ELECTROMAGNETIC BRAKING SYSTEM

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Abstract

In this paper, we delve into the intricacies of Electromagnetic Braking systems and their influence on traditional braking methods. Ensuring driver safety and comfort on the road is paramount for any braking system. Conventional braking systems, including Drum Brakes, Disc Brakes, Hydraulic Brakes, and Pneumatic Brakes, rely on friction to decelerate vehicles, leading to heat generation and wear on braking components, thereby diminishing efficiency over time. Electromagnetic Braking emerges as a viable alternative, boasting superior efficiency characterized by a high power-to-torque ratio and reduced friction. This paper examines the transition to electromagnetic braking and its implications for conventional braking methodologies.

Keywords: Electromagnetic Braking; Traditional Braking; Friction; Heat Generation; Efficiency.

I. INTRODUCTION

Ensuring effective retardation is imperative for any braking system. Accidents often result from ineffective braking mechanisms, leading to vehicle mishaps. The electromagnetic braking system, utilizing the electromagnetic effect of electrical current, addresses this issue by employing a solenoid coil. This system combines electrical and mechanical components, utilizing electrical energy to apply braking torque efficiently, generating negative power twice that of the machine's power.

II. EXISTING BRAKING SYSTEM

Current braking systems typically involve a brake pedal or lever, translating force applied through the foot into hydraulic or mechanical pressure. However, these systems rely on mechanical contacts, resulting in friction and excessive heat generation, consequently reducing the lifespan of braking components.

III. PRINCIPLE OF WORKING

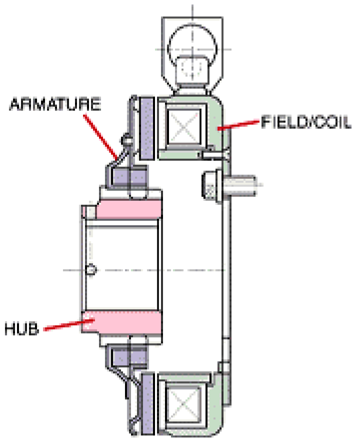
The principle of electromagnetism serves as the foundation for the functioning of the electromagnetic braking system. When a specific amount of electrical current passes through a circular conductor, it generates a magnetic field that is uniformly distributed across the conductor. The strength of this magnetic field is directly proportional to the current flowing through the conductor and the number of turns in the conductor. Greater current flow and more turns result in the creation of a stronger magnetic field. In the context of electromagnetic braking, a solenoid—a coil with a high number of turns—is employed to generate a robust magnetic field. This magnetic field is utilized to facilitate braking by interacting with other components of the braking system. By harnessing the principles of electromagnetism, electromagnetic braking achieves effective and controlled deceleration of the vehicle.

IV. CONSTRUCTION AND DESIGN OF ELECTROMAGNETIC BRAKING SYSTEM

The electromagnetic brake comprises of three main components:

1. Field
2. Armature
3. Hub (serving as the input of the brake)

Typically, the magnetic field is either bolted to the machine frame or supported by a torque arm capable of withstanding brake torque. As the armature is attracted towards the magnetic field, braking torque is transmitted into the field housing and then into the machine frame, effectively decelerating the load. This process can occur rapidly, within seconds. Disengagement is straightforward: as the magnetic field weakens, the armature separates. A spring is utilized to maintain a predetermined air gap between the armature and its corresponding contact surface.



Components of Electromagnetic Braking System:

Disc Liner: The lining converts kinetic energy into heat during braking. It must withstand high temperatures without excessive wear, which could lead to frequent part replacements, or outgassing, resulting in reduced braking power. Typically, brake linings consist of a tough, heat-resistant material with a high coefficient of dynamic friction, mounted onto a solid metal backing using high-temperature adhesives or rivets.

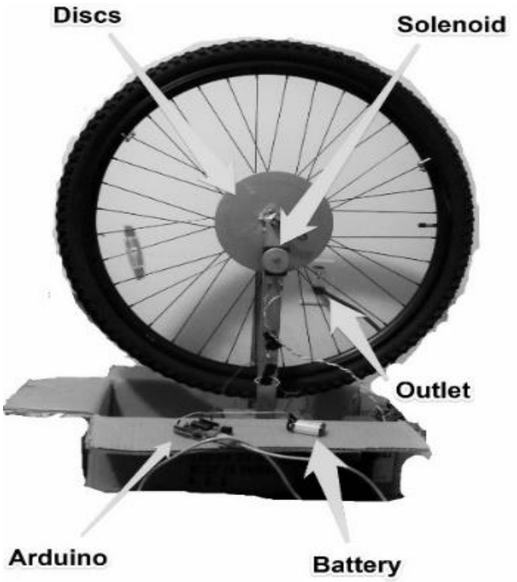
Braking Coil: A solenoid coil is formed by winding a conductor around a core to create an electromagnet. When an electric current flows through the coil, it generates a magnetic field. Coils may consist of one or more turns, with electrical connection terminals called taps often connected to facilitate use in electronic circuits. Coils are commonly coated with varnish or wrapped with insulating tape for additional insulation and to secure them in place. A completed coil assembly with one or more sets of coils and taps is typically referred to as windings.

Tension Spring: A spring is an elastic component used to store mechanical energy. Springs can be constructed from various materials depending on the design and required operating environment. When compressed or stretched, a spring exerts a force proportional to its change in length.

Battery: A battery serves as a device converting chemical energy directly into electrical energy. It comprises multiple voltaic cells, each consisting of two half cells connected by a conductive electrolyte containing anions and cations. One half-cell houses the electrolyte and the electrode attracting anions, known as the anode or negative electrode. The other half-cell contains the electrolyte and the electrode attracting cations, known as the cathode or positive electrode. In the redox reaction powering the battery, cations undergo reduction at the cathode, while anions undergo oxidation at the anode. Despite the electrodes not physically touching, they are electrically connected through the electrolyte. Some cells utilize two half-cells with varying electrolytes. A separator between the half cells permits ion flow while preventing electrolyte mixing. Each half-cell possesses an electromotive force determined by its capacity to drive electric current from the cell's interior to its exterior. The net electromotive force of the cell is the difference between the electromotive forces of its half-cells, as initially recognized by Volta. Thus, if the electrodes exhibit electromotive forces, the net electromotive force is the disparity between the reduction potentials of the half-reactions.

Alloy Wheel: Alloy wheels have witnessed increased prevalence since 2000. These wheels, typically crafted from aluminum or magnesium alloys, offer lighter weight for equivalent strength, superior heat conduction, and enhanced aesthetic appeal compared to steel wheels. Initially, light alloy wheels were fashioned from magnesium alloys. Alloy wheels have become standard equipment on higher-priced luxury or sports cars, with larger or exclusive alloy wheels often available as options. Due to their high cost, alloy wheels are enticing to thieves; hence, automakers and dealers frequently utilize locking wheel nuts requiring a special key for removal. Most alloy wheels are produced through casting, although some are forged.

Electromagnet: An electromagnet represents a type of magnet where the magnetic field results from electric current flow. Electric current passing through a wire generates a magnetic field around the wire. In electromagnets, the wire is wound into a coil with numerous turns lying side by side to concentrate the magnetic field. The magnetic field of all wire turns traverses the coil's center, generating a potent magnetic field therein. The direction of the magnetic field through a wire coil can be determined using the right-hand rule. The primary advantage of an electromagnet over a permanent magnet lies in its ability to swiftly manipulate the magnetic field over a broad range by controlling electric current magnitude.



Conclusion

The electromagnetic braking system emerges as a more reliable solution compared to traditional braking systems. In oil or air braking systems, even a minor leakage can result in complete brake failure. Conversely, electromagnetic braking systems feature individual coils and firing circuits attached to each wheel. Even if one coil fails, the brake remains functional as the remaining coils continue to operate effectively. Moreover, this system requires minimal maintenance. It's noteworthy that approximately 80% of all power-applied brake applications utilize electromagnetic brakes. These brakes serve as supplementary retardation equipment alongside regular friction brakes in heavy vehicles. By reducing the frequency of friction brake usage, the risk of overheating is significantly mitigated. Consequently, brake linings endure longer periods before requiring maintenance, and the issue of "brake fade" is effectively addressed. This enhanced braking system not only ensures effective braking but also aids in accident prevention, thereby minimizing accident frequency. Additionally, electromagnetic brakes mitigate the danger arising from prolonged brake usage beyond their heat dissipation capability. Overall, electromagnetic braking systems represent a significant advancement in vehicle safety and efficiency.

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