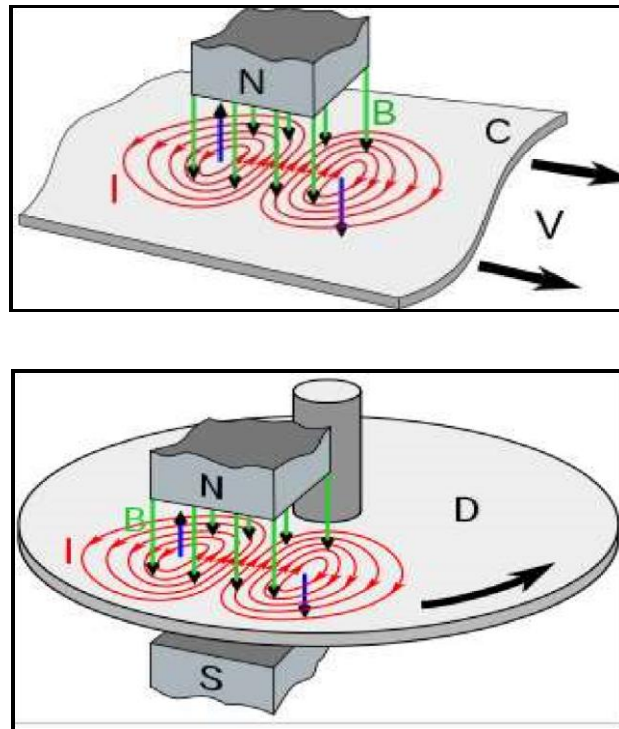
Fig.1 FBD of Eddy Current Principal   [7]

II. LITERATURE REVIEW

Oscar Rodrigues et al. [2016] [1], The purpose of the study was to perform a comparative study of theoretical and practical

braking time and establish a practical air gap limit beyond which the electromagnetic brakes lose their effectiveness. From theoretical calculations and experimented braking time values, a maximum reduction in braking time 23.97% is found and max air gap limit of 3 mm is obtained beyond with electromagnetic brakes are found to be ineffective.

Baoquan Kou et al [2015] [2], in this paper, a novel hybrid excitation linear eddy current brake was presented. The hybrid

excitation linear eddy current brake has the advantages of high force density and low excitation loss compared to the electric excitation linear eddy current brakes. The validity of the analytical model was verified by the FEM and experimental tests, therefore the analytical model can be used in the preliminary design of eddy current brakes. Parametric analysis was performed to explore the influence of the design parameters on the eddy current brake performance. Moreover, the experimental results show that the eddy current brake can generate objective braking force using the controller proposed in this paper. It has been found that the proposed eddy current brake system can be used in road and rail vehicles.

Arunesh Kumar Singh et al [2014] [3] this paper presented a detailed study of different types Eddy Current Braking System. Various applications of ECBS such as retarders in high speed trains, in automobiles, dampers, couplers and in the air bearing system have been studied. Various design parameters on which the performance of ECBS depends have been discussed. It has been observed that some parameters like air gap length, the electrical conductivity of conductor, the speed of conductor are common in all the applications. Effect of parameters on the performance of ECBS has also been discussed. Main parameters which affect the performance of ECBS are the thickness of conductor, air-gap length, the electrical conductivity of conductor, magnetic properties of conductor. The value of design parameters should be taken in such a way to achieve optimum braking performance.

Yasuaki Sakamoto et al [2008] [4], they have estimated the performance of the eddy current brake using a LIM for dynamic

braking from experimental results of a fundamental test machine. We confirmed that the LIM under constant current excitation has an approximately constant braking force regardless of both the velocity and frequency, for relatively low frequencies. The LIM generates electric power which is determined by only the frequency. The peak value of the reduction ratio of rail heating is 60%. These characteristics are convenient for designing a controller for the LIM rail brake system.

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Sohel Anwar and Bing Zheng [2007] [5], they have a nonlinear sliding-mode-type controller is presented for slip regulation
in a braking event for an eddy-current-based BBW system in this paper. It is also shown that the closed-loop system is stable in the sense of Lyapunov. Experimental results show very good slip regulation in a braking event on the low friction coefficient surface when compared with the non-ABS braking condition. The results show that the proposed ABS controller provided a smooth ABS stop as evident from the vehicle speed plots.

P. J Wang and S. J Chiueh [1998] [6], in this paper, comparison on the operating characteristics of eddy current brakes of
high speed railway between numerical simulation and experimental data are shown. The results based on finite difference method shows that braking forces are over predicted due to the assumption on the 2-D flux distribution confined on the pole face in the airgap. But the results based on Fourier series method show that the braking forces are under predicted due to the assumption on sinusoidal travelling flux.

III. PROBLEM DEFINATION

We are designing and developing a "Test rig on Eddy-Current braking system" a portable equipment, which can be used
as a frictionless braking system. This system is based on the principle Faraday's law and Lorentz principle.

Objectives:
- Development of test rig
- It must be easy to use
- The test rig should give the accurate and precise results
- It must be robust and insensitive

IV. PROPOSED METHODOLODGY

A. *Concept Design*

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 e.m.f 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.

Essentially the eddy current brake consists of two parts, a stationary magnetic field system and a solid rotating part, which
include a metal disc. During braking, the metal disc is exposed to a magnetic field from an electromagnet, generating eddy currents in the disc. The magnetic interaction between the applied field and the eddy currents slow down the rotating disc. Thus the wheels of the vehicle also slow down since the wheels are directly coupled to the disc of the eddy current brake, thus producing smooth stopping motion.

B. *Market Survey*

According to our concept of the project, we study many types of eddy current braking system and compare the design of
our braking system. On the basis of the survey, we have selected of data which is further discussed in material selection.

C. *Material Selection*

1) *Rotor Disc*: The rotor is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon– carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To retard the wheel, friction material in the form of brake pads, mounted on the brake calliper, is forced mechanically, hydraulically, pneumatically, or electromagnetically against both sides of the rotor. Friction causes the rotor and attached wheel to slow or stop.

2) *Shaft*: A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it. The material used for ordinary shafts is mild steel. When high strength is required, an alloy steel such as nickel, nickel-chromium or chromium-vanadium steel is used. Shafts are generally formed by hot rolling and

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finished to size by cold drawing or turning and grinding. C45 is a medium carbon steel is used when greater strength and hardness is desired than in the "as rolled" condition. Extreme size accuracy, straightness, and concentricity combine to minimize wear in high speed applications. Turned, ground and polished.

3) *Permanent Magnet*: In an eddy current brake the magnetic field may be created by a permanent magnet, or an electromagnet so the braking force can be turned on and off or varied by varying the electric current in the electromagnet's windings. Another advantage is that since the brake does not work by friction, there are no brake shoe surfaces to wear out, necessitating replacement, as with friction brakes. A disadvantage is that since the braking force is proportional to velocity the brake has no holding force when the moving object is stationary, as is provided by static friction in a friction brake, so in vehicles, it must be supplemented by a friction brake. D. *Existing Method*

1) *Ordinary Brakes*: Moving things have kinetic energy and, if you want to stop them, you have to get rid of that energy somehow. If you're on a bicycle going fairly slowly, you can simply put your feet down so they drag on the ground. The soles of your feet act as brakes. Friction (rubbing) between the rough ground and the grip on your soles slows you down, converting your kinetic energy into heat energy (do it long enough and your shoes will get hot). Brakes on vehicles work pretty much the same way, with "shoes" that press rubber pads (brake blocks) against discs mounted to the wheels.

2) *Eddy Current Brakes*: If the conductor we are moving through the magnetic field isn't a wire that allows the electricity to flow neatly away. We still get electric currents, but instead of flowing off somewhere, they swirl about inside the material. These are what we call eddy currents.
They're electric currents generated inside a conductor by a magnetic field that can't flow away so they swirl around instead, dissipating their energy as heat. One of the interesting things about eddy currents is that they're not completely random: they flow in a particular way to try to stop whatever it is that causes them. This is an example of another bit of electromagnetism called Lenz's law (it follows on from another law called the conservation of energy, and it's built into the four equations summarizing electromagnetism that were set out by James Clerk Maxwell).

Here's an example. Suppose you drop a coin-shaped magnet down the inside of a plastic pipe. It might take a half second to get to the bottom. Now repeat the same experiment with a copper pipe and you'll find your magnet takes much longer (maybe three or four seconds) to make exactly the same journey. Eddy currents are the reason. When the magnet falls through the pipe, you have a magnetic field moving through a stationary conductor (which is exactly the same as a conductor moving through a stationary magnetic field). That creates electric currents in the conductor—eddy currents, in fact. Now we know from the laws of electromagnetism that when a current flows in a conductor, it produces a magnetic field. So the eddy currents generate their own magnetic field. Lenz's law tells us that this magnetic field will try to oppose its cause, which is the falling magnet. So the eddy currents and the second magnetic field produce an upward force on the magnet that tries to stop it from falling. That's why it falls more slowly. In other words, the eddy currents produce a braking effect on the falling magnet. It's because eddy currents always oppose whatever causes them that we can use them as brakes in vehicles, engines, and another machine.

E. *Calculation*   Mild steel C-45 is

selected for our project.

1. Easily available in all sections.

2. Welding ability

3. Machining ability

4. Cutting ability 5. Cheapest in all other metals.

Material = C 45 (mild steel)   Take F.O.S.
2 $\sigma_t = \sigma_b = 540/F.O.S. = 270$ N/mm^2 $\sigma_s =$
$0.5 \sigma_t$
   $= 0.5 \times 270$
   $= 135$N/mm^2

DESIGN OF MOTOR

Power of motor = 373 N- m /s
Rpm of motor = 1140 rpm
Calculation for final speed & torque   Power of motor
$= P = 373$ watt.

$$P = 2\pi N T / 60$$

Where,

N→ Rpm of motor = 1140 rpm

T →Torque transmitted

$373 = (2\pi \times 1140 \times T)/60$

$T = 3.12$ N-m

$T_1 = 3124$ N-mm

Now, pulley of 75 and 125 diameter is mounted

So, ratio: 1.66

$T_2 = 5206.6$ N-mm

$N_2 = 686.7$ rpm

V. CONCLUSIONS

While concluding this part, we feel quite satisfied with having completed the project synopsis well on time. We had enormous practical experience on the manufacturing schedules of the working project model. We are, therefore, happy to state that the inculcation such of mechanical aptitude proved to be very useful. We are overwhelmed at the arriving of the targeted mission. Undoubtedly the joint venture had all the merits of interest and enthusiasm shown by all us the credit goes to the healthy coordination of our batch colleague in bringing out a resourceful fulfilment of our assignment described by the university. The design criterion imposed challenging problems which however were welcome by us due to the availability of good research papers. The selection of choice of raw materials helped us in minimizing the level of wear and tear.

Thus we have learned that by the use of eddy current braking system we can reduce the wear, maintenance cost, increased durability is achieved. Hence, due to all these factors, overall cost is reduced. Eddy current braking system is used for dynamic braking. Due to its various applications as discussed earlier, it can use as a secondary braking system.

REFERENCES

[1]. Oscar Rodrigues, Omkar Tasker, Shrutika Sawardekar, Henderson Clemente, Girish Dalvi, "Design & Fabrication of Eddy Current Braking System", International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 04 |

[2]. Apr-2016

[3]. Baoquan Kou, Yinxi Jin, Lu Zhang and He Zhang, "Characteristic Analysis and Control of a Hybrid Excitation Linear Eddy Current Brake", Energies 2015, 8, 7441-7464; doi: 10.3390/en8077441

[4]. Arunesh Kumar Singh, Ibraheem, Amit Kumar Sharma, "Parameter Identification of Eddy Current Braking System for

[5]. Various Applications", International Conference on Innovative Applications of Computational Intelligence on Power, Energy, and Controls with their Impact on Humanity (CIPECH14) 28 & 29 November 2014

[6]. Yasuaki Sakamoto, Takayuki Kashiwagi, Takashi Sasakawa, Nobuo Fujii, Member IEEE, "Linear Eddy Current Brake for Railway Vehicles Using Dynamic Braking", Proceedings of the 2008 International Conference on Electrical Machines

[7]. Sohel Anwar and Bing Zheng, "An Antilock-Braking Algorithm for an Eddy-Current-Based Brake-By-Wire System", IEEE Transactions On Vehicular Technology, Vol.56, No. 3, May 2007

[8]. P. J. Wang and S. J. Chieuh, "Analysis of Eddy-Current Brakes for High Speed Railways" Transactions On Magnetics, VOL

[9]. 34, NO.4, JULY 1998

[10]. https://en.wikipedia.org/wiki/Eddy_current_brake