

RESEARCH PAPER

“Design, Analysis and Development of Hand Brake System for Electric Three-Wheeler”

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Abstract

The rapid growth of electric vehicles has increased the demand for reliable and safe braking systems. This project focuses on the design, analysis and development of a hand brake system for an electric three-wheeler. The proposed hand brake system is intended to provide effective parking and emergency holding capability, ensuring vehicle safety on inclined and uneven surfaces.

The system consists of a hand brake lever, cable mechanism, ratchet and pawl arrangement, and rear wheel braking assembly. The hand brake operates mechanically and allows the driver to securely lock the vehicle when parked. The design emphasizes simplicity, low maintenance, ease of operation, and cost effectiveness. Proper material selection and component design are considered to improve durability and performance.

The project includes design calculations, force analysis, stress evaluation, and fabrication of the hand brake mechanism. Basic testing and performance analysis are carried out to determine the braking efficiency and holding capacity of the system under different operating conditions. The developed system enhances vehicle safety, improves parking reliability, and reduces the risk of accidental vehicle movement.

Overall, the proposed hand brake system provides a practical and economical solution for electric three-wheelers. The results demonstrate that the system is safe, efficient, easy to operate, and suitable for daily transportation applications

Keywords

Hand Brake System, Electric Three-Wheeler, Parking Brake, Brake Lever, Brake Cable, Safety Mechanism, Force Analysis, Vehicle Safety

1. INTRODUCTION

The increasing adoption of electric vehicles has created a growing demand for reliable and efficient safety systems. Among the various safety components used in vehicles, the hand brake system plays a significant role in preventing unwanted vehicle movement during parking and emergency situations. This project focuses on the design, analysis and development of a hand brake system for an electric three-wheeler to improve safety, stability, and operational reliability.

A hand brake, also known as a parking brake, is a mechanical braking system used to keep a vehicle stationary when parked. It operates independently of the main braking system and is generally applied through a hand-operated lever connected to the brake mechanism by means of cables or linkages. In electric three-wheelers, a reliable hand brake system is essential because these vehicles are frequently used in urban and rural transportation where parking on inclined or uneven surfaces is common.

The proposed hand brake system is designed for a rear wheel drum brake arrangement. When the hand brake lever is engaged, the force is transmitted through a brake cable to the drum brake assembly, creating sufficient braking torque to prevent wheel rotation. The system includes major components such as a hand brake lever, brake cable, ratchet and pawl mechanism, drum brake assembly, return spring, and mounting brackets. The ratchet mechanism helps maintain the braking force without requiring continuous effort from the driver.

Proper design of the hand brake system is important for ensuring vehicle safety and minimizing the risk of accidental movement. The braking performance depends on various factors such as lever length, cable tension, braking force, drum dimensions, and friction characteristics of the brake lining material. Selection of suitable materials and components improves durability, efficiency, and service life of the system.

The project involves design calculations, force analysis, material selection, and performance evaluation of the hand brake mechanism. Parameters such as braking torque, cable force, lever ratio, and holding capacity are analyzed to ensure safe operation under different loading conditions. Basic design validation and testing are also performed to evaluate system effectiveness.

2. LITERATURE SURVEY

1] **R. S. Khurmi and J. K. Gupta** discuss the design principles and working of mechanical braking systems used in automobiles. The study explains the importance of braking force, friction material selection, and brake drum design in achieving effective vehicle control. The authors emphasize that a properly designed hand brake system improves vehicle safety during parking and emergency situations. The study also highlights the importance of force transmission mechanisms such as cables and linkages in mechanical brake operation.

2] **V. B. Bhandari et al.** explain the design and analysis of machine components used in automotive systems. The research focuses on stress analysis, material selection, and safety considerations for mechanical components. The study indicates that proper design of brake levers, shafts, and connecting elements improves durability and reliability. The findings are useful in developing a strong and efficient hand brake mechanism for electric three-wheelers.

3] **M. G. Layne and R. Limpert** focus on automotive brake systems and their performance characteristics. The study explains various braking methods used in passenger and commercial vehicles. The authors discuss braking torque, friction force, stopping performance, and parking brake efficiency. The research highlights that an effective hand brake system should provide sufficient holding force to prevent vehicle movement on inclined surfaces and under varying load conditions.

4] **S. Rajasekaran et al.** studied the development of parking brake systems for light commercial vehicles. The research explains the use of drum brake mechanisms and cable-operated hand brake systems in vehicle safety applications. The study evaluates braking performance, maintenance requirements, and operational reliability. The results show that mechanical hand brake systems are economical, easy to maintain, and suitable for small vehicles including electric three-wheelers.

5] **J. Y. Wong et al.** present research related to vehicle dynamics and braking performance. The study explains the relationship between braking force, vehicle load, wheel dimensions, and surface conditions. The authors conclude that proper brake design significantly improves vehicle stability and safety. The research also suggests that efficient hand brake systems reduce the risk of accidental vehicle movement during parking and contribute to overall vehicle reliability.

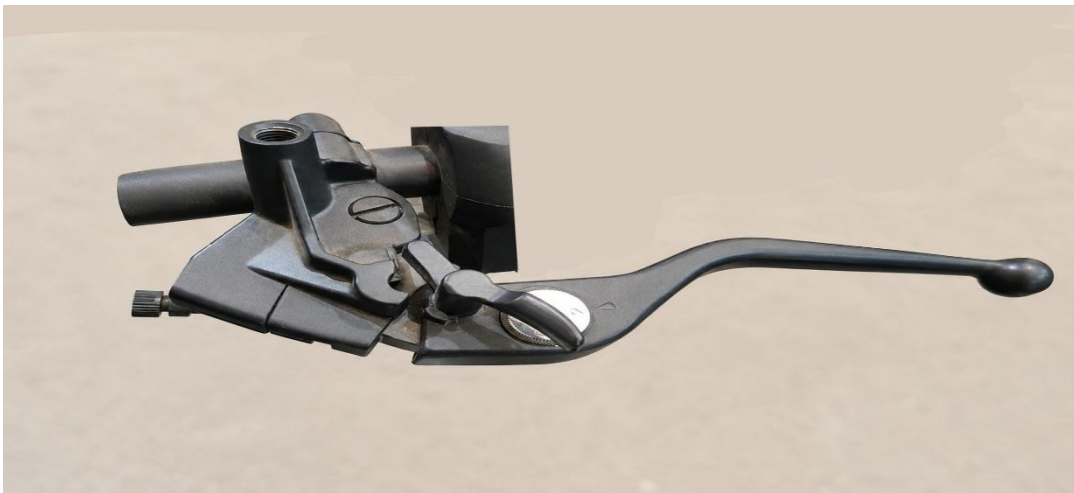
3. OBJECTIVES

- 1)To design and develop a hand brake system for an electric three-wheeler using a rear wheel drum brake mechanism.
- 2)To provide effective parking safety by preventing unwanted vehicle movement on inclined and uneven surfaces.
- 3)To analyze the braking force, cable tension, and braking torque required for efficient hand brake operation.
- 4)To ensure simple, reliable, and easy operation through a mechanical lever and cable arrangement.
- 5)To improve vehicle safety and stability while maintaining low manufacturing and maintenance costs.

4. COMPONENTS

4.1 Hand Brake Lever :

The hand brake lever is the primary control component of the hand brake system. It is manually operated by the driver to apply the parking brake and prevent unwanted vehicle movement during stationary conditions. The lever is designed to provide sufficient mechanical advantage, allowing the driver to generate the required braking force with minimum effort. When the lever is actuated, the applied force is transmitted through the brake cable to the rear wheel drum brake assembly. The hand brake lever is generally manufactured from high-strength steel or aluminum alloy to withstand repeated operating loads and ensure long service life. Its ergonomic design provides comfortable handling and smooth operation.



4.2 Brake Cable :

The brake cable is a flexible mechanical component used to transmit the force generated by the hand brake lever to the rear wheel drum brake assembly. It consists of a high-strength steel wire enclosed within a protective outer casing that ensures smooth and efficient force transmission. When the driver applies the hand brake lever, the force is transferred through the brake cable to the drum brake mechanism, resulting in braking action at the rear wheel.

The brake cable is designed to withstand repeated loading, vibration, and operating conditions while maintaining reliable performance. Its flexible structure allows easy installation and routing within the vehicle chassis. The protective outer covering minimizes friction, prevents corrosion, and increases service life. Proper adjustment of the brake cable ensures effective braking force and improves the overall efficiency of the hand brake system. Therefore, the brake cable plays a vital role in providing safe parking, reliable operation, and enhanced vehicle stability in electric three-wheelers.

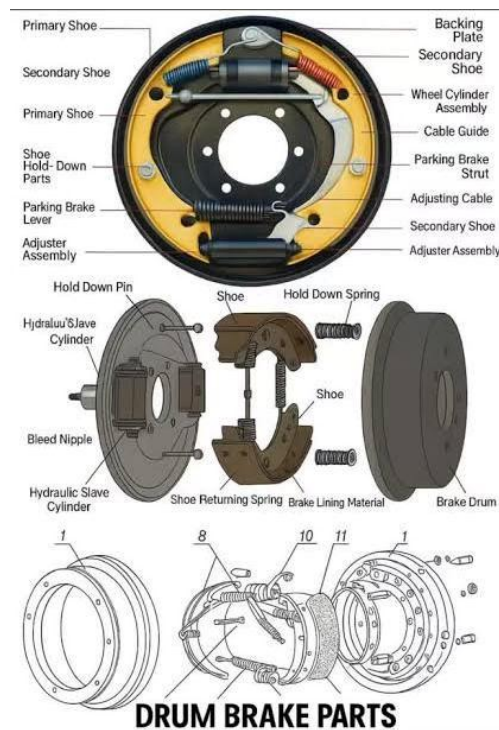


4.3 Rear Wheel Drum Brake Assembly :

The rear wheel drum brake assembly is the primary braking unit of the hand brake system. It consists of various components such as brake drum, brake shoes, return springs, backing plate, adjuster mechanism, and parking brake lever. The assembly is mounted on the rear wheel and is responsible for generating the braking force required to hold the vehicle in a stationary position during parking conditions.

When the hand brake lever is operated, force is transmitted through the brake cable to the drum brake assembly. This force causes the brake shoes to expand outward and press against the inner surface of the brake drum. The friction generated between the brake shoes and brake drum creates braking torque, which restricts wheel rotation and prevents vehicle movement. The return springs help restore the brake shoes to their original position when the hand brake is released.

The drum brake assembly is widely used in electric three-wheelers due to its simple construction, low manufacturing cost, reliable operation, and easy maintenance.



4.4 Brake Shoe :

The brake shoe is an important friction component used in the drum brake system. It is positioned inside the brake drum and is lined with a high-friction material that helps generate the braking force required to stop or hold the vehicle. When the hand brake lever is applied, the force transmitted through the brake cable activates the drum brake mechanism, causing the brake shoes to expand outward against the inner surface of the brake drum.

The friction generated between the brake shoe lining and the brake drum creates braking torque, which restricts wheel rotation and keeps the vehicle stationary. The brake shoe is designed to withstand repeated braking operations, high frictional forces, and wear conditions while maintaining consistent performance. Proper selection of friction lining material improves braking efficiency, reduces wear, and increases service life.



4.5 Return Spring

The return spring is an important component of the drum brake system that is used to restore the brake shoes to their original position after the hand brake is released. It is mounted between the brake shoes and provides the necessary restoring force required for smooth brake operation. The spring ensures that the brake shoes move away from the inner surface of the brake drum when braking force is removed.



4.6 Brake Drum :

The brake drum is a cylindrical component mounted on the rear wheel of the vehicle and forms an important part of the drum brake assembly. It rotates together with the wheel during vehicle motion and provides the friction surface against which the brake shoes operate. When the hand brake lever is applied, the brake shoes expand outward and press against the inner surface of the brake drum, generating the frictional force required to stop or hold the vehicle.

The brake drum is generally manufactured from high-quality cast iron due to its excellent wear resistance, strength, and heat dissipation properties. It is designed to withstand repeated braking operations and varying load conditions without significant deformation. The inner surface of the brake drum is precisely machined to ensure uniform contact with the brake shoes and improve braking efficiency.



4.7 Mounting Brackets and Fasteners :

Mounting brackets and fasteners are essential supporting components used to securely install and maintain the alignment of the hand brake system. These components provide a strong mechanical connection between the hand brake assembly and the vehicle chassis. Proper mounting ensures that the braking force generated by the hand brake lever is transmitted efficiently without any misalignment or loss of force.

The mounting bracket is designed to withstand operational loads, vibrations, and repeated braking forces while maintaining structural stability. Fasteners such as bolts, nuts, washers, and pins are used to securely hold various components in their required positions. These fastening elements prevent loosening of parts during vehicle operation and improve overall system reliability.



5. PROBLEM STATEMENT

The increasing use of electric three-wheelers for passenger transportation and short-distance travel has created a need for safe and reliable parking systems. Although electric vehicles provide an eco-friendly and economical transportation solution, vehicle safety during parking remains an important concern. In many cases, vehicles are parked on inclined roads, uneven surfaces, or crowded areas where accidental movement can create safety risks for passengers and surrounding vehicles.

A hand brake system is an essential safety mechanism used to prevent unwanted vehicle movement during parking. However, many existing hand brake systems suffer from problems such as insufficient braking force, excessive wear of components, cable stretching, poor force transmission, and reduced reliability. These issues can affect the overall performance of the braking system and increase maintenance requirements. Improper operation of the hand brake system may also reduce parking stability and compromise vehicle safety.

6. Working

The hand brake system is an important safety mechanism used in electric three-wheelers to prevent unwanted vehicle movement during parking and stationary conditions. Unlike the primary braking system, which is mainly used for slowing down or stopping the vehicle during motion, the hand brake system is specifically designed to hold the vehicle in a fixed position after it has come to a stop. The system operates mechanically and provides a simple, reliable, and cost-effective solution for parking safety.

The developed hand brake system consists of a hand brake lever, brake cable, rear wheel drum brake assembly, brake shoes, return spring, brake drum, and mounting brackets. These components work together to generate the required braking force and prevent wheel rotation. The hand brake lever is manually operated by the driver and acts as the primary input device of the system. When the lever is pulled upward, a mechanical force is generated and transmitted through the brake cable.

The brake cable plays an important role in transmitting force from the hand brake lever to the rear wheel drum brake assembly. As the cable is pulled, tension is developed within the cable, which activates the drum brake mechanism. The transmitted force is then transferred to the brake shoes located inside the brake drum. The brake shoes are lined with friction material and are designed to expand outward when force is applied.

As the brake shoes move outward, they come into contact with the inner surface of the brake drum. This contact creates friction between the brake shoe lining and the brake drum surface. The frictional force generated opposes the rotational motion of the rear wheel and gradually stops wheel movement. Once sufficient braking force is developed, the wheel becomes locked and the vehicle remains stationary. This mechanism prevents accidental movement of the vehicle during parking, especially on inclined roads and uneven surfaces.

The brake drum is connected directly to the rear wheel and rotates along with it during vehicle motion. When the hand brake is applied, the friction developed between the brake shoes and brake drum produces braking torque. This braking torque restricts wheel rotation and increases the holding capacity of the vehicle. The effectiveness of the braking system depends on several parameters such as brake drum diameter, brake shoe dimensions, friction coefficient, cable tension, and lever ratio.

A return spring is provided within the drum brake assembly to restore the brake shoes to their original position when the hand brake is released. The return spring prevents continuous contact between the brake shoes and brake drum, thereby reducing wear and friction losses. When the driver lowers the hand brake lever, the cable tension decreases and the return spring pulls the brake shoes away from the drum surface. As a result, the wheel rotates freely and normal vehicle operation is restored.

The mounting brackets and fasteners are used to securely support all components of the hand

brake system. These components ensure proper alignment and stability of the mechanism during operation. Proper mounting of the hand brake system improves reliability and prevents loosening of components under repeated loading conditions. The use of suitable materials further enhances durability and service life.

The developed hand brake system offers several advantages such as simple construction, easy operation, low maintenance requirements, and reliable braking performance. The system is particularly suitable for electric three-wheelers because it provides effective parking safety without requiring complex hydraulic or electronic control systems. The mechanical arrangement ensures consistent operation and reduces overall system cost.

Proper design and analysis of the hand brake mechanism help improve vehicle safety, parking stability, and operational reliability. The system is capable of generating sufficient braking force to hold the vehicle under different loading conditions. Therefore, the proposed hand brake system provides an efficient, economical, and dependable solution for electric three-wheelers.

7 .Maintenance and Safety Considerations

The performance of the hand brake system depends on proper maintenance and periodic inspection of all components. Regular checking of the hand brake lever, brake cable, brake shoes, return spring, and brake drum helps ensure safe and reliable operation. Any signs of wear, corrosion, cable stretching, or damage should be addressed immediately to prevent braking fail

The brake cable should be properly lubricated and adjusted to maintain smooth movement and efficient force transmission. Excessive cable slack can reduce braking effectiveness, while excessive tension may cause unnecessary wear of brake components. The brake shoes should be inspected periodically for lining wear and replaced whenever the friction material reaches its wear limit.

The brake drum surface should remain clean and free from excessive wear, cracks, or deformation. A damaged drum can reduce frictional performance and affect the holding capacity of the hand brake system. Similarly, return springs must maintain sufficient elasticity to restore the brake shoes to their original position after brake release.

Proper tightening of mounting brackets and fasteners is also essential to maintain component alignment and system stability. Loose fasteners can lead to vibration, noise, and reduced braking performance. Regular maintenance not only improves safety but also increases component life and reduces overall operating costs.

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