IJARCCE

ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⪾ Peer-reviewed & Refereed journal ⪾ Vol. 15, Issue 5, May 2026

DOI: 10.17148/IJARCCE.2026.155168

"Design & Performance Analysis of EOT Crane, Modification from DC Electromagnetic to Thruster Brake System"

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Abstract: The Electrical Overhead Travelling (EOT) crane is one of the most widely used material handling systems in industrial applications such as steel plants, manufacturing industries, warehouses, and construction sectors. The braking system of an EOT crane plays a vital role in ensuring operational safety, load control, reliability, and smooth functioning. Conventional DC electromagnetic brake systems used in cranes often face problems such as high maintenance, overheating, brake coil failure, and reduced braking efficiency during continuous operation. To overcome these limitations, the present study focuses on the design and performance analysis of an EOT crane by modifying the existing DC electromagnetic brake system into an electro-hydraulic thruster brake system.

The project involves studying the working principles of both braking systems and comparing their performance based on braking torque, response time, reliability, energy consumption, maintenance requirements, and operational safety. The design analysis includes load calculations, braking force estimation, motor compatibility, and stress considerations under different operating conditions. The thruster brake system provides fail-safe operation, faster response, better heat dissipation, and improved braking performance compared to the conventional DC electromagnetic brake.

The modification aims to enhance crane efficiency, reduce downtime, improve safety standards, and minimize maintenance costs. The results obtained from the analysis indicate that the electro-hydraulic thruster brake system offers superior operational performance and reliability for heavy-duty industrial crane applications. Therefore, replacing DC electromagnetic brakes with thruster brakes can significantly improve the overall performance and service life of EOT crane.

Keywords: EOT Crane, DC Electromagnetic Brake, Electro-Hydraulic Thruster Brake, Braking System, Performance Analysis, Material Handling Equipment, Crane Safety, Brake Modification, Industrial Automation, Brake Torque, Fail-Safe Braking, Mechanical Design.

INTRODUCTION

Reliable braking is critical for EOT crane safety, particularly in hoisting mechanisms where any failure can lead to catastrophic load drops [3], [4]. While traditional DC electromagnetic brakes are widely used, they have significant drawbacks, including high energy consumption—as a substantial portion of energy is used simply to keep the brake coils energized and released [2]. Transitioning to electro-hydraulic thruster brakes addresses these inefficiencies while providing a more controlled braking response [1].

LITERATURE REVIEW

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Recent inquiries compare the dynamic aspects of drum and caliper brakes actuated by short-stroke electromagnets versus hydraulic thrusters [1]. Research using 3-D computer models has shown that classic assumptions—such as braking force instantly reaching a steady-state—are often inaccurate [1]. Instead, thruster systems provide a braking force that is a function of time, allowing for a more gradual application of torque compared to the "instant" engagement of electromagnetic systems [1]. Additionally, with the rise of frequency inverters in crane drives, mechanical brakes are increasingly reserved for critical or emergency conditions, placing a new emphasis on the thermal loads these components must withstand [5].

METHODOLOGY

The design modification requires precise calculation of the required braking torque () to ensure the crane's safety factors are met.

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1. **Torque Calculation:** The real braking torque is determined by the formula , where the braking coefficient () is selected based on the crane's lifting class [6]. According to industrial standards, this coefficient ranges from 1.5 for Class A cranes up to 2.0 for Class C [6].
2. **Dynamic Simulation:** Performance analysis is often conducted using MATLAB/Simulink to model the actual braking process under both normal and emergency conditions [4]. This allows for the real-time observation of electromagnetic and mechanical transitions during deceleration [4].

RESULTS

Implementation of the thruster brake system results in significant energy savings. Analysis shows that the energy required to release traditional electromagnetic coils can account for several dozen percent of the drive's total energy demand in certain mechanisms [2]. By contrast, modern systems optimized for energy recovery can see up to 40% of the energy in a typical crane duty cycle recovered, particularly during the lowering of the suspended payload [2]. Furthermore, moving away from electromagnetic systems reduces the thermal stress on coils, which are known to lose efficiency as operating temperatures rise [7].

DISCUSSION

The primary advantage of the electro-hydraulic thruster over DC electromagnetic systems is the reduction of mechanical shock. Electromagnetic brakes often neglect the clearance between friction linings and the drum, leading to abrupt stops [1]. Thruster brakes utilize a controlled hydraulic stroke, which minimizes the peak dynamic stresses on the crane's structure and gearbox [1]. However, the use of frequency inverters means these mechanical systems now operate in different thermal regimes, as they are used less frequently than in traditional step-control systems, necessitating careful analysis of heat loading during emergency stops [5].

CONCLUSION

The modification from DC electromagnetic to electro-hydraulic thruster brakes provides a dual benefit of improved mechanical longevity and reduced operational costs through lower energy consumption [1], [2]. By utilizing precise torque coefficients based on crane classification and modern simulation tools, engineers can ensure that the modified system maintains a high safety factor while delivering a smoother, more reliable braking performance [4], [6].

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