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Design and Fabrication of a Motorized Screw Jack for Automotive Applications

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Abstract

A screw jack is a mechanical device used for lifting the heavy-duty vehicles. Screw jack is employed by the screw threads for lifting purpose. To operate the screw the handle is used and when the handle is operated clockwise then it lifts the work similarly when the handle is operated in anti-clockwise then it lowers the work. In case of tire flat or changing the tire, the screw jack is very important and useful device. The screw jack is operated manually and when the ancient people when they want to change the tire it is not so easy. So, to overcome the situation it can be employed automatically so that the time is reduced and they can conveniently replace the tire. The motorized screw jack features user-friendly controls, robust safety systems like automatic locks and emergency shut-off functions, and is constructed from durable materials to ensure long-term reliability. It operates via a 12V power supply, typically sourced from a vehicle's cigarette lighter socket. The project demonstrates that the motorized screw jack can lift a vehicle safely and efficiently, making it a valuable tool for both professional mechanics and everyday vehicle owners. The prototype's performance in load tests confirms its capability to handle substantial weights with improved lifting speed and minimal manual effort.

Key words: Motorized Screw Jack, Lifting Mechanism, Automated Jacking System, 12V DC Motor Drive, Load Handling Efficiency

Introduction

Manual screw jacks have long been utilized as essential lifting devices in automotive and industrial applications due to their simple design and reliable mechanical operation. However, their dependence on manual effort often leads to inefficiencies, user fatigue, and increased risk of accidents, particularly during heavy-load operations. In recent years, attempts to automate lifting systems have emerged, yet existing designs continue to face challenges in terms of operational consistency, convenience, and intelligent control integration. This study presents the design and development of a motorized screw jack aimed at addressing these shortcomings through the application of modern mechatronic principles. The proposed system incorporates an electric motor drive mechanism, an integrated sensor network, and an IoT-based monitoring and control interface that allows users to operate and supervise the lifting process remotely. Safety features such as overload protection, automatic stop mechanisms, and real-time status feedback are embedded to ensure reliable and secure operation.

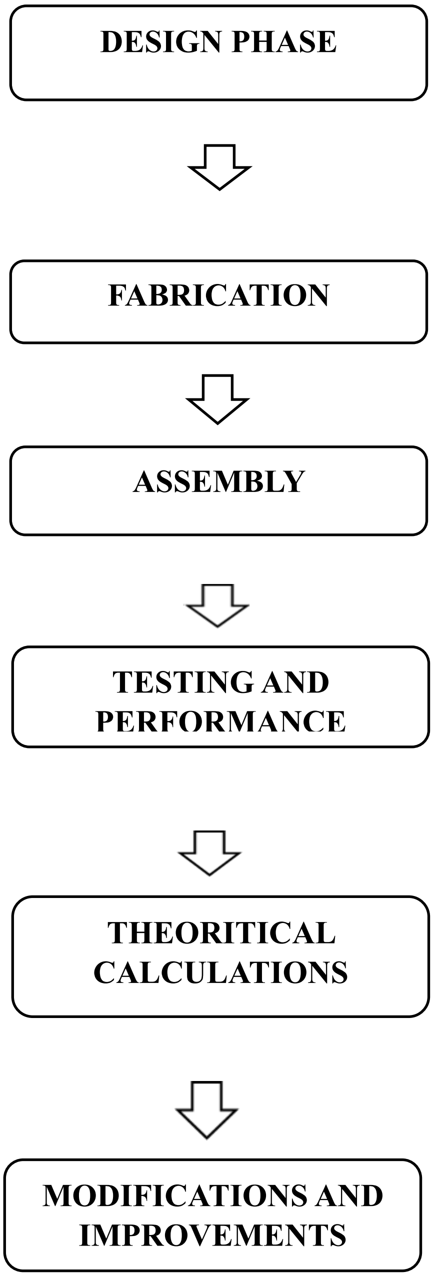
The research methodology involves mechanical Modeling of the screw jack, selection of appropriate drive systems, embedded control design, and IoT system integration using microcontroller-based architecture. The developed prototype is evaluated for parameters including load capacity, lifting speed, energy efficiency, and control accuracy. Results demonstrate that the motorized IoT-enabled screw jack significantly improves operational safety, reduces manual exertion, and enhances usability compared to conventional manual jacks. By combining mechanical design innovation with digital control and connectivity, this project contributes to the advancement of intelligent lifting technologies and supports the broader transition toward automation and smart mechanical systems in vehicle maintenance and industrial lifting applications.

Literature Survey

The need for efficient and reliable lifting mechanisms in automotive maintenance has driven significant advancements in screw jack automation. Traditional manually operated screw jacks, though simple in design, are often inefficient and unsafe during emergency tire replacement or maintenance operations. Recent research has focused on automating these systems using electromechanical and control-based approaches to improve ease of operation, safety, and precision. [1] developed an improved screw jack system for light vehicles by optimizing the load transfer mechanism and reducing operator effort through mechanical leverage enhancement. Similarly, Ajayi and Adeyinka [2] presented an automatic scissor-type car jack driven by a DC motor, highlighting significant reductions in lifting time and manual strain. Their work established a foundation for incorporating automation into portable lifting devices. Borse et al. [3] designed a screw jack mechanism focused on minimizing input torque requirements using improved lead screw geometry, demonstrating the mechanical advantage achievable with optimized design parameters. [4] expanded upon this concept by implementing wireless remote control for a motorized screw jack, enabling driver operation without physical interaction and thereby improving convenience and safety. [5] fabricated a motorized screw jack machine integrating a high-torque DC motor with gear reduction, emphasizing load-carrying stability for automotive applications. The integration of mobile applications into mechanical systems has also been explored.[6][7] introduced Android-controlled jacking systems for light and heavy vehicles, using microcontroller-based logic to ensure controlled lifting and stopping operations. Nagaraja et al. [8] proposed a remote-controlled hydraulic jack, bridging the gap between purely mechanical and electro-hydraulic systems. This hybrid approach reduced power losses and improved operational efficiency compared to traditional screw jacks. Further advancements have emphasized automation and control precision.[9] designed an automated two-way rotational screw jack allowing both clockwise and counterclockwise actuation for lifting and lowering using dual-switch controls. The study.[10] also highlighted the importance of material selection, where aluminium alloys were found to balance strength and weight efficiency. In addition to manual automation, intelligent and wireless control systems have emerged. Studies, [11] demonstrated the use of Arduino and Bluetooth modules for wireless control, allowing precise control of lifting height through smartphone interfaces. These systems are particularly beneficial in modern electric vehicles where onboard electronics can integrate with control modules for automated tire replacement. The work by and the MDPI study on non-back-drivable screw mechanisms [12] emphasized the importance of safety in mechanical locking and back-drive prevention. Overall, the literature indicates a shift from manual mechanical jacks to intelligent, remotely operated, and energy-efficient systems. Current trends aim at enhancing portability, stability, and operational ease through automation, microcontroller integration, and ergonomic design improvements [13]. Despite these developments, further research is required to standardize control systems, minimize energy consumption, and ensure compatibility across different vehicle types [14], [15]thus, the evolution of motorized screw jacks signifies the fusion [16] of mechanical engineering principles with modern automation technologies, aligning with the growing demand for safety and efficiency in the automotive service industry.

Proposed Method:

The proposed system focuses on designing and fabricating a motorized screw jack to simplify the vehicle lifting process during maintenance and tire replacement. Traditional manual jacks require significant human effort and time, often posing safety risks. The motorized screw jack integrates an electric motor, lead screw mechanism, and control switch to automate the lifting and lowering operations. This system ensures efficient, safe, and reliable vehicle elevation with minimal manual input. Designed for automotive applications, the proposed model enhances portability, reduces operation time, and provides a user-friendly solution adaptable for both light and medium-duty vehicles.



Define requirements: lifting capacity W, stroke, compactness, and safety factor FS. Select lead-screw geometry (mean diameter d_m, lead L) and motor specs. Key equations: torque to raise load (approximate)

$$T_{\text{raise}} \approx W\left(\frac{L}{2\pi} + \frac{\mu d_m}{2}\right)$$

efficiency

$$\eta \approx (L/2\pi)/(L/2\pi + (\mu d\_m)/2)$$

and motor power

$$P = T_{\text{raise}} \cdot \omega, \qquad \omega = \frac{2\pi N}{60}.$$

Choose materials so allowable stress $= (\sigma_y)/FS$exceeds calculated stresses. Document ergonomics, control interface, and protection (limit switches, overload cutout).

Fabrication:

machining allowances and residual stresses. For shaft torsion use shear stress

$$\tau = \frac{T\,c}{J} = \frac{16T}{\pi d^3}$$

where $d$is shaft diameter.

For threaded member strength,

check shear on thread roots using shear area $A_s$and compare $\tau_{\text{thread}} = W/A_s$with allowable shear

Assembly:
Assemble components ensuring concentricity and preload,

Control clearances: radial runout <bearing spec,

Use interference press-fit calculations

$p = \frac{E\Delta r}{r}$ to size shrink fits,

Torque-tighten fasteners to specified preloads $F_p = \frac{T_{bolt}}{kd}$(approx.),

where $k$is nut factor.

And calculate induced bending moments M.

static load test:

For static load verify deflection δwithin limits; for column members use Euler buckling

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}.$$

Use power-screw relation for raising/lowering and compute expected RPM $N$for desired lifting speed $v = L \cdot N/60$.

Torsional design:

$J = \pi d^4/32$and

shear $\tau = 16T/(\pi d^3)$.

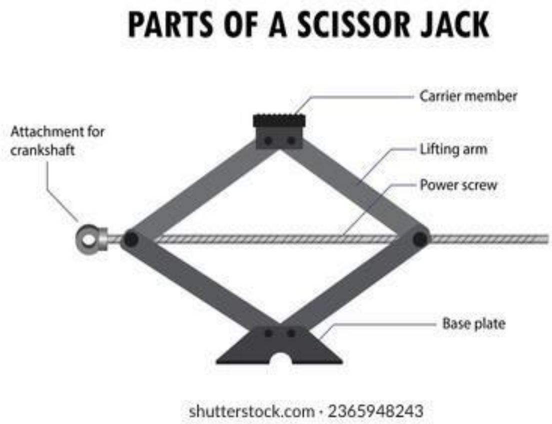
Check bending stresses with Euler–Bernoulli beam equations $\sigma = \frac{My}{I}$

for cantilever supports. Thermal rise in motor: $\Delta T = P_{\text{loss}}/(mc_p)$for short tests.

Working Principle of a Screw Jack:

A screw jack operates on the principle of mechanical advantage using a screw mechanism to convert rotational motion into linear motion. Here's a step-by-step breakdown:

Input Motion (Rotational):



The screw jack consists of a threaded screw and a rotating handle or motor.

When the handle is turned, it rotates the screw inside the jack.

Thread Engagement:

The screw is engaged with a nut or worm gear, which moves along the threads as the screw rotates. he pitch of the screw determines how much linear movement occurs per rotation.

Linear Motion Generation:

As the screw rotates, the nut moves upward or downward, depending on the direction of rotation. This movement lifts or lowers the load placed on the jack.

Mechanical Advantage:

The screw thread provides a mechanical advantage, allowing a small force applied to the handle to lift a heavy load. The force required to lift the load depends on the thread pitch, friction, and efficiency of the screw jack.

Self-Locking Feature:

Due to the friction between the screw and nut, the jack remains in position even when the force is removed. This prevents unintended movement and ensures stability.

Components of Screw Jack: Engages with the screw to facilitate movement. Moves along the screw when rotated

Screw (Lifting Screw): The main threaded shaft that moves up or down when rotated.

Converts rotational motion into linear motion.

Nut (Lifting Nut): Engages with the screw to facilitate movement. Moves along the screw when rotated.

Handle or Motor: Used to apply force to rotate the screw. Can be manual (hand-operated) or motorized for automation.

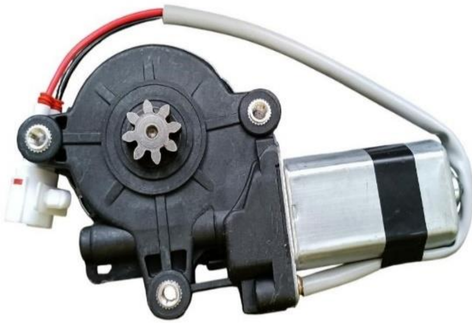
Housing or Base: Encloses and supports internal components. Provides stability and rigidity to the jack. Made from steel, aluminium, or cast iron. Prevents misalignment and excessive vibrations be.

Load Platform: The surface where the load is placed. Designed to distribute weight evenly.

Can be flat or grooved, depending on the application**.**

Power Window Motor:

A power window motor is an electrically powered device used in modern vehicles to control the movement of windows. It replaces the manual crank system, making window operation smooth, effortless, and automated. These motors work with window regulators, which help raise or lower the window glass.



Specifications:

Voltage – 12V DC.

Current (NO LOAD) – Less than 2 Amp.

Current (WITH LOAD) – Less than 12 Amp.

Fig: Power Window Motor

Customization & Upgrades – Can be equipped with remote or voice control for modern vehicles.

A rechargeable battery, storage battery, or secondary cell, is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction.

Fig: Rechargeable Battery

Assemble and Modeling: For the welding process, we have taken two L – Shaped metal pieces and a rectangular metal piece which has a hole at one end. Using arc welding process, we have welded the L – Shaped metal pieces to the screw jack at one side, where it gives support for the power window motor. The motor has a small spur gear; the rectangular metal piece is welded to this small gear so that it helps for the revolution of the power screw of the screw jack. The screw jack and the motor are attached using nut and bolts.

Fig: Complete Assembly of the Motorized Screw Jack.

S.NO	Car Name	Weight(kg)	Ground Clearane (mm)	Time(se)
1	Maruthi Suzuki Swift	1000	163	65
2	Maruthi Suzuki Alto	850	160	50
3	Maruthi Suzuki Alto 800	800	160	55

Conclusion: As per testing results of the project model, we have observed that by using this model we can lift the car weight up to 1000 kg to 1100 kg and the ground clearance of 155mm to 165mm. If we want to lift more car weight, we have to upgrade the components like screw jack size, upgrading the capacity of the power window motor like (wiper motor) and battery capacity. So that we can able to lift more car weight (say more than 1500kg). By upgrading the jack size, we can able to lift the car which have more ground clreance.

Fig: Model Testing

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Table: Testing analysis

Future Scope:

As a development to this project, instead of going to welding for the screw jack at the corners, we can use nut and bolt mechanism by making holes to the metal links. By this development, we can assemble and disassemble the whole model easily. If the motor is damaged or we want to upgrade the motor we can easily change by disassembling the nut and bolt mechanism

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