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Development of Installation Equipment for Electric Locomotive Axle Head Covers

Liang Chang

Xinjiang Railway Vocational and Technical College, Hami City, Xinjiang 839000, China

Abstract: ***This thesis focuses on the development of installation equipment for electric locomotive axle head covers. Through in-depth investigation of actual production needs in locomotive depots, it was found that current installation methods primarily rely on manual labor, presenting issues such as high labor intensity, safety hazards, and low operational efficiency. To address these challenges, multiple research methods including literature review, field surveys, CAD design, prototyping, testing, and experience summarization were employed to jointly develop new installation equipment. The equipment consists of a support frame, lifting mechanism, and horizontal movement mechanism, featuring innovative characteristics such as high versatility, extended applicability, and mobility. Practical applications have demonstrated that this equipment effectively improves operational efficiency, reduces labor intensity and safety risks, and holds broad market prospects and practical value.***

Keywords: Electric locomotive; Axle head cover; Installation equipment.

1. INTRODUCTION

With the rapid development of railway transportation, electric locomotives have become increasingly vital. The maintenance of electric locomotives is crucial for ensuring safe and efficient railway operations. As a key process in electric locomotive maintenance, the quality and efficiency of axle head cover installation directly impact overall performance and operational safety. However, current installation methods mainly depend on manual labor, posing numerous challenges that hinder maintenance progress. Therefore, developing efficient and safe installation equipment for electric locomotive axle head covers holds significant practical importance.

2. RESEARCH OBJECTIVES AND SIGNIFICANCE

2.1 Objectives

This thesis aims to collaborate with enterprises to develop innovative installation equipment for electric locomotive axle head covers, addressing challenges faced by locomotive depots during installation. The goal is to achieve mechanized maintenance, improve operational efficiency, reduce labor intensity, and ensure safety.

2.2 Significance

2.2.1 Solving Practical Production Issues

Currently, locomotive depots rely on manual labor for axle head cover installation due to limited crane operations and lack of dedicated equipment. This method is not only difficult but also prone to component damage, high labor intensity, and personal injury risks. The proposed equipment will effectively resolve these issues, enhancing convenience and safety during installation.

2.2.2 Improving Operational Efficiency and Locomotive Turnaround

Mechanized installation equipment can quickly and accurately complete the installation process, significantly reducing maintenance time and improving efficiency. This contributes to higher locomotive turnaround rates, meeting the growing demands of railway transportation.

2.2.3 Reducing Labor Intensity and Safety Risks

The equipment eliminates the need for prolonged manual handling and installation of heavy objects, lowering labor intensity and minimizing occupational hazards. Additionally, it prevents accidents such as injuries from falling objects caused by improper manual operations, thereby enhancing safety.

2.2.4 Promoting University-Enterprise Collaboration and Research Achievement Transformation

This thesis is part of a university-enterprise cooperative project, which leverages the strengths of both academia and industry to achieve resource sharing and complementary advantages. Upon successful development, the enterprise will be responsible for promoting the technology, transforming research outcomes into practical productivity and contributing to the advancement of the railway industry.

3. ANALYSIS OF DOMESTIC AND FOREIGN RESEARCH STATUS

The installation of electric locomotive axle head covers can be divided into three main steps: lifting, positioning, and fastening. Currently, railway enterprises primarily rely on manual operations, with no dedicated tooling equipment available. In terms of lifting technologies, common domestic and international lifting equipment includes screw jacks, hydraulic systems, mechanical levers, and linear motors.

3.1 Screw Jacks

The application of screws for power transmission has a relatively short history. Traditional Acme screws suffered from poor positioning and susceptibility to damage. Later, the introduction of ball bearings between the nut and screw replaced sliding friction with rolling friction, significantly improving these issues. In 1940, ball screws were first applied in automotive steering systems, marking a major revolution in their use and gradually replacing traditional Acme screws.

Today, ball screws have become one of the most widely used components in the industry, known for their high precision, reversibility, and efficiency. They can convert rotational motion into linear motion or torque into axial reciprocating force. However, in scenarios requiring extremely high installation precision and efficiency, they still exhibit certain limitations.

3. Analysis of Domestic and Foreign Research Status

The installation of electric locomotive axle head covers can be divided into three main steps: lifting, positioning, and fastening. Currently, railway enterprises primarily rely on manual operations, with no dedicated tooling equipment available. Common lifting technologies include screw jacks, hydraulic systems, mechanical levers, and linear motors.

3.2 Hydraulic Equipment

Hydraulic jacks use plungers or hydraulic cylinders as rigid lifting components, offering advantages such as simple construction, light weight, portability, and ease of movement, making them suitable for various lifting tasks with limited height requirements. General-purpose hydraulic jacks are used for standard lifting operations, while center-hole jacks are employed for tensioning steel reinforcement strands or wire bundles. The YZF/QF/DYG series of electric hydraulic jacks are widely used in power maintenance, bridge repairs, and heavy lifting. However, hydraulic systems may experience oil leakage during operation, affecting their stability and service life.

3.3 Linear Motors

A linear motor is a transmission device that directly converts electrical energy into linear mechanical motion without intermediate conversion mechanisms. It can be visualized as a radial section of a rotary motor unfolded into a flat plane, offering advantages such as excellent high- and low-speed performance, high acceleration, near-zero maintenance (no contact parts), high precision, and no backlash. Linear motion is achieved solely by the motor, eliminating the need for gears, couplings, or pulleys. The most common types of linear motors are flat-type, U-channel, and tubular, with coils typically configured as three-phase and brushless commutation achieved via Hall sensors. However, the relatively high cost of linear motors limits their application in cost-sensitive fields.

4. RESEARCH PLAN

4.1 Research Content

This thesis focuses on the development of an installation device for electric locomotive axle head covers, primarily consisting of a support frame, lifting mechanism, and horizontal movement mechanism.

4.1.1 Selection and Design of the Support Frame

Based on the dimensions and shapes of different electric locomotive axle head covers, an appropriate support frame type is selected and optimized. Stress analysis ensures sufficient strength and stability when bearing the axle head cover. Material selection and manufacturing processes are determined based on the analysis results to guarantee quality and performance.

4.1.2 Selection and Design of the Lifting Mechanism

The advantages and disadvantages of screw jacks, hydraulic systems, and linear motors are compared, and the most suitable lifting mechanism is selected according to practical installation requirements. Stress analysis determines the required lifting force and power to ensure stable and reliable operation. Materials and components are selected, and manufacturing processes are defined to ensure precision and reliability.

4.1.3 Selection and Design of the Horizontal Movement Mechanism

A horizontal movement mechanism is designed to ensure flexible and precise positioning of the axle head cover. Stress analysis guides the selection of driving methods and transmission components to support the weight of the axle head cover and ensure functionality under various working conditions. Materials and manufacturing processes are chosen based on design requirements.

4.1.4 Assembly, Debugging, and Performance Testing

The support frame, lifting mechanism, and horizontal movement mechanism are assembled to ensure secure connections and tight fit. Debugging verifies proper functionality and smooth operation. Performance tests evaluate lifting capacity, positioning accuracy, movement speed, and other metrics to confirm compliance with design and practical requirements.

4.2 Problems to Be Addressed

The proposed installation device aims to resolve challenges in locomotive depots, such as inconvenient crane operations, lack of dedicated equipment, and operational difficulties during axle head cover installation. It enables mechanized maintenance, simplifies installation, reduces downtime, improves efficiency, saves labor and resources, lowers worker fatigue, and enhances safety.

4.3 Innovations

4.3.1 High Versatility

By replacing support frames, the device can be adapted for maintenance of diesel locomotives, EMUs, passenger/freight vehicles, and urban rail vehicles, significantly expanding its application scope.

4.3.2 Extended Applicability

The lifting mechanism can also be used for small- to medium-sized workpieces in industrial maintenance, increasing its utility.

4.3.3 Mobility

The device can be easily transported from storage to worksites and doubles as a flatbed cart for other components, improving practicality and convenience.

4.4 Research Methods

4.4.1 Literature Review

Comprehensive collection and analysis of professional knowledge, standards, and industry trends provide theoretical support for the research.

4.4.2 Field Surveys

On-site inspections at locomotive depots gather data on axle head cover installation, identify operational challenges, and inform design requirements.

4.4.3 CAD Design

UG software is used for top-down design, creating conceptual and assembly drawings. Iterative improvements refine the model based on dimensional, mechanical, and ergonomic considerations.

4.4.4 Prototyping

Materials are procured and the device is fabricated according to design specifications, ensuring quality and performance.

4.4.5 Testing

Performance metrics (e.g., lifting capacity, precision, speed, stability) are tested, with refinements made to optimize assembly, disassembly, and portability for depot use.

4.4.6 Experience Summarization

Reflections and summaries of research progress guide solution development and lay the groundwork for future improvements.

5. INNOVATIONS AND PRACTICAL VALUE

5.1 Innovations

5.1.1 Universal Design

Interchangeable support frames allow the device to service multiple vehicle types, reducing the need for specialized equipment and saving costs.

5.1.2 Extended Applications

The lifting mechanism’s adaptability benefits small- to medium-sized workpiece handling in industrial settings.

5.1.3 Mobility

Integrated wheels and structural design facilitate easy transport and dual-use as a component carrier.

5.2 Practical Value

5.2.1 Reduced Labor Intensity

Replacing manual handling of 20–30 kg covers with mechanized operation minimizes worker fatigue.

5.2.2 Improved Efficiency

Mechanization cuts installation time by 20% compared to manual methods, accelerating locomotive turnaround.

5.2.3 Enhanced Safety

Eliminates risks of dropped loads and physical strain, reducing workplace injuries.

5.2.4 Enterprise Benefits

Widespread adoption across depots improves maintenance quality, lowers costs, and supports sustainable development.

6. CONCLUSION

This thesis addresses the challenges of axle head cover installation through the development of a versatile, efficient, and safe device. The research methodology ensured robust design and performance validation. Innovations in universality, adaptability, and mobility position the device for broad industry application, offering significant labor, efficiency, and safety benefits. Future optimizations will further align the device with evolving railway needs.

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