

Eddy Current Embedded Conventional Braking System

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ABSTRACT: Eddy current is the one among comparing with ordinary brakes, which are being used to stop the vehicle by means of mechanical blocking. This leads to skidding and wear& tear of the vehicle. And if the speed of the vehicle is very high, the brake does not provide that amount of high braking force and it will cause problems. Because of these drawbacks of ordinary brakes arises a simple and effective mechanism of braking system 'The eddy current brake'. It is a frictionless method for braking of vehicles including trains.

Eddy current is one of the most outstanding of electromagnetic induction phenomena. Even though it appear many technical problems because dissipative nature it has some valuable contributions.

This paper explores to achieve the effective braking performance without any physical contact, the only solution to overcome this problem is Eddy Current Embedded conventional braking system. As it is a frictionless brake, periodic change of braking components are reduced. If Embedded Eddy Current brake is employed in automobiles, the braking would be more efficient than the present friction based brake and braking cost in automobiles could be reduced to a larger extend. Also toxic smell caused by friction brakes during vehicle motion can be reduced.

KEYWORDS: Conventional Braking System, Eddy Current Braking System, Eddy Current Embedded conventional Braking System

I. INTRODUCTION

"EDDY" the term was developed by Focault Bae J. S.(2004) found that when the magnetic flux is linked with a metallic conductor changes, induced currents are developed a conductor in the form of closed loops. These currents are known as eddy current.

When there is a conductive material, which breaks through a time varying magnetic flux, eddy current are developed in the conductor. These eddy current flow inside the conductor developing a magnetic field of opposite polarity as the applied magnetic field founded by Bae J. S.(2004). The interaction of two magnetic fields causes a force that resists the change in magnetic flux. However, due to internal resistance of conductive material, the eddy current will be dissipated into heat and the force will die out.

There are some main literature references which is mentioned here as follows.

[1]. "Analysis of Eddy-Current and Magnetic Rail Brakes for High-Speed Trains"- Sergey Kitanov et al - The investigation of eddy-current and magnetic rail brake structures is described. It is demonstrated that a brake built up from permanent magnet pieces that combines both magnetic rail brake and eddy-current brake permits of the most profitable braking action through the whole range of acceptable speeds – from zero (a parking brake) to 350 km/hr.

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- [2]. “A Parametric Analysis of Magnetic Braking – The Eddy Current Brakes – For High Speed and Power Automobiles and Locomotives- Er. Shivanshu Shrivastava - In this paper, eddy current braking system is modelled in SIMULINK and effects of various parameters are observed over the overall braking. This would provide a comparative study between the various parameters involved and understand the braking system.
- [3]. “Innovative Electro Magnetic Braking System”- Sevvel et al - In this paper the advantage of using the electromagnetic braking system in automobile is studied. These brakes can be incorporated in heavy vehicles as an auxiliary brake. The electromagnetic brakes can be used in commercial vehicles by controlling the current
- [4]. “Experiments with eddy currents: the eddy current brake”- Manuel I Gonzalez- This paper shows qualitative and quantitative results by means of experimental setup to be measured the eddy current losses and to relate them the various relevant parameters. For each experiment the typical results are presented, and compared with theoretical predictions are included.
- [5]. “Enhancement of Braking System in Automobile Using Electromagnetic Braking”-Akshyakumar S.Puttewar et al-. In this paper aims with a view to enhance to the braking system by minimizing the brake failure to avoid the road accidents in automobile, a prototype model is fabricated and analyzed. An advantage of this system is that it can be used on any vehicle with minor modifications to the transmission and electrical systems.
- [6]. “The Design of Eddy-Current Magnet brakes “-Der-Ming Ma et al- In this paper, concentrating only the constant magnetic field is the simplest and easiest design to implement an experimental braking system using constant magnetic field is build to demonstrate the design procedure.
- [7]. “Eddy Current Braking Embedded System”- Virendra Kumar Maurya et al-This paper explores the working principle of eddy current brake mechanism, which can be analyzed by Maxwell 3D Transient solver. An eddy current brake, like a conventional friction brake, is responsible for slowing an object, such as a train or a roller coaster etc. Unlike the friction brakes, which apply pressure on two separate objects, eddy current brakes slow an object by creating eddy currents through electromagnetic induction which create resistance, and in turn either heat or electricity.
- [8].” Brake Performance Analysis of ABS for Eddy Current and Electrohydraulic Hybrid Brake System- Ren He et al- This paper introduces an eddy current and electro-hydraulic hybrid brake system to solve problems such as wear, thermal failure, and slow response of traditional vehicle brake system. Mathematical model was built to calculate the torque of the eddy current system and hydraulic brake system and analyze the braking force distribution between two types of brake systems.
- [9]. “A laboratory activity on the eddy current brake”-J A Molina-Bol´ıvar et al-The aim of this paper is to provide a low-cost experimental setup to study the eddy current brake, which considers the motion of a sliding magnet on an inclined conducting plane and they a set of quantitative experiments performed to study the influence of the geometrical and electromagnetic properties of the magnet on the magnetic drag force
- [10]. “Design of an Innovative Car Braking System using Eddy Currents”- David Jose Torres Cruz-This paper describes Finite element modelling of the system provided computational results that allowed an ensuing parametric study of the behaviour of the innovative car actuator system.

II. TYPES OF EDDY CURRENT BRAKES

Eddy current brakes are divided as follows:-

- (i) Circular eddy current brake and
- (ii) Linear eddy current brake system.

CIRCULAR EDDY CURRENT BRAKE SYSTEM

Electromagnetic brakes are similar to electrical motors; non-ferromagnetic metal discs (rotors) and are connected with a rotating coil, a magnetic field between rotor and the coil creates a resistance and generate an electricity. If electromagnets are used, control of braking action is made possible by varying the strength of magnetic field. A braking force is possible when an electric current is passed through electromagnets. The movement of the metal through

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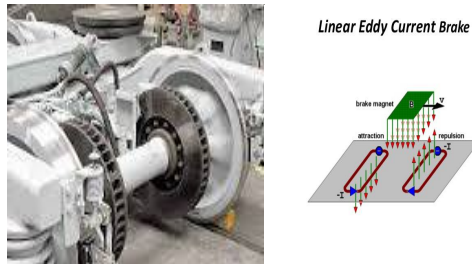
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magnetic field of electromagnets creates eddy current in the discs. These eddy current produce an opposing force, which then resists the rotation of the discs, providing braking force.

LINEAR EDDY CURRENT BRAKE

The principle of this brake has been elaborated by the French physicist "Focault", the linear eddy current brake consists of a magnetic centre with coils positioned along the rail, which are being magnetized alternating both south as well as north magnetic poles. This magnet does not touch the rail, as with the magnetic brake, because it is fixed at small distance from the rail. It does not move along the rail, exerting only a vertical pull on the rail. When the magnet moves with the rail, it develops a non-stationary magnetic field in the head of the rail, which then develops electrical tension, and causes eddy current. These disturb the magnetic field in such a way that the magnetic force towards the opposite direction of the movement thus creating a horizontal force which works in opposite direction of movement of the magnet.



*Circular and Linear Eddy Current Braking
Fig 1 shows*

III. EDDY CURRENT BRAKING

Eddy current flow in a circular path. In order to generate eddy current for an inspection a "probe" is used. Inside the probe is a length of electrical conductor which is formed into a coil. Alternating current is allowed to flow in the coil at required frequency for the test involved. A dynamic expanding and collapsing magnetic field forms in and around the coil as the alternating current flows through the coil. When a conductor is placed in the magnetic field electromagnetic induction will occur and eddy current will be generated in the material. Eddy current flowing in the material will generate their secondary magnetic field which will oppose the coil's primary magnetic field acc. to the Lenz's rule.

IV. EDDY CURRENT BRAKING INSTALLATION AND LOCATION

The installation location of Electromagnetic brakes near to the moving part. Electromagnetic brakes satisfy all the energy requirements of braking at high speeds, completely frictionless. Due to its specific installation location (transmission line of rigid vehicles), electromagnetic brakes have better heat dissipation capability to avoid problems that friction brakes face.

The propeller shaft is split and fitted with a sliding universal joint and is connected to the coupling flange on the brake. The brake is fitted into the chassis of the vehicle by means of anti-vibration mounting. The practical location of the retarder in the vehicle prevents the direct impingement of a iron the retarder caused by the movement of the vehicle. Any air flow within the chassis of the vehicle is found to have a relatively insignificant effect on the air flow in tire areas and also on the temperature of both front and rear discs. So the application of the retarder will not affect the temperature of the regular brakes. In that way, the retarders help to extend the life duration of the regular brakes and keep them cool for emergency situation.

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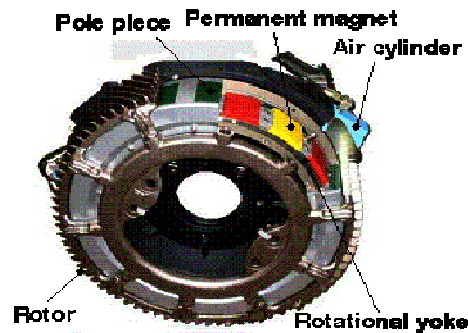
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*Images of Eddy Current Braking System- Parts
Fig 2 Shows*

V. FRICITIONLESS EDDY CURRENT BRAKING SYSTEM

The simulation of eddy current brakes is difficult because,

- (1) A fine loop is required due to very small skin depths. A transient solution with time-stepping is necessary.
- (2) Physical effects such as nonlinear saturation, skin effects and motion induced eddy current must be considered simultaneously.
- (3) A multiple domain eddy current regions are needed including master/slave boundaries.

The results from three unique simulations will be shown while pointing out the challenges of each design and the methodology needed to allow the simulation to be successful Collaborative.

They can be analyzed by Maxwell 3D Transient solver .Which is well suited for magnetic problems with motion. Solves transient magnetic fields caused by time-varying or moving electrical sources and permanent magnets. It uses both linear and nonlinear materials. The excitation can be DC, sinusoidal and transient voltages or currents.

VI. WORKING PRINCIPLE OF EDDY CURRENT EMBEDDED CONVENTIONAL BRAKING SYSTEM

When a conductor in the form of disc rotating at a high speed, its breaks the magnetic flux lines, hence an electro motive force will be induced in the disc, every emf has certain amount of voltage present in it, being voltage has a magnetic property in nature.

The brake consist of a two permanent magnets on both the sides, against the disc while applying brake, the magnets come against the disc, due to the magnetic repulsion between the eddy current produced in the disc and the magnet would decrease the speed gradually at (high speed) In order to bring the vehicle to abrupt rest,(at low speed)conventional brakes were coupled together, being the conductor was also magnetic in nature, the opposing magnetic field caused by the two permanent will bring the disc to rest abruptly. The eddy current produced in the metallic conductor will be carried by the carbon brushes and stored in the battery with the help of ECU. Most important thing is, it's contactless, frictionless and maintenance is easy.

Wide variety of brakes had been introduced since the beginning of industrial revolution to bring the vehicle to rest. In earlier days braking is done by mechanical blocking. In 1930's Hydraulic braking systems were used allowing more consistent force distribution. Then in 1960's Disk brakes were introduced resulting in shorter stopping distances. But much like drum brakes it has limited thermal mass.

Friction produces heat in all these braking systems and the heat loss is more. Use of friction lead to some disadvantages. In conventional braking system, Friction plays a major role. Friction results in the generation of heat thus losing energy While travelling at high speeds sudden braking leads to either brake jamming or upsetting the

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vehicle and also leads to wear of brake pads and tyres. These problems can be resolved by “EDDY CURRENT EMBEDDED CONVENTIONAL BRAKING SYSTEM”.

Electromagnetic induction is the principle behind eddy current embedded conventional braking system. Eddy current brakes make use of opposing tendency of eddy currents. Eddy current embedded conventional braking system is a merging of eddy current brake and conventional brake. These brakes have been used in trains and roller coasters successfully. So far no ideas had been that much effective in implementing the eddy current embedded conventional braking system in automobiles. “Eddy Current Embedded Conventional Braking System” is the only way to solve this.



*Images of Eddy Current Braking System
Fig 3 Shows*

VII. ADVANTAGES & DISADVANTAGES OF EDDY CURRENT EMBEDDED CONVENTIONAL BRAKING SYSTEM:

Some of the main advantages are

i) These are non mechanical, no moving parts hence no friction., ii) Fully resettable, no parts need to be replaced., Can be activated at will via electrical signal., iii) Low maintenance cost, iv) Operates at any rotational speed.

Few Disadvantages are

i) Braking force diminishes as speed diminishes with no ability to hold the load in position at standstill.
ii) That could be considered to be a safety issue, but it really means that friction braking may need to be used as well.,

Eddy-current brakes can only be used where the infrastructure has been modified with **Eddy Current Embedded Conventional Braking System** to accept them.

VIII. CONCLUSION

With all the advantages of electromagnetic brakes over friction brakes, they have been widely used on heavy vehicles where the ‘brake fading’ problem is serious. The same idea is being implemented for application on lighter vehicles.

A Halbach magnetized mover was applied to a high-speed eddy current braking system. According to 2-D field solutions considering dynamic end effect, the magnetic field, eddy current flow through the system, and forces as per the secondary relative permeability and conductivity were presented.

It was observed that the air-gap flux density has a non uniform distribution for the high speed.

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