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Review on Design and Performance of Hand Brake System for Electric Three-Wheeler

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Abstract: *This paper presents a comprehensive review of the design, performance, and safety aspects of a hand brake system used in electric three-wheelers. The study focuses on major components that influence braking efficiency, vehicle stability, and parking safety. The review includes the hand brake lever, brake cable, rear wheel drum brake assembly, brake shoe, return spring, brake drum, and mounting brackets. The force transmission mechanism and braking action of the system are analyzed to understand their effect on vehicle performance and operational reliability. Proper braking is essential for preventing unwanted vehicle movement during parking, especially on inclined and uneven road surfaces. The effectiveness of the hand brake system depends on component design, friction characteristics, cable tension, and mechanical efficiency. The study also highlights the advantages of drum brake-based parking systems, including simple construction, low maintenance requirements, durability, and cost effectiveness. The combined assessment of these components provides an overall understanding of hand brake system operation and its importance in improving safety and reliability in electric three-wheelers*

Keywords: Electric Three-Wheeler, Hand Brake System, Brake Lever, Brake Cable, Drum Brake

I. INTRODUCTION

Electric vehicles (EVs) are becoming increasingly popular due to their low operating cost, reduced environmental pollution, and improved energy efficiency. Among various electric vehicle configurations, electric three-wheelers are widely used for passenger transportation and short-distance travel in urban as well as rural areas. As the demand for electric mobility increases, the importance of vehicle safety systems has also grown significantly. One of the most important safety mechanisms used in electric three-wheelers is the hand brake system, which helps prevent accidental vehicle movement during parking conditions. The hand brake system is a mechanically operated braking arrangement that acts independently of the main braking system. Its primary function is to hold the vehicle in a stationary position after it has been stopped. The system generally consists of a hand brake lever, brake cable, rear wheel drum brake assembly, brake shoes, return springs, and mounting components. When the driver operates the hand brake lever, the applied force is transmitted through the brake cable to the drum brake mechanism. The brake shoes expand against the inner surface of the brake drum, generating frictional force and braking torque. This braking action prevents wheel rotation and keeps the vehicle securely parked.

Proper design of the hand brake system is essential for ensuring reliable operation and effective parking performance. Factors such as braking force, cable tension, friction coefficient, brake shoe material, and drum dimensions directly affect the efficiency of the system. A well-designed hand brake system improves vehicle stability, enhances passenger safety, and reduces the risk of unintended movement on inclined roads. In addition, the system should be durable, easy to operate, and capable of providing consistent performance under different loading conditions. With advancements in electric vehicle technology and increasing focus on safety standards, the development of efficient hand brake systems has become an important area of study. Therefore, this review focuses on the design, working principles, major components, and performance characteristics of hand brake systems used in electric three-wheelers. The study aims to

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provide a better understanding of braking mechanisms and their contribution to vehicle safety, reliability, and operational efficiency.

II. LITERATURE SURVEY

1] Rudolf Limpert (2010) :Brake Design and Safety Rudolf Limpert presented a detailed study on automotive brake systems and their importance in vehicle safety. The research focused on braking force generation, friction characteristics, and parking brake mechanisms used in light vehicles. The study highlighted that drum brake systems provide reliable parking performance due to their simple construction and effective force multiplication. The author explained that proper brake shoe design, friction lining selection, and drum dimensions directly influence braking efficiency. The study also emphasized the importance of parking brake systems in preventing accidental vehicle movement on inclined surfaces. These findings support the use of a rear wheel drum brake-based hand brake system in electric three-wheelers and provide guidance for improving braking reliability and safety. [1]

2] V. B. Bhandari (2017): Design of Machine Elements V. B. Bhandari discussed various design principles related to machine elements used in mechanical systems. The study focused on stress analysis, material selection, force transmission mechanisms, and safety factors required for reliable operation. The research highlighted that components such as levers, cables, springs, and brackets must be designed to withstand repeated loading conditions without failure. Proper material selection improves durability, strength, and service life. The author also emphasized the importance of efficient force transmission through mechanical linkages. These concepts are directly applicable to the design of hand brake systems where braking force is transferred from the hand brake lever to the drum brake assembly through a cable mechanism. [2]

3] J. Y. Wong (2008): Theory of Ground Vehicles J. Y. Wong presented research on vehicle dynamics and braking performance. The study explained the relationship between braking force, wheel load, friction coefficient, and vehicle stability. The author concluded that an effective parking brake system plays a major role in maintaining vehicle safety and preventing unwanted movement during stationary conditions. The research also highlighted the effect of road conditions, vehicle weight, and braking torque on parking performance. The study suggested that proper distribution of braking force improves vehicle stability and operational safety. These findings are useful for understanding the braking characteristics of electric three-wheelers and the performance requirements of hand brake systems. [3]

4] H. Heisler (2002): Advanced Vehicle Technology H. Heisler discussed various braking technologies and automotive safety systems used in modern vehicles. The study provided detailed information regarding drum brake construction, force transmission mechanisms, and parking brake arrangements. The author explained the working principle of drum brakes and emphasized their advantages, including low cost, simple maintenance, and reliable operation. The research highlighted that proper integration of brake shoes, brake drums, springs, and cables significantly improves braking performance. The findings support the use of drum brake-based hand brake systems in electric three-wheelers due to their simplicity and effectiveness. [4]

5] T. D. Gillespie (1992): Fundamentals of Vehicle Dynamics T. D. Gillespie explained the fundamental principles of vehicle dynamics and braking systems. The study focused on braking torque, frictional forces, wheel locking conditions, and vehicle control. The author emphasized that parking brake systems are essential for ensuring vehicle safety when the vehicle is stationary. The research also highlighted that braking efficiency depends on component design, operating conditions, and friction characteristics. Proper analysis of these parameters improves system performance and reliability. The study concluded that effective hand brake systems enhance parking safety and reduce the risk of accidental vehicle movement. [5]

6] Bosch Automotive Handbook (2018): The Bosch Automotive Handbook provides comprehensive information regarding automotive brake systems and safety mechanisms. The handbook explains the construction and operation of drum brakes, parking brakes, and mechanical force transmission systems. It highlights the importance of proper component selection and regular maintenance to achieve consistent braking performance. The study also discusses

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various materials used in brake shoes and drums to improve durability and wear resistance. These concepts are useful for improving the design and performance of hand brake systems used in electric three-wheelers. [6]

7] R. S. Khurmi and J. K. Gupta (2014): Machine Design Khurmi and Gupta discussed the design methodology for mechanical components such as levers, springs, shafts, and fastening elements. The study highlighted the importance of strength, rigidity, and safety considerations in machine design. The authors emphasized that mechanical systems subjected to repeated loads must be designed with adequate safety factors. The findings are useful in the design and development of hand brake system components where reliable force transmission and structural stability are required. Proper design of these components improves operational reliability and service life.

8] R. K. Rajput (2016): Automobile Engineering R. K. Rajput presented a detailed study of automobile braking systems and vehicle safety mechanisms. The research explained the operation of drum brakes, parking brake systems, and braking force distribution. The author highlighted the importance of efficient braking systems in improving vehicle control and safety. The study concluded that drum brake-based parking systems continue to be widely used due to their simple design, low maintenance requirements, and effective performance. These findings support the application of hand brake systems in electric three-wheelers. [8]

9] William F. Milliken and Douglas L. Milliken (1995): Race Car Vehicle Dynamics:

William F. Milliken and Douglas L. Milliken presented a comprehensive study on vehicle dynamics, braking performance, and force distribution in wheeled vehicles. The research focused on the interaction between tire-road friction, braking torque, load transfer, and vehicle stability during braking operations. The authors emphasized that effective brake system design requires proper balancing of braking forces to ensure vehicle control and safety under various operating conditions. The study also highlighted the importance of parking brake mechanisms in maintaining stationary vehicle stability, particularly on inclined surfaces. Furthermore, the research discussed the influence of mechanical linkages and brake actuation systems on overall braking efficiency. These findings are useful for the design and analysis of hand brake systems in electric three-wheelers, where reliable parking performance and safe force transmission are essential. [9]

10] Crouse, W. H., and Anglin, D. L. (2007): Automotive Mechanics. W. H. Crouse and D. L. Anglin presented a detailed study on automotive braking systems, maintenance practices, and vehicle safety mechanisms. The research explained the construction and operation of drum brakes, parking brakes, brake shoes, return springs, and cable-operated brake systems commonly used in light vehicles. The authors emphasized that parking brake systems provide an important secondary braking function and ensure vehicle stability when parked on slopes or uneven surfaces. The study highlighted that proper adjustment of brake cables, selection of friction materials, and regular maintenance significantly improve braking performance and reliability. The findings indicate that drum brake-based parking brake systems are economical, durable, and effective for vehicles requiring simple mechanical actuation. These concepts are directly applicable to the design and development of hand brake systems for electric three-wheelers, where safety, reliability, and cost-effectiveness are key considerations. [10]

III. PROBLEM STATEMENT

Electric three-wheelers are widely used for passenger transportation and short-distance travel because of their low operating cost and environmentally friendly operation. However, vehicle safety during parking remains an important concern. Many vehicles rely on the primary braking system for holding the vehicle in a stationary position, which may not provide sufficient braking force under all operating conditions. When parked on inclined roads or uneven surfaces, the risk of unintended vehicle movement increases, creating safety hazards for passengers and surrounding vehicles.

The effectiveness of a hand brake system depends on the proper design and integration of components such as the hand brake lever, brake cable, brake shoes, return spring, and drum brake assembly. Improper design of these components may result in insufficient braking force, excessive wear, cable stretching, and reduced operational reliability. In addition, poor force transmission can decrease parking performance and increase maintenance requirements.

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Therefore, there is a need to review and analyze the design and performance of hand brake systems used in electric three-wheelers. The study aims to evaluate the major components, working principles, and operational characteristics of the system in order to improve parking safety, vehicle stability, braking efficiency, and overall reliability. This review will help identify important design considerations and provide a better understanding of hand brake system performance in electric three-wheeler applications.

IV. LIMITATION

1] Brake Cable Wear and Stretching :The brake cable is responsible for transmitting force from the hand brake lever to the rear wheel drum brake assembly. Continuous operation may cause cable stretching, wear, or corrosion over time. Excessive stretching can reduce braking force and affect parking performance. Regular inspection and adjustment are required to maintain proper operation. Poor cable condition may lead to delayed brake response and reduced reliability.

2] Brake Shoe Wear: Brake shoes are subjected to continuous friction during braking operation. Over a period of time, the friction lining becomes worn and reduces braking efficiency. Excessive wear may increase stopping distance and reduce parking brake holding capability. Replacement of worn brake shoes is necessary to maintain safe braking performance and vehicle stability.

3] Spring Fatigue and Mechanical Failure: Return springs are used to restore the brake shoes to their original position after braking action. Repeated loading and unloading cycles may cause fatigue failure or loss of elasticity. A damaged return spring can affect brake release and lead to improper brake operation. Periodic maintenance is required to ensure reliable performance.

4] Environmental and Operating Conditions: Brake system performance may be affected by dust, moisture, mud, and temperature variations. Exposure to harsh environmental conditions can accelerate component wear and corrosion. High operating loads and frequent braking may also increase mechanical stress on the system. These factors can reduce braking efficiency and component life if proper maintenance is not performed.

V. OBJECTIVE

- To design and analyze a hand brake system for an electric three-wheeler.
- To study the working principle of the hand brake lever and brake cable mechanism.
- To evaluate the performance of the rear wheel drum brake assembly.
- To improve vehicle parking safety and prevent unintended movement.
- To ensure reliable braking performance under different operating conditions.
- To study the effect of component selection on braking efficiency and durability.

VI. SELECTION OF MATERIAL

Material selection plays an important role in the design and performance of the hand brake system used in electric three-wheelers. Each component is selected based on mechanical strength, durability, corrosion resistance, cost, and ease of manufacturing. The hand brake lever is generally manufactured from mild steel or forged steel to provide high strength and long service life. These materials can withstand repeated operating forces without deformation and ensure reliable braking action. The brake cable is commonly made from high tensile steel wire with a protective outer sheath. This construction provides flexibility, durability, and resistance to wear and corrosion. High-strength steel cables are capable of transmitting braking force efficiently while maintaining structural integrity under repeated loading conditions. Brake shoes are manufactured using steel backing plates combined with friction lining materials. The friction lining provides adequate braking force while maintaining wear resistance and thermal stability. Proper selection of friction material improves braking efficiency and increases service life. The return spring is generally fabricated from spring steel due to its high elasticity and fatigue resistance. Spring steel ensures reliable restoration of brake shoes after braking action and maintains consistent performance throughout its operating life. The brake drum is typically manufactured from cast iron because of its excellent wear resistance, heat dissipation capability, and mechanical

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strength. Cast iron brake drums provide stable braking performance and withstand repeated frictional loads generated during operation. Mounting brackets and fastening elements are usually fabricated from alloy steel or mild steel to provide sufficient structural support. These components maintain proper alignment of the braking mechanism and ensure safe operation under various loading conditions.

In conclusion, proper material selection improves braking efficiency, durability, reliability, and safety of the hand brake system. The use of suitable engineering materials ensures long service life, reduced maintenance requirements, and effective operation of the electric three-wheeler under different environmental and operating conditions.

VII. SELECTION AND LAYOUT OF MATERIALS

Hand Brake Lever: The hand brake lever serves as the primary control component of the braking system. It is usually manufactured from mild steel or forged steel due to its high strength, durability, and resistance to deformation. The lever converts the driver's manual effort into mechanical force and transfers it to the brake cable. Force Transmission: It provides sufficient mechanical advantage to apply the required braking force with minimum effort. Safety: In emergency or parking situations, the hand brake lever helps prevent unwanted vehicle movement. Mounting Base: It is securely mounted near the driver's seat for easy accessibility and operation. Reliability and Durability: The lever is designed to withstand repeated operating cycles without failure and ensures consistent braking performance throughout its service life.

Brake Cable: The brake cable is responsible for transmitting force from the hand brake lever to the rear wheel drum brake assembly. It is generally made from high tensile steel wire enclosed within a protective outer casing. Force Transfer: The cable efficiently transfers braking force with minimal energy loss. Protection: The outer sheath protects the cable from dust, moisture, corrosion, and mechanical damage. Flexibility: The cable can be routed easily through the vehicle structure while maintaining smooth operation. Durability: High-strength steel construction ensures long service life under repeated loading conditions. Proper cable selection improves braking response and overall system reliability.

Brake Shoe: Brake shoes are designed to create friction against the inner surface of the brake drum during braking operation. They are manufactured using steel backing plates combined with friction lining material. Braking Function: When actuated, the shoes expand outward and press against the drum surface to generate braking force. Wear Resistance: The friction lining is designed to withstand repeated friction and thermal loading. Heat Dissipation: Proper lining material helps maintain braking performance under different operating conditions. Safety: Efficient brake shoes improve vehicle control and parking stability while reducing maintenance requirements.

Return Spring: The return spring is an important component used to restore the brake shoes to their original position after brake release. It is typically fabricated from spring steel due to its excellent elasticity and fatigue resistance. Brake Release: The spring ensures complete disengagement of the brake shoes after operation. Component Protection: It reduces unnecessary contact between the shoes and drum, thereby minimizing wear. Reliability: High-quality spring materials provide consistent performance throughout the operating life. Durability and Safety: Proper spring action improves braking response and overall system efficiency.

Rear Wheel Drum Brake Assembly: The rear wheel drum brake assembly consists of the brake drum, brake shoes, return springs, and supporting hardware. It is responsible for converting mechanical force into braking torque at the wheel. Structural Support: The assembly provides a compact and reliable braking mechanism suitable for electric three-wheelers. Braking Performance: Proper integration of all components ensures effective stopping and parking capability. Safety: The assembly improves vehicle stability and prevents unintended movement during parking conditions. Maintenance: Drum brake systems are simple, durable, and economical for long-term operation

Brake Drum: The brake drum is generally manufactured from cast iron because of its excellent wear resistance, heat dissipation capability, and structural strength.

Friction Surface: It provides the surface against which brake shoes operate.

Heat Management: The drum dissipates heat generated during braking and prevents excessive temperature rise.

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Mounting Brackets and Fasteners: Mounting brackets and fastening elements are used to securely support all braking components. These components are generally fabricated from mild steel or alloy steel to provide sufficient mechanical strength and durability.

Structural Support: They maintain proper alignment of the braking mechanism

Problem Identification
↓
Literature Review & Data Collection
↓
Selection of Hand Brake Components
↓
(Hand Brake Lever, Brake Cable, Brake Shoe, Return Spring, Brake Drum Assembly)
↓
Conceptual Design & System Planning
↓
Material Selection and Layout Design
↓
Fabrication & Assembly of Hand Brake System
↓
Installation on Electric Three-Wheeler
↓
Testing of Braking Performance
↓
Parking Safety Evaluation
↓
Result Analysis & Optimization
↓
Final Report & Presentation

Project Development Chart

9. Production: Purpose- Manufacture and assemble the hand brake system according to the approved design, ensuring that all safety, durability, and performance requirements are satisfied.

Implementation Steps: Material Selection: Select suitable materials for the hand brake lever, brake cable, brake shoe, return spring, brake drum, and mounting brackets by considering strength, durability, corrosion resistance, and cost-effectiveness.

Manufacturing Process: Construct the hand brake system based on the approved design using appropriate fabrication and assembly methods.

Production Process:

- Hand brake lever fabrication and mounting.
- Brake cable installation and routing.
- Brake shoe and return spring assembly.
- Rear wheel drum brake assembly installation.
- Mounting bracket and fastener fixing.
- System alignment and adjustment.
- Functional testing and quality inspection.

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VIII. CONCLUSION

In conclusion, the hand brake system plays a significant role in improving the safety and reliability of electric three-wheelers. The system provides an effective parking mechanism that prevents unintended vehicle movement during stationary conditions. Components such as the hand brake lever, brake cable, brake shoe, return spring, rear wheel drum brake assembly, and mounting brackets work together to provide reliable braking performance.The selected materials and component arrangement ensure sufficient strength, durability, and operational efficiency. The mechanical force generated through the hand brake lever is effectively transmitted through the brake cable to the drum brake assembly, producing the required braking torque at the rear wheel. Proper integration of these components improves parking safety and reduces the possibility of vehicle rollaway accidents.The study demonstrates that a well-designed hand brake system can provide consistent braking action, low maintenance requirements, and long service life. The system is simple, economical, and suitable for electric three-wheelers used in urban and rural transportation. Overall, the project highlights the importance of efficient braking mechanisms in enhancing vehicle safety, reliability, and user confidence during operation..

IX. FUTURE SCOPE

Improved Braking Materials: Advanced friction lining materials can be used to improve braking efficiency, wear resistance, and operational life of brake shoes..

Corrosion Resistant Components: The use of stainless steel cables, coated springs, and corrosion-resistant fasteners can increase durability under harsh environmental conditions.

Smart Brake Monitoring: Sensors can be integrated to monitor brake wear, cable tension, and braking performance in real time, improving maintenance planning and operational safety.

Lightweight Components: The use of lightweight alloy materials for brake levers and mounting brackets can reduce overall system weight while maintaining structural strength.

Enhanced Safety Features: Future systems may include electronic parking brake mechanisms and automatic brake locking systems to further improve vehicle safety and user convenience.

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