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Design and Fabrication of a Multi Nut Removal Tool

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Abstract

In the automotive and industrial sectors, maintenance operations often involve the removal and tightening of multiple nuts and bolts. Conventional tools such as spanners and wheel wrenches require each nut to be operated individually, resulting in increased maintenance time, operator fatigue, and reduced productivity. This paper presents the design and fabrication of a multi nut removal tool capable of loosening or tightening multiple nuts simultaneously through a gear-driven mechanism. The system is designed to distribute torque uniformly to multiple sockets, ensuring efficient operation while minimizing manual effort. The design process included literature review, conceptual design, computer-aided modeling using CATIA software, component selection, fabrication, assembly, and testing. Experimental evaluation demonstrated a significant reduction in operation time compared with traditional methods. The developed prototype is economical, user-friendly, and suitable for automotive workshops and industrial maintenance applications.

Keywords: Multi nut removal tool, Gear mechanism, Torque transmission, Automotive maintenance, Fabrication, Mechanical design.

1. Introduction

Maintenance activities play a vital role in ensuring the reliability, safety, and efficiency of automotive and industrial machinery. Among the various maintenance operations, tightening and loosening nuts and bolts is one of the most frequently performed tasks. In automobile wheel servicing, multiple wheel nuts must be removed before a tire can be replaced or repaired. Traditionally, mechanics use spanners, L-wrenches, or impact tools to remove each nut separately. This process is repetitive, time-consuming, and physically demanding.

A multi nut removal tool offers an innovative solution by enabling simultaneous operation of multiple nuts. Such a system can significantly reduce the time required for wheel maintenance while ensuring uniform torque application across all nuts.The concept behind the proposed tool is based on mechanical power transmission through a gear arrangement. By transmitting rotational motion from a single input source to multiple output sockets, several nuts can be loosened or tightened at the same time. This not only improves efficiency but also reduces the physical effort required from the operator.

The present work focuses on the design, fabrication, and performance evaluation of a compact multi nut removal tool suitable for automotive wheel maintenance. The project demonstrates the practical application of mechanical design principles, gear mechanisms, and fabrication techniques to solve a real-world maintenance problem.

2. Objectives

The main objectives are as follows:

1. To design and fabricate a tool capable of removing or tightening multiple nuts simultaneously.
2. To reduce the overall maintenance and servicing time.
3. To minimize operator effort and physical fatigue.
4. To provide uniform torque distribution to all wheel nuts.
5. To improve maintenance efficiency and productivity.
6. To develop a compact, reliable, and cost-effective system.
7. To explore the practical implementation of gear-driven torque transmission mechanisms.

Achieving these objectives can help improve workshop operations and reduce downtime during maintenance activities.

3. Methodology

The development of the multi nut removal tool was carried out through a systematic engineering approach consisting of several stages.

3.1 Literature Review

A detailed review of existing wheel nut removal tools and related research papers was conducted. Various designs and mechanisms used in automotive maintenance were studied to identify limitations and potential improvements.

3.2 Concept Development

Different concepts were generated and evaluated based on simplicity, cost, efficiency, and ease of fabrication. A gear-driven mechanism was selected due to its ability to distribute torque evenly to multiple outputs.

3.3 CAD Modeling

The selected concept was modeled using CATIA software. Individual components such as gears, shafts, sockets, and frame structures were designed and assembled virtually to verify dimensional compatibility and functionality.

3.4 Component Selection

Appropriate mechanical and electrical components were selected according to torque requirements, durability, availability, and cost considerations. Particular attention was given to gear dimensions and motor specifications.

3.5 Fabrication

The fabrication process involved cutting, drilling, welding, machining, and assembly operations. Standard workshop equipment and manufacturing techniques were used to produce the prototype.

3.6 Testing and Evaluation

The fabricated prototype was tested under practical operating conditions. Parameters such as operation time, ease of use, torque transmission, and reliability were evaluated and compared with conventional methods.

4. Components and Design

The multi nut removal tool consists of several mechanical and electrical components that work together to perform the required operation.

4.1 PMDC Motor

A 12 V Permanent Magnet DC (PMDC) motor is used as the primary power source. The motor converts electrical energy into mechanical rotational motion and provides the required torque to drive the gear system.

4.2 Battery

A rechargeable 12 V battery supplies electrical power to the motor. The battery enables portability and independent operation without external power connections.

4.3 Spur Gears

Spur gears are used to transmit rotational motion from the motor to the output sockets. A 1:1 gear ratio is employed to ensure equal rotational speed and torque distribution among all sockets. The gears are easy to manufacture and provide efficient power transmission.

4.4 Sockets

Sockets are attached to the output shafts and engage directly with wheel nuts. The sockets are selected according to standard automotive wheel nut dimensions.

4.5 Base Frame

The frame supports all components and maintains proper alignment of gears and shafts. Mild steel was selected due to its strength, durability, and ease of fabrication.

4.6 Switch and Wiring

The electrical switch controls motor operation, while insulated wires connect the battery and motor safely.

4.7 Handle

A handle is provided for manual support and positioning of the tool. It improves ergonomics and user comfort during operation.

4.8 Cover Plates

Protective cover plates are installed to prevent accidental contact with rotating gears and moving components.

5. Working Principle

The operation of the multi nut removal tool is based on the principle of torque transmission through a gear train. When the motor is switched on, rotational motion is generated and transmitted to the primary gear. This motion is further transferred to interconnected spur gears arranged within the system.

The gears rotate multiple output shafts simultaneously. Each output shaft is connected to a socket that engages with a wheel nut. As all sockets rotate together, multiple nuts can be loosened or tightened in a single operation.

The equal gear ratio ensures uniform distribution of torque among all sockets. This prevents uneven loading and ensures smooth operation. The simultaneous action significantly reduces servicing time and enhances maintenance efficiency.

The tool can be operated with minimal effort and provides a practical solution for workshops where wheel maintenance is performed frequently.

6. Results and Discussion

The fabricated prototype was successfully assembled and tested. During testing, the tool demonstrated satisfactory performance in removing and tightening multiple nuts simultaneously.

The major observations include:

- Significant reduction in maintenance time compared with conventional methods.
- Reduced physical effort required by the operator.
- Smooth and reliable torque transmission through the gear system.
- Improved efficiency during wheel servicing operations.
- Stable operation without excessive vibration or misalignment.

The gear-driven mechanism effectively distributed torque to all sockets, allowing simultaneous operation of multiple nuts. The prototype performed consistently during repeated trials and showed good mechanical reliability.

Compared with traditional methods where each nut must be removed individually, the developed tool improved productivity and reduced maintenance downtime. The results indicate that the proposed design can be successfully implemented in automotive workshops and industrial maintenance applications.

7. Advantages

The developed multi nut removal tool offers several advantages:

- Reduces maintenance time considerably.
- Improves productivity and efficiency.
- Decreases operator fatigue.
- Provides uniform torque distribution.
- Easy to operate and maintain.
- Compact and portable design.
- Economical compared with advanced automated systems.
- Suitable for automotive and industrial applications.

8. Future Scope

Several improvements can be incorporated into future versions of the tool:

1. Integration of automatic torque control systems.
2. Use of lightweight materials such as aluminum alloys.
3. Incorporation of digital torque monitoring sensors.
4. Development of wireless or remote-control operation.
5. Integration with battery management systems for extended operating time.
6. Adaptation for different wheel sizes and industrial applications.
7. Use of advanced manufacturing methods for improved precision and durability.

These enhancements can further improve performance, safety, and usability.

9. Conclusion

The multi nut removal tool developed in this project provides an effective solution for reducing the time and effort associated with wheel nut maintenance operations. The gear-driven mechanism successfully enables simultaneous operation of multiple nuts while ensuring uniform torque transmission. The fabricated prototype demonstrated reliable performance, reduced operator fatigue, and improved maintenance efficiency. The design is economical, practical, and suitable for real-world automotive and industrial applications. With further development and automation, the tool has significant potential for widespread adoption in maintenance workshops and service centers.

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