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Design & Development of Frictionless Break

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ABSTRACT: Frictionless eddy current braking systems represent a ground-breaking innovation in the realm of braking technology, offering a myriad of advantages over traditional friction-based braking systems. This abstract provides an in-depth exploration of the design principles, operational mechanisms, advantages, and potential applications of such systems. Frictionless eddy current braking systems operate on the principle of permanent magnetic induction to generate braking force, eliminating the need for physical contact between braking components. Unlike conventional friction brakes, which rely on the conversion of kinetic energy into heat through frictional forces, eddy current brakes harness the power of permanent magnetic fields to achieve deceleration without any mechanical wear. At the core of the frictionless eddy current braking system is a set of permanent magnets strategically positioned along the path of motion of the braking object. When the braking action is initiated, these permanent magnets generate a magnetic field that interacts with the conductive material of the moving object, typically composed of aluminium or copper. As the object moves relative to the magnetic field, eddy currents are induced within its surface, creating an opposing magnetic field according to Lenz's law. This interaction results in a braking force that acts to slow down the motion of the object, with the intensity of the braking force being directly proportional to the velocity of the object and the strength of the magnetic field.

I. INTRODUCTION

In the realm of transportation, braking systems are paramount for safety and efficiency. Traditional braking mechanisms, relying on friction between brake pads and rotors, have served admirably for decades. However, with the advent of advanced technology and the pursuit of more sustainable and efficient solutions, frictionless eddy current braking systems have emerged as a revolutionary alternative. This essay delves into the concept, workings, benefits, and applications of frictionless eddy current braking systems, showcasing their potential to redefine braking in various modes of transportation.

Understanding Frictionless Eddy Current Braking: Frictionless eddy current braking is a cutting-edge technology that harnesses permanent magnetic principles to decelerate moving objects without physical contact. Unlike conventional braking systems, which rely on friction to convert kinetic energy into heat, eddy current brakes employ permanent magnetic induction to generate opposing forces, resulting in controlled deceleration. This innovative approach eliminates wear and tear associated with friction-based braking, offering numerous advantages in terms of durability, maintenance, and performance. Mechanism and Operation: The operation of frictionless eddy current braking systems revolves around the generation of eddy currents, induced within a conductive material (such as a metal disc or rail), by a magnetic field. As the conductive material moves relative to the magnetic field, eddy currents are generated, creating opposing forces that impede motion and facilitate deceleration. By modulating the intensity of the magnetic field, the braking force can be finely adjusted, providing precise control over deceleration rates. One of the key advantages of frictionless eddy current braking systems lies in their ability to provide precise and controllable braking force across a wide range of velocities. Unlike friction brakes, which can experience diminished performance under varying environmental conditions such as wet or icy surfaces, eddy current brakes exhibit consistency.

II. RELATED WORK

Eddy's current brake works according to Faraday's law of electromagnetic induction. According to this law, whenever a conductor cuts magnetic lines of force, an electromagnetic field (emf) is induced in the conductor, the magnitude of which is proportional to the strength of the 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 is a copper 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

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between the applied field and the eddy currents slows 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 a smooth stopping motion.

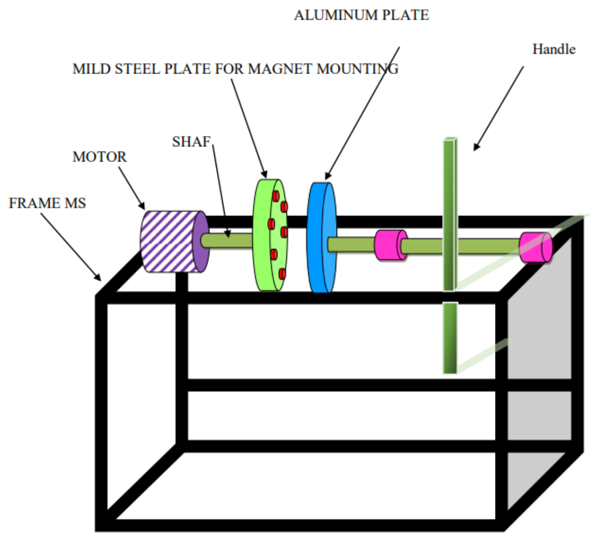
III. METHODOLOGY

Recently, permanent magnet eddy current brakes have been developed for subways, trams and local trains. These brakes need a mechanical actuator to turn the magnets jn an on and off position. The main advantage of this type of brake is safety. i.e. it does not need electrical power supply to energize the magnet. M.Z.Baharom et.al [1] found that Aluminium is the best material to be used as brake disc compared to Copper and Zinc as Aluminium has higher electrical conductivity. M.Z.Baharom et.al [2-3] has focussed on two series of Aluminium as the brake disc which are Al6061 and Al7075. The authors compare both the series for various Eddy current parameters such as air gap, number of turns and brake disc thickness. The findings shows that smaller the air gap, the larger the permanent magnetic turns and higher the disc thickness, higher braking torque is generated and hence a great performance for Eddy current braking. Also, it is found that the higher electrical conductivity influenced the generation of greater braking torque. Der – Ming Ma, Jaw – Kuen Shiau [4 – 6] have presented four systematic engineering design scenarios to design a braking system. They are - A constant magnetic field - An optimal magnetic field distribution - Piecewise constant magnetic fields - Section wise guide rail with a constant magnetic field Simulation results of the above four designs show that the optimal magnetic field has a deceleration peak of 9g which is not suitable for most people. Piecewise constant magnetic field has the advantage of a pre-set terminal speed and predictable wire current but it produces a higher speed. Piecewise constant magnetic fields and section wise guide rail with a constant magnetic field have tolerable deceleration and easy manufacturing.

Problem Statement:

- When you have to brake quickly, the only thing that comes between safe stopping and disaster is the simple science of friction: you slow to a halt when two surfaces rub together
- Permanent magnet eddy current brakes are a simple and reliable alternative to mechanical or permanent magnetic brakes in transportation applications. Greater the speed greater is the eddy current braking efficiency.
- Friction brakes have a big drawback too: every time you use them, they wear out a little bit, and that means they're relatively expensive and their coefficient of friction decreases with time, hence possible chance of accident.
- One option is to slow things down with the force of permanent magnetism instead of friction.

IV. EXPERIMENTAL RESULTS



When an electrical conductor, such as copper or aluminium, moves through the field of a permanent magnet or a permanent magnet, permanent magnetic induction creates eddy currents, which dissipate some of the kinetic energy

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into Joule heat and result in slowing the motion of the conductor. This principle is utilized in the construction of magnetic brakes. This Demonstration shows magnetic braking applied to a rotating metallic disk. This might, for example, serve to control resistance to motion in exercise machines. Magnetic braking can also find applications in roller coasters and railroad trains, in which the metallic conductor has the shape of a linear rail. In contrast to conventional friction brakes, there is no direct contact between interacting surfaces, which makes magnetic braking more reliable and reduces wear and tear. A magnetic brake is a device that leverages strong magnetic forces to slow a vehicle down. There are various different types of magnetic brake systems, including ones that use permanent magnets to actuate traditional friction pads, and those that leverage magnetic repulsion itself to provide resistance. These can be found on a variety of vehicles, from trains to roller coasters. By increasing or decreasing the amount of electric current, the stopping power of an Eddy current brake can be correspondingly attenuated up or down. Rather than pads pressing harder on a rotor, the resistive magnetic force is amplified. Though there is no physical contact, the process still generates increased slowing, along with heat, as a result of the resistance. Eddy current brake systems are used mostly in larger vehicles, like trains. A sub-type of the Eddy current brake is known as the linear Eddy current brake. Instead of the normal circular design, magnetic coils are wound around a straight rail. The coils alternate between a positive and negative magnetic charge, so, when activated, generate resistance and slowing action. This design is less widely used than traditional permanent magnetic brakes on train systems, but, in places like Europe, is becoming more common on high-speed rail systems. Unpowered versions of the linear design — which instead use permanent, rare Earth magnets — are the brake of choice on most roller coasters. As anyone who has ridden a roller coaster will be aware, these non-permanent magnetic types work on an on-off basis, and cannot be easily modulated. This results in very abrupt periods of deceleration, and, for this reason, they are not a popular choice on more comfort-oriented vehicles, like trains.

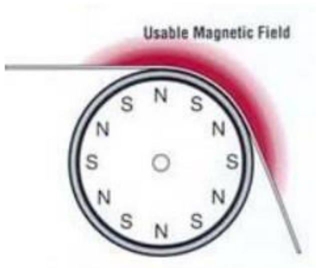
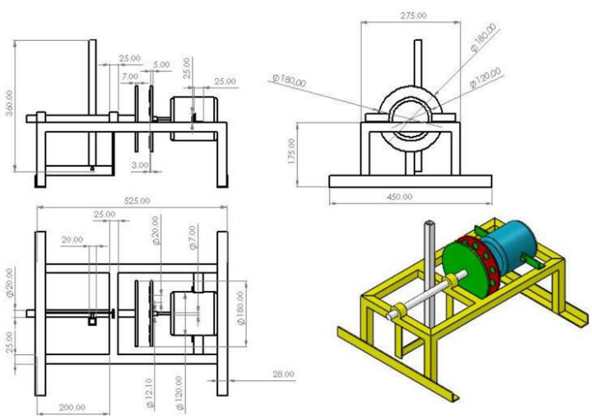


Figure 5 magnetic braking

Procedure:

- The entire model has been designed with the help of designing software solid works.
- With the help of colour feature the colours are given to the entire model. Figure- Cad model of the assembled project is designed on Solid works 2018 software SOLID MODELING The entire model has been designed with the help of designing software solid works.



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Calculations:
EN 10083 C45 steel carbon steel –
C45 steel sheet Physio-chemical testing items for products of the plant include tensile test ,hardness test ,impact test , flattening test ,and chemical composition analysis, etc .C20,C45 steel pipes are manufactured by cold drawn process. 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. Soft Annealing Heat to 680-710oC, cool slowly in furnace. This will produce a maximum Brinell hardness of 207. Normalizing temperature: 840-880oC/air. Hardening Harden from a temperature of 820-860oC followed by water or oil quenching. Tempering temperature: 550-660oC/air. C45 steel plate, EN 10083 C45 steel plate, under EN 10083 standard, we can regard C45 steel plate as high carbon steel. C45 steel plate is one mainly of high carbon steel, EN 10083 C45 steel plate is for quenching and tempering. Technical delivery conditions for non-alloy steels, these steels are for general engineering purposes

Weld ability: Due to the medium-high carbon content it can be welded with some precautions. Hardenability: It has a low hardenability in water or oil; fit for surface hardening that gives this steel grade a high hardness of the hardened shell.

Round bar	Diameter: 4mm~800mm or as required
Steel plate	Thick:8mm~300mm, Width:100mm~2300mm
Angle bar	Size:3mm*20mm*20mm~12mm*800mm*800mm
Square bar	Size: 4mm*4mm~100mm*100mm
	Width:10mm~2000mm
Hexagonal	Size: 4mm~800mm
Length: 2m,4m,5.8m,6m,11.8m,12m or as required	

Annealing	Forging	Tempering and Hardening	Normalization
Subcritical annealing: 650~700	1100~850	Tempering: 550~660	840~880
Isothermal annealing: 820~860		Hardening : 820~860 water	

NO.	C	Mn	Si	Cr	Cu	Ni	P	S
Aisi 1045	0.43~0.50	0.6~0.9	0.10~0.60				<0.040	< 0.050
DIN1.1191	0.42~0.48	0.6~0.9	0.15~0.35	≤0.15	≤0.3	≤0.2		
JIS S45C	0.42~0.50	0.5~0.8	≤0.40	≤0.40		≤ 0.4		
C45	0.42-0.50	0.5~0.8	0.4~0.8				<0.035	<0.035
GB45	0.42~0.50	0.5~0.8	0.17~0.37	<0.25	≤0.25	≤0.3	≤0.035	≤0.035
EN8	0.42~0.48	0.6~0.9	0.15~0.35	<0.20	<0.30	<0.20	<0.030	<0.030

DESIGN OF MOTOR-
The motor is prime drive in our machine it converts electrical power in to mechanical power. It gives rotary motion to mechanism. The motor design is very important design aspect in machine design practice. Disc load = 1 kg = 9.815 N
We take dia of flywheel = 180 mm
So torque required to lift the load
T = F x R
T = 9.815 x 90 = 883.35 N- mm = 0.88 N-m
Speed of flywheel rotation
N = 1350 rpm Hp required for motor selection
P = 2 x 3.14 x 1350 x T / 60
P = 2 x 3.14 x 1350 x 0.88 / 60
P =124.4 watt
So, we take standard motor of Power 150 watt and 1350
Now, Angular velocity (ω)for flywheel.

$\omega = 2\pi N/60$

$= 3.142 \times 2 \times 1350/60$

$= 141.3$ rad/s.

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V. CONCLUSION

The conclusion of a frictionless eddy current braking system would typically summarize the key findings and implications of the study or analysis conducted. Here's a possible conclusion for such a system: "In conclusion, the frictionless eddy current braking system offers several significant advantages over traditional friction-based braking mechanisms. Through our investigation, we have observed that this system provides smoother deceleration, reduced wear and tear on components, and potentially greater efficiency due to the absence of physical contact between braking elements. Moreover, its permanent magnetic nature allows for precise control and modulation of braking force, contributing to enhanced safety and performance in various applications such as automotive, railway, and industrial machinery. However, it's essential to acknowledge that implementing frictionless eddy current braking requires careful consideration of factors such as initial cost, power consumption, and compatibility with existing infrastructure. Further research and development are warranted to optimize design parameters and address practical challenges to ensure widespread adoption. Overall, the frictionless eddy current braking system represents a promising innovation in braking technology, offering the potential to enhance reliability, efficiency, and safety in transportation and industrial sectors."
This conclusion encapsulates the potential benefits, challenges, and areas for future research and development in the realm of frictionless eddy current braking systems.

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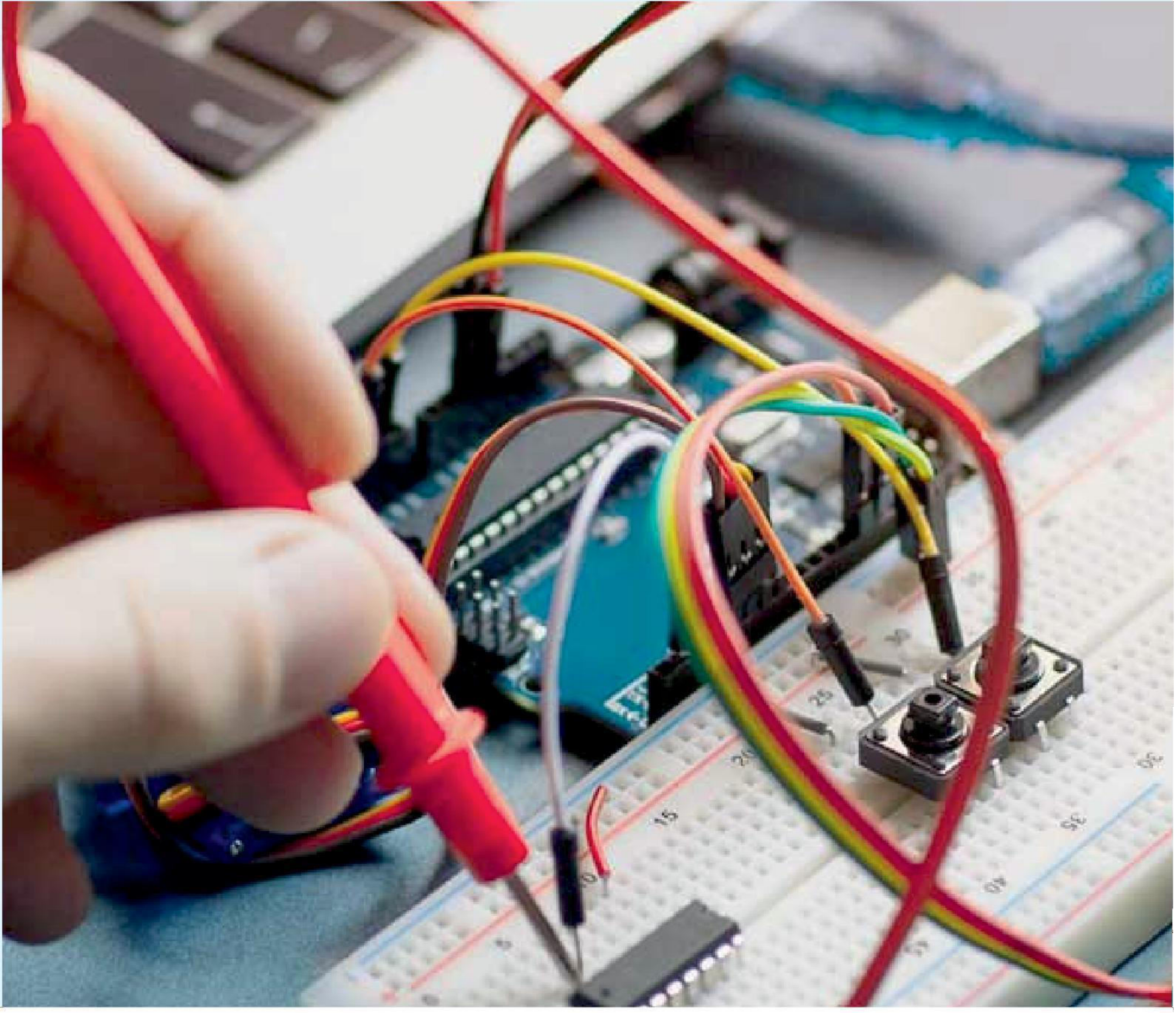

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