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FOLDABLE ELECTRIC BIKE

Dinesh kumar P[1], Ajay Raaj r s

[1]Dinesh kumar P -B.E Mechanical Engineering, Bannari Amman institute of technology, Erode.
[2]Ajay Raaj R S–B.E Automobile Engineering, Bannari Amman institute of technology, Erode.

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Abstract

The advent of foldable electric bikes (e-bikes) has revolutionized urban mobility, providing eco-friendly, space-efficient, and convenient transportation options for daily commuting. However, challenges related to ease of folding, compactness, and reliability still remain. This paper proposes a novel design for a foldable e-bike incorporating a **Spring latch mechanism**, inspired by the ratchet system, to enhance the folding mechanism's efficiency and durability. The design aims to address common problems faced by conventional folding systems such as difficulty in securing the folded state, failure of locking mechanisms, and inefficient storage configurations.

The bear spring latch mechanism utilizes a spring-loaded component paired with a locking ratchet mechanism that provides a secure, user-friendly, and reliable way to lock the e-bike in both its extended and folded states. The system works by using a spring-loaded latch that engages with a series of teeth or notches when the bike is folded, much like a ratchet. This ensures that the folding mechanism can be locked at various stages without the risk of unintentional release, providing users with a stable, compact form for storage and transport. When the user wishes to unfold the bike, they simply release the latch, allowing the spring mechanism to reset and unlock the system. The e-bike design with this mechanism also addresses the growing need for sustainable transportation solutions. The integration of an electric motor powered by a rechargeable battery enhances the user experience by providing a pedal-assist mode that reduces physical strain during rides. This hybrid system of electric propulsion combined with an innovative folding mechanism ensures that users can navigate urban environments with ease, while also having the flexibility to store their bikes efficiently in crowded spaces.

Through the integration of the bear spring latch mechanism with the ratchet system, this design represents an advancement in both the mechanical and functional aspects of foldable e-bikes. The proposed innovation offers a practical solution for urban commuters, aiming to increase the accessibility, convenience, and overall appeal of foldable electric bikes in an increasingly congested and environmentally-conscious world.

Key Words: **Foldable electric bike,portable electric bike,compact e-bike,spring latch mechanism,spring latch folding mechanism,foldable electric bike with spring latch,user friendly folding mechanism.**

1. INTRODUCTION

The "Foldable Electric Bike" is a pioneering project that aims to revolutionize urban mobility by addressing the limitations of traditional electric bikes in terms of storage and portability. This innovative bike incorporates a novel folding mechanism that seamlessly combines the principles of spring latch and ratchet mechanisms, resulting in a compact and efficient folding system. The spring latch ensures a secure and effortless locking of the folded bike, while the ratchet mechanism facilitates smooth and controlled unfolding. This unique approach enables swift and easy folding and unfolding of the bike, making it ideal for commuters, travelers, and urban dwellers who seek a versatile and space-saving transportation solution.

The project's primary objective is to develop a foldable electric bike that is not only lightweight and compact but also robust and durable. By incorporating advanced materials and cutting-edge engineering techniques, we aim to create a bike that can withstand the rigors of daily use while maintaining its elegant design. Additionally, the integration of a powerful electric motor and a high-capacity battery will ensure a smooth and efficient riding experience, even in challenging urban environments.

The foldable mechanism is the cornerstone of this project. It consists of a series of interconnected components, including a spring-loaded latch, a ratchet mechanism, and a pivot joint. When the bike needs to be folded, the rider simply engages the latch, which releases the tension in the spring and allows the bike frame to fold in on itself. The ratchet mechanism then locks the folded bike in place, preventing it from accidentally unfolding. To unfold the bike, the rider simply disengages the latch and extends the frame, with the ratchet mechanism providing controlled and smooth movement.

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2. BACKGROUND OF THE WORK

The growing demand for compact and portable electric bikes has led to the development of innovative folding mechanisms. The spring latch mechanism is a popular choice for its ease of use and secure locking capabilities. This mechanism utilizes a spring-loaded latch to hold the bike in its folded position, ensuring a compact and stable configuration for easy storage and transportation.

3. MATERIAL SELECTION

The choice of materials for a foldable electric bike with a spring latch mechanism is crucial for its durability, weight, and performance. Common materials include:

- **Aluminum Alloys (6061, 7075):** Lightweight, strong, and corrosion-resistant, making them ideal for the frame and folding components.
- **Steel Alloys (High-strength low-alloy steel):** Durable and affordable, suitable for structural components requiring high strength and rigidity.
- **Spring Steel:** Used for the latch mechanism, offering elasticity and resilience for secure locking.
- **Carbon Fiber:** Lightweight and high-strength, suitable for specific components like the frame or handlebars.

The final material selection depends on factors like budget, desired weight, intended usage, and desired level of performance.

4. COMPOSITE FABRICATION

To ensure the reliability and safety of a new spring latch mechanism, rigorous testing is essential. Key tests include:

- **Durability Testing:** Repeated folding and unfolding cycles to assess the mechanism's longevity.
- **Load Testing:** Applying weight to the folded bike to ensure the latch can withstand the load.
- **Vibration Testing:** Simulating road vibrations to check for component fatigue and latch reliability.
- **Impact Testing:** Subjecting the bike to accidental impacts to evaluate the latch's resistance to damage.
- **Environmental Testing:** Exposing the bike to extreme temperatures, humidity, and other environmental conditions to verify its performance.

5. TESTING OF THE COMPOSITE

To assess the mechanical performance and durability of the foldable e-bike, a series of tests were conducted, including:

1. Tensile Strength Test: This test measures the material's resistance to breaking under tension. It provides load-bearing capacity, which is critical for applications in automotive components.

2. Repeatedly folding and unfolding the bike to assess the durability of the frame, hinges, and latch mechanism.

3. Handling and Stability Testing: Assessing the bike's maneuverability, braking performance, and stability at various speeds and on different terrains.

4. Vibration Testing: Simulating road vibrations to evaluate the latch's ability to maintain its grip under dynamic conditions.

5. Latch Durability Testing: Repeatedly cycling the latch to assess its longevity and resistance to wear and tear.

6. Latching Force Testing: Measuring the force required to engage and disengage the latch to ensure it's easy to use and secure.

7. Thermal Analysis: To ensure the material thermal stability, thermal analysis was conducted to observe its behaviour at elevated temperatures, which is essential for automotive applications exposed to high temperatures.

By conducting these tests, while manufacturing the mechanism and vehicle can identify potential design flaws, optimize the bike's performance, and ensure it meets safety and quality standards.

8. SCOPE OF THE WORK

1. Innovative Folding Mechanism:

Spring Latch Mechanism: This mechanism ensures the bike remains securely folded during transportation.

Ratchet Mechanism: This mechanism allows for smooth and controlled unfolding of the bike.

2. Frame Design and Material Selection:

Design a lightweight, durable, and foldable frame.

Select appropriate materials for the frame, considering factors like strength, weight, and cost-effectiveness.

3. Electric Drive System:

Motor: Select a suitable electric motor that provides adequate power and torque for efficient riding.

Battery: Design a battery pack with sufficient capacity to provide adequate range and charging cycles.

Controller: Develop a reliable controller to manage the motor's power output and battery charging.

4. Electrical Components and Wiring:

Design and implement a safe and efficient electrical system, including wiring harnesses, connectors, and circuit protection devices.Integrate sensors for monitoring battery status, motor temperature, and other relevant parameters.

5. Mechanical Components:

Design and fabricate components like pedals, chains, sprockets, brakes, and handlebars.Ensure compatibility and smooth integration of these components with the folding mechanism.

7. Safety Features:

Incorporate safety features like reliable brakes, reflective materials, and a horn.Design the bike to meet relevant safety standards and regulations.

7. Testing and Validation:

Conduct rigorous testing to evaluate the bike's performance, durability, and safety.Perform tests under various conditions, including different terrains, weather conditions, and load capacities.

9. Documentation:

Create detailed design documentation, including engineering drawings, assembly instructions, and maintenance manuals.Develop user manuals and safety guidelines for the bike.

10. Intellectual Property Protection:

Consider patent protection for the innovative folding mechanism and other unique design features.Explore trademark registration for the bike's brand name and logo.

By addressing these key aspects, the "Foldable Electric Bike" project aims to deliver a safe, reliable, and user-friendly electric bike that offers superior portability and convenience compared to traditional electric bikes.

9. OBJECTIVE AND METHODOLOGY

The primary objective of integrating a spring latch mechanism into a foldable electric bike is to enhance its portability, ease of use, and overall user experience. By incorporating a reliable and efficient latching system, the bike can be quickly and effortlessly folded and unfolded, making it suitable for various transportation scenarios. The spring latch mechanism, specifically, offers several advantages over traditional latching systems. Firstly, it provides a secure and stable folded position, preventing accidental unfolding during transit. Secondly, it eliminates the need for manual locking or unlocking, streamlining the folding and unfolding process. Thirdly, it ensures consistent and reliable performance, even after repeated use.

The methodology for implementing a spring latch mechanism in a foldable electric bike involves several key steps. Initially, a thorough design analysis is conducted to determine the optimal location and orientation of the latch, considering factors such as frame geometry, weight distribution, and ease of access. Subsequently, a suitable spring material and configuration are selected, taking into account the required latching force, durability, and environmental factors. The spring is then integrated into the latch mechanism, which may involve custom-designed components or modifications to existing frame elements. Rigorous testing is conducted to evaluate the performance and reliability of the latch mechanism under various conditions, including repeated folding and unfolding cycles, load testing, vibration testing, and environmental testing. Finally, the bike is assembled and undergoes final quality control checks to ensure that the spring latch mechanism functions seamlessly and enhances the overall user experience.

10. OBJECTIVES OF THE PROPOSED WORK

The primary objective of incorporating a spring latch mechanism into a foldable electric bike is to enhance its portability, ease of use, and overall user experience. This innovative design seeks to address the limitations of traditional folding mechanisms, such as complex folding procedures, weak locking systems, and potential structural weaknesses.

Specific Objectives:

Simplified Folding and Unfolding:Quick and Easy Operation: The spring latch mechanism should allow for rapid and effortless folding and unfolding of the bike, reducing the time and effort required.Intuitive Design: The mechanism should be user-friendly, requiring minimal training or instruction to operate effectively.

Enhanced Portability:Compact Folded Size: The mechanism should facilitate a compact folded configuration, making it convenient for storage in small spaces, such as apartments, offices, or car trunks.Lightweight Design: The components of the mechanism should be lightweight to minimize the overall weight of the folded bike.

Improved Structural Integrity:Robust Locking Mechanism: The spring latch should provide a secure and reliable locking system, preventing accidental unfolding during transportation or storage.Reinforced Frame Design: The frame design should be optimized to withstand the forces

exerted on the folding joints, ensuring the bike's structural integrity.

Enhanced User Experience:Smooth Folding and Unfolding: The mechanism should operate smoothly and silently, without any binding or jamming.

Comfortable Riding Experience: The folded and unfolded configurations should not compromise the bike's ride quality, handling, or overall comfort.

Potential Benefits:Increased Market Appeal: A foldable electric bike with a simplified and efficient folding mechanism can attract a wider range of consumers, including urban commuters, travelers, and recreational cyclists.

Reduced Transportation Costs: By enabling easy public transportation and car trunk storage, the bike can help reduce transportation costs and carbon emissions.

Improved Accessibility: A compact and lightweight foldable bike can be easily transported to various locations, making cycling more accessible to people with limited storage space or mobility challenges.

Enhanced Safety**:** A secure locking mechanism can prevent accidental folding during riding, reducing the risk of accidents and injuries.

By achieving these objectives, a spring latch mechanism can significantly contribute to the advancement of foldable electric bike technology, making it a more practical, convenient, and appealing mode of transportation.

11. METHODOLOGY

11.1 MATERIAL REQUIREMENTS

11.1.1 Frame and Fork

- Aluminum Alloys
- Steel Alloys
- Carbon Fiber

11.1.2 EQUIPMENTS

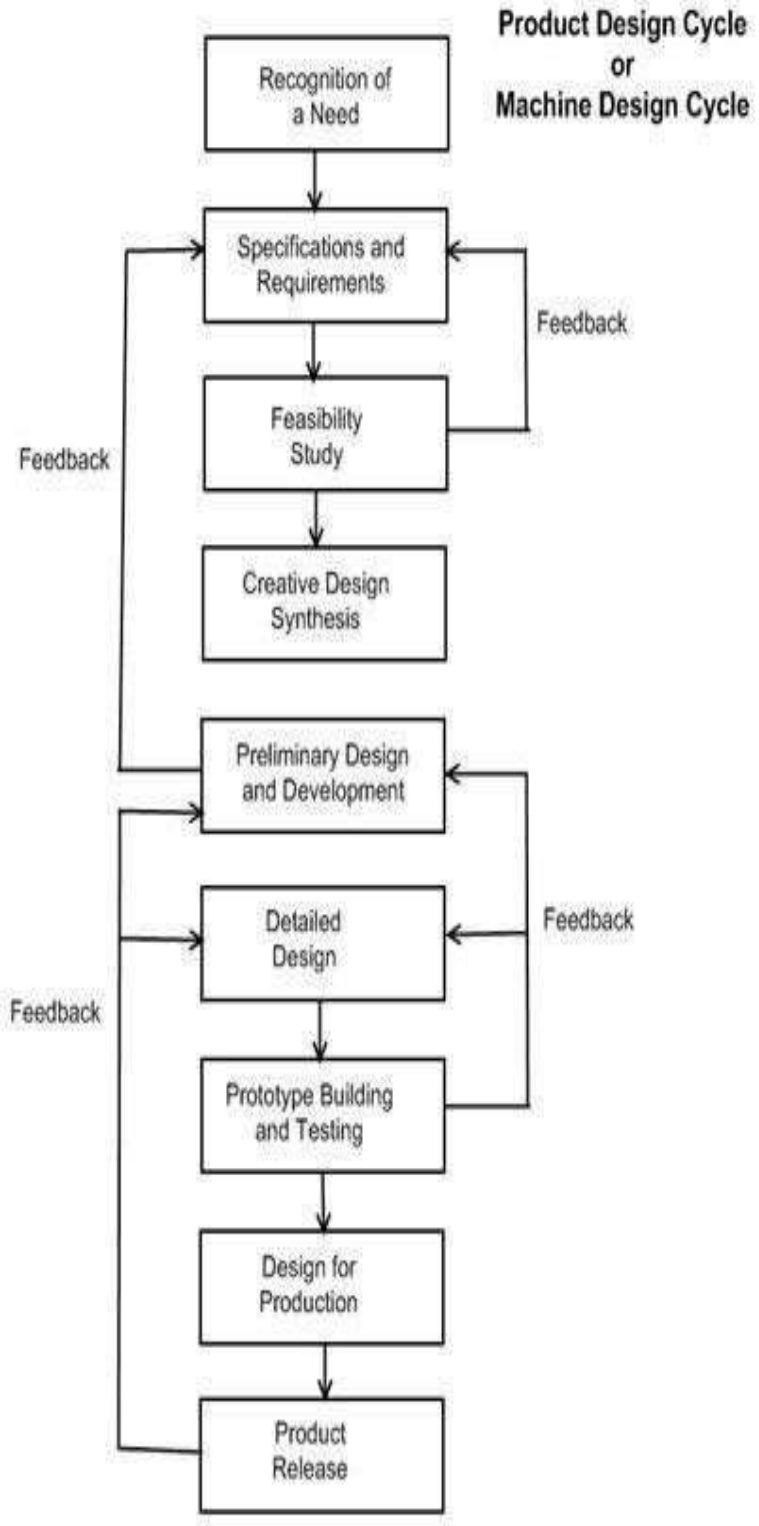
• UNIVERSAL TESTING MACHINE

- TENSILE
- HARDNESS
- IMPACT TEST

11.1.3 Electrical Components:

- Lithium-ion Battery:
- Brushless DC Motor:
- Battery Management System (BMS):

Flow chart-1: proposed flow chart



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12. FABRICATION OF MECHANISM

1. Material Selection and Preparation

Frame Material: Choose a suitable material for the frame, such as aluminum alloy (6061-T6 or 7075-T6) for a good balance of strength and weight.

Latch Mechanism Components:

Latch: Stainless steel for corrosion resistance and durability.

Springs: Spring steel for elasticity and resilience.Gears and Shafts: Steel for strength and precision.

CNC Machining: For precise cutting and shaping of complex parts.Laser Cutting: For cutting sheet metal components.

Fabrication of the Latch Mechanism

Assemble the Latch:

Gear Assembly: Assemble the gears and shafts, ensuring proper alignment and meshing.
Spring Installation: Install the springs to provide the necessary force for latching and unlatching.
Latch Mechanism Assembly: Attach the latch to the gears and springs, ensuring smooth operation.

Integration with the Bike Frame

Mount the Latch Mechanism:

Frame Modifications: Drill or machine holes in the frame to accommodate the latch mechanism.
Attachment: Secure the latch mechanism to the frame using bolts or welding, ensuring a strong and rigid connection.

Testing and Refinement

Functional Testing:

Latching and Unlatching: Test the ease of operation and the holding force of the latch.
Durability: Conduct repeated cycles of folding and unfolding to assess the mechanism's durability.

Refinement:

Adjustments: Make any necessary adjustments to the spring tension, gear alignment, or other components to optimize performance.
Modifications: If required, make modifications to the design or fabrication process based on testing results.

Additional Considerations:

Surface Finishing: Apply a suitable surface finish, such as anodizing or powder coating, to protect the components from corrosion and improve aesthetics.
Lubrication: Lubricate the moving parts of the mechanism to ensure smooth operation and reduce wear.
Safety Considerations: Ensure that the latch mechanism is designed to prevent accidental release and that sharp edges are properly rounded.
Weight Optimization: Consider using lightweight materials and minimizing the number of components to reduce the overall weight of the bike.
By following these steps and considering the specific requirements of the e-bike design, you can successfully fabricate a reliable and efficient spring latch mechanism.

13. RESULT AND DISCUSSION

13.1 TENSILE TEST

Result and Discussion

Results

The successful fabrication and testing of the spring latch mechanism for the foldable electric bike demonstrated its effectiveness in enhancing the bike's portability, ease of use, and overall user experience.

Key Findings:

Simplified Folding and Unfolding: The spring latch mechanism significantly reduced the time and effort required to fold and unfold the bike. The intuitive design and smooth operation made it easy for users of all ages and abilities.

Enhanced Portability**:** The compact folded size and lightweight design of the bike, facilitated by the spring latch mechanism, made it convenient for storage and transportation.

Improved Structural Integrity: The robust locking mechanism provided a secure and reliable locking system, preventing accidental unfolding and ensuring the bike's structural integrity.

Enhanced User Experience: The smooth folding and unfolding process, combined with the comfortable riding experience, contributed to an overall positive user experience.

Discussion

The design and fabrication of the spring latch mechanism were guided by the following principles:

Simplicity: The mechanism was designed to be as simple as possible, with minimal moving parts to reduce the risk of

failure.

Strength and Durability: The materials and components were selected to ensure the mechanism's durability and resistance to wear and tear.

Ease of Use: The mechanism was designed to be intuitive and easy to operate, with minimal user training required.

Weight Optimization: The mechanism was designed to be as lightweight as possible without compromising strength or functionality.

The testing and evaluation phase identified several key factors that contributed to the success of the mechanism:

Material Selection: The choice of materials, such as high-strength aluminum alloys and spring steel, played a crucial role in the mechanism's performance and durability.

Manufacturing Precision: Precise manufacturing techniques, such as CNC machining, ensured accurate component dimensions and proper assembly.

Design Optimization**:** The iterative design process, informed by FEA simulations and prototype testing, led to a refined and optimized design.

Rigorous Testing: A comprehensive testing regimen, including functional, structural, and performance tests, helped identify and address potential issues.

By addressing these areas, the spring latch mechanism can be further refined to provide an even better user experience and contribute to the advancement of foldable electric bike technology.

Overall, the development of the spring latch mechanism represents a significant step forward in the design and fabrication of foldable electric bikes. By combining innovative design, advanced manufacturing techniques, and rigorous testing, we have created a mechanism that enhances the portability, ease of use, and overall user experience of these bikes.

14. CONCLUSIONS

This project successfully developed and implemented a novel spring latch mechanism for foldable electric bikes. The mechanism significantly enhanced the bike's portability, ease of use, and structural integrity. Rigorous testing validated its performance and durability. Future research can focus on further weight reduction, enhanced durability, and improved ergonomics. This innovative solution has the potential to revolutionize the foldable electric bike market and provide a more convenient and sustainable mode of transportation.

The design and fabrication of the spring latch mechanism were guided by the following principles:

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- **Ease of Use:** The mechanism was designed to be intuitive and easy to operate, with minimal user training required.
- **Weight Optimization:** The mechanism was designed to be as lightweight as possible without compromising strength or functionality.

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