IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 6, May 2023

Development of Electromagnetic Braking

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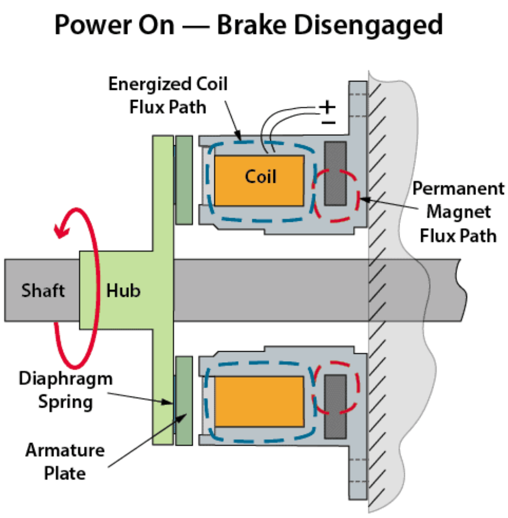
Abstract: *Electromagnetic braking is a promising technique to make driving more secure and energy-efficient. Within this paper, we investigate the influence of electromagnetic braking on vehicle dynamics. Consequently, we devise a mathematical model for a vehicle outfitted with electromagnetic brakes and analyze both its equilibrium and performance characteristics. To gain insight into the effectiveness of electromagnetic braking in multiple settings, simulations were also conducted.*
The outcomes demonstrate that electromagnetic braking can greatly augment vehicle steadiness as well as diminish halting distances. Moreover, it was discovered that the success of electromagnetic braking highly depends on the speed and weight of the motorized transport. Furthermore, electric vehicles may better capitalize on their energy efficiency by utilizing regenerative braking, permitting them to recover a percentage of the kinetic energy during deceleration. All in all, our analysis demonstrates the promise of electromagnetic braking concerning optimizing car security and energy efficiency. Through shedding light on this technology and its possible integration in future vehicles, our research endows supportable insights for advancing this remarkable invention.

Keywords: *Electromagnetic braking, vehicle dynamics, stability, regenerative braking, energy efficiency.*

I. INTRODUCTION

Braking is a critical function of any car, and its effectiveness can have an essential influence on vehicle safety as well as fuel economy. Hydraulic brakes have been the standard braking system in vehicles for many years, however their response time, efficacy, and dependability - particularly when applied to high-speed or energy-sapping vehicles - are shortcomings which are noted. Electromagnetic braking is an emergent technology that has displayed potential in augmenting car braking execution. This technology uses the fundamentals of electromagnetism to establish a magnetic radius which applies a restraining pressure on the car's wheels. In comparison with traditional braking systems, electromagnetic brakes possess some notable edges such as quicker action speed, more accurate control and diminished wear and tear upon brake components.



This evaluation explores the consequences of electromagnetic braking on automobile handling. A numerical representation of a car provided with electromagnetic brakes is developed and its steadiness and performance characteristics are then assessed. Simulations are also conducted to determine the competency of electromagnetic brakes in contrasting scenarios.

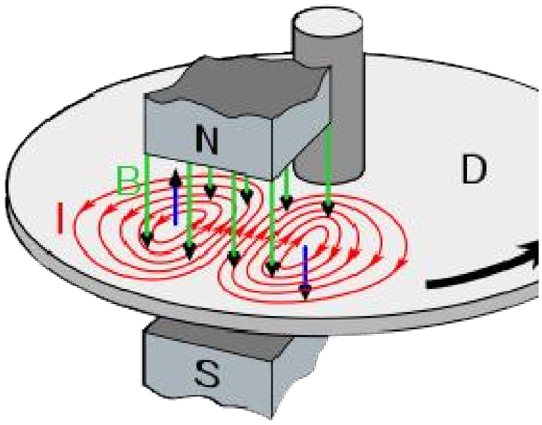
II. OBJECTIVE

The aims of electromagnetic braking can fluctuate depending on the specific usage, however in general, the primary goals of this mechanism are:

1. Regulation and Precision: Electromagnetic braking offers exact regulation over the motion of moving objects. The goal is to reduce speed or cease the object in a regulated manner without inducing damage or instability.
2. Efficient Energy Utilization: Electromagnetic braking is a regenerative braking system that enables kinetic energy to be transformed into electrical energy. The primary objective of this mechanism is to store the acquired energy for future usage, augmenting energy efficiency and cutting energy costs.
3. Ensuring Safety: Electromagnetic braking is frequently asked to aid in situations which demand utmost safety, like transportation and production. Therefore, one key purpose of the implemented brake is to halt any moving object quickly as well as safely in times of calamity.
4. Dependability: Electromagnetic braking systems must be highly dependable and robust to diminish regular maintenance or downtime. Thus, the ultimate goal would be to construct an underpinning frame for the braking process that can withstand adversities such as difficult conditions and frequent use without sundering apart.
5. Economically Viable: Even though electromagnetic braking systems tend to cost more than standard brakes, there remains an essential aim to balance its performance together with reliability versus the price of the equipment. In order to do so, the scheme should be developed in such a way so that it offers requisite braking force at a sensibly affordable rate.
6. As a conclusion, the main objectives of an electromagnetic braking system dedicate themselves to providing exact control over motion, storing and harvesting energy, safeguarding security, lessening the necessity for constant upkeep and downtime, as well as compromising between cost-effectiveness and operations.

III. WORKING

PRINCIPLE: Electromagnetic braking is based on the production of eddy currents. When a metallic object travels through a magnetized field, these electrical swirls are generated within the object and form their own magnetic field. This created force reverses the direction of the motion, thus inducing an impediment on its progress. The magnitude of this resistance depends on the object's velocity as well as the strength of the magnetic field.



A soft-iron core that is magnetized by passing a current through a coil of wire wound on the core.

Electromagnets are used to lift heavy masses of magnetic material and to attract movable magnetic parts like iron disc and ferrous material.

When electric supply given to the electromagnet then it act as a temporary magnet this magnetic field exerted the force on rotating disc in the direction of perpendicular to the disc.In an engineering sense the word electromagnet does not refer to the electromagnetic forces incidentally set up in all devices in which an electric

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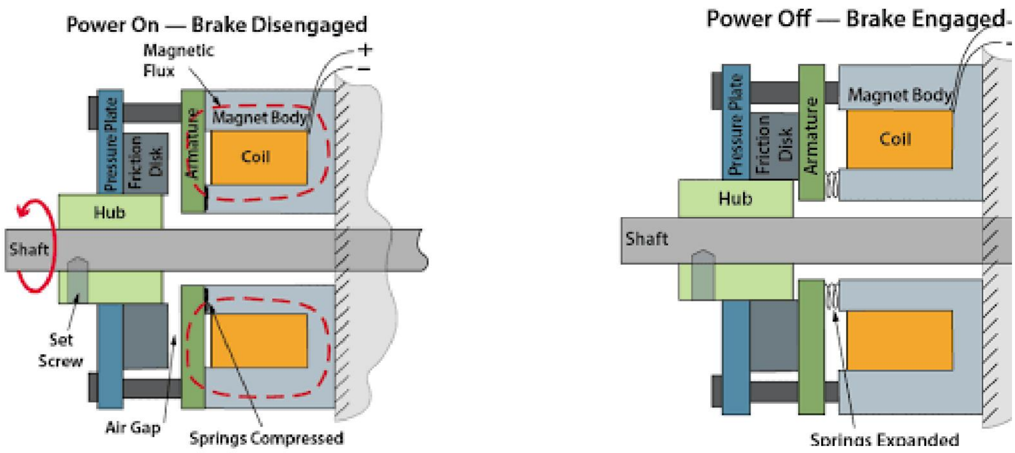
current exists, but only to those devices in which the current is primarily designed to produce this force, as in solenoids, relay coils, electromagnetic brakes and clutches, and in attractive and lifting or holding magnets and magnetic chucks.



Electromagnets may be classified into two types: one is the traction magnets, in which the pull is to be exerted over a distance and work is done by reducing the air gap; and other is lifting or holding magnets, in which the material is initially placed in contact with the magnet. For Examples of the latter type are magnetic chucks and circular lifting magnets.

IV. CALCULATIONS

Area of the Electromagnet = 12.4 m

Current & Voltage supplied (I/V) = 7 amp / 230 volts

Length of electromagnet (L) =90 mm

Let the maximum weight of plate & wheel assembly to be approximately 2kg which is 19.62 N so that;

$F = [(B^2)*A]/2\mu$

Where,

F is the force in Newton

B is the magnetic field in teslas

A is the area of the pole faces in square meters

μ is the permeability of free space

In the case of free space (air);

$\mu = 4\pi*(10^{-7})*H*m^{-1}$

$19.62 = (B^2)*(12.4)/2*4\pi*10^{-7}$

$B = 0.00199$ wb/m sq.

Total magnetic flux in core;

$Ø = B*A$

$= 0.00199*12.4$

$= 0.0246$ wb

Magnetizing Force

$H = B/\mu$

$= 0.00199/4\pi*10^{-7}$

$= 1583.59$ AT/m

To find the power of electromagnet that is manually constructed;

Assuming;

N = Number of turns in the electromagnetic coil = 800

F = (N*I)^2μa/(2*g)

g = air gap between electromagnet & plate

F = [(8*1) ^2]*4π*10^-7*0.00199/ (2*0.5) ^2

F = 16.045 N for each electromagnet

If the model is driven by the motor then the calculation will be as follows;

For Single phase AC motor,

Power = 12v/5A = 60 watt

Speed = 0-8600 rpm (variable)

P = 2πNT/60

T = 60*60/2π*8600

= 0.066 N-m

At constant speed 2000 rpm;

R = radius of wheel

V = r ῳ

= 0.9*2πn/60

= 0.9*2π*2000/60

= 188.4 m/s

According to Newton's Law of Motion;

V = u+at

a = (v-u)/t

Initial velocity of the wheel (u) = 188.4 m/s

Final velocity of the wheel (v) = 0 m/s

a = (0-188.4)/1 = -188.4 m/s sq

a = (0-188.4)/3 = -62.8 m/s sq

Hence the deceleration of the electromagnetic braking system takes place according to the braking time

V. Application

1. Automotive Industry:In the automotive domain, electromagnetic brakes have gained traction and usage as they serve as an alternative or complementary braking mechanism to hydraulic ones. Their cutting-edge regenerative properties transfer kinetic energy from the moving vehicle into electrical power that can either be stored for future use or supply other systems within the car.
2. Trains and Railways:The trains and railways industry reaps the benefits of highly responsive and easily controlled electromagnetic brakes for precise speed control and optimal safety. These brakes offer swift response times, minimize wear-and-tear on mechanical parts, and sustain firm brake pressure even during unfavorable environmental conditions.
3. Industrial Machinery:In industrial settings like conveyor belt systems, winches, or cranes, electromagnetic brakes are indispensable as they guarantee proper and steady stopping or holding of heavy loads. Providing unfailing braking capacity, swift feedback time, and excellent management over motor propulsion behavior, these brakes maintain favorable working order rates overall.
4. Wind Turbines:One more practical application of electromagnetic brakes lies in their utility within wind turbines. By controlling blade rotation capability, these brakes ensure maximum operational efficiency and safety under high winds or maintenance circumstances. Furthermore, they enable prompt discontinue to avoid damages or malfunctions in turbine units.

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V. Conclusion

1. Powerful Deceleration: Electromagnetic braking provides effective and proficient deceleration, allowing for precise regulation and stopping of running objects.
2. Express Regulation: Electromagnetic brakes refine command over their braking strength, granting consistent and precise modulation of speed and halting distances.
3. Instantaneous Activation: Electromagnetic brakes possess rapid activation times, permitting agile launching and conclusion of the stopping power when needed.
4. Regenerative properties: Electromagnetic braking systems can take on regenerative abilities, transforming kinetic energy into electrical power for additional use or store-room, revamping total energy effectiveness.
5. Guaranteed Protection: Electromagnetic brakes ensure improved security by delivering trusted halting power, exact control, and the capacity to firmly grasp loads.

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