ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25aug292

Design and Development of an Inbuilt Jack System for Vehicle an Integrated Approach Using Brake Oil Reservoir Pressure for Efficient Lifting Mechanism

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Publication Date: 2025/08/22

Abstract: This research presents the design and development of an inbuilt hydraulic jack system integrated directly into a vehicle chassis to streamline the process of vehicle maintenance, vehicle washing, tyre replacement, and anywhere requires to lifting of the vehicle or a single tyre. The proposed mechanism utilizes hydraulic pressure from the brake oil reservoir to actuate lifting cylinders, eliminating the need for external jacks or manual effort. The system comprises a hydraulic cylinder assembly, control valve unit, and dedicated lifting arms designed for structural stability and ease of operation. Upon activation through a control switch, pressure is directed to the lifting mechanism, enabling smooth elevation of the vehicle. This compact design ensures minimal modification to the vehicle structure and offers significant advantages in terms of time efficiency, safety, and roadside convenience. The inclusion of safety features such as check valves and mechanical locks ensures isolation from the main braking system, making it reliable during real-time use. The model demonstrates an effective, low-cost, and user-friendly alternative to conventional tyre replacement methods in automobiles.

Keywords: *Hydraulic Jack System, Brake Oil Pressure, Inbuilt Lifting Mechanism, Automobile Maintenance, Tyre Replacement, Chassis Design, Vehicle Automation.*

How to Cite: Dnyaneshwari V. Gophane; Akshay N. Lokare; Anand D. Kamble; Vijaykumar P. Devkate; Mauli S. Gore (2025) Design and Development of an Inbuilt Jack System for Vehicle an Integrated Approach Using Brake Oil Reservoir Pressure for Efficient Lifting Mechanism. *International Journal of Innovative Science and Research Technology*, 10(8), 927-930. https://doi.org/10.38124/ijisrt/25aug292

I. INTRODUCTION

The process of vehicle maintenance, vehicle washing, and tyre replacement, particularly in roadside emergencies, often involves considerable manual effort and time. Conventional jacking systems, such as mechanical scissor jacks or hydraulic bottle jacks, require the driver to locate, position, and operate external tools, which may not always be feasible under adverse conditions or on uneven terrain. These traditional methods not only pose ergonomic challenges but also increase the risk of injury and damage due to improper use or placement.

To address these challenges, the automotive industry has seen increasing interest in automation and integrated mechanisms that enhance user convenience and operational safety. One such promising innovation is the inbuilt hydraulic jack system, which eliminates the need for external tools by embedding a lifting mechanism directly into the vehicle's chassis. These systems operate on the principle of hydraulic pressure, which is known for its ability to generate high force with minimal manual input and high reliability in confined spaces.

This study proposes a novel inbuilt hydraulic jack system that utilizes the pressure available from the vehicle's brake oil reservoir (oil sump) to actuate a lifting mechanism for tyre replacement. By leveraging an existing fluid circuit, the system minimizes the need for additional hardware, conserving space, cost, and complexity. The design includes a retractable hydraulic cylinder, mounting assembly, and support components that work in coordination to lift the vehicle's frame at a targeted point without disrupting the primary braking operation.

The goal of this project is to improve roadside serviceability, reduce driver dependency on manual tools, and enhance safety through the integration of locking

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mechanisms and control valves. Also, to provide smoothness in vehicle maintenance and vehicle washing. The design is compact, adaptable to various vehicle types, and provides a scalable solution for implementation in commercial and personal automobiles.

II. RESEARCH GAP

Several studies and existing solutions in the domain of vehicle lifting mechanisms have primarily focused on external hydraulic and mechanical jacks, including scissor jacks, bottle jacks, and pneumatic lifting systems. While these tools are effective in controlled environments such as service canters, they present substantial limitations in real- time roadside scenarios, especially for individuals with limited physical strength or experience in using manual lifting tools.

In recent years, advancements have been made in developing automated or semi-automated vehicle lifting systems; however, most of these rely on separate, complex hydraulic circuits or additional fluid reservoirs, leading to increased manufacturing costs and larger system footprints. Moreover, such mechanisms often require extensive structural modifications to the vehicle, limiting their commercial adaptability in mass-market automobiles.

Another observed limitation in prior designs is the lack of integration with the vehicle's existing hydraulic systems, such as the brake oil circuit, which holds potential as a reliable pressure source. There is also minimal emphasis on incorporating robust safety features such as check valves and mechanical locks that ensure the primary braking system remains isolated and unaffected during lifting operations.

Therefore, there exists a significant research gap in developing a compact, cost-effective, and chassis-integrated hydraulic lifting system that utilizes the vehicle's existing brake oil reservoir as a pressure source. Addressing this gap can lead to a simplified, low-cost, and safer alternative to traditional tyre replacement methods, particularly for roadside and emergency applications. Also, in vehicle maintenance and vehicle washing.

➢ *Problem Statement*

Conventional tyre replacement methods rely heavily on external jacking tools that require manual effort, physical strength, and time-consuming setup. These methods are not only inconvenient but also pose safety risks, especially during roadside emergencies or under unfavourable weather conditions. Additionally, carrying and operating traditional jacks can be challenging for certain user groups, including elderly drivers and those with limited mechanical experience.

There is a clear need for a compact, integrated lifting mechanism that eliminates dependency on external tools while ensuring safety, ease of use, and minimal impact on the existing vehicle structure and systems. The absence of a reliable, low-cost, inbuilt jack system that operates efficiently using the vehicle's own hydraulic pressure highlights the need for a new solution in modern automobile design.

➢ *Objectives*

The primary goal of this project is to design an integrated hydraulic lifting mechanism that improves vehicle maintenance efficiency. The specific objectives of the study are as follows:

- To design and develop a compact, chassis-mounted hydraulic jack system integrated within the vehicle structure.
- To utilize the vehicle's existing brake oil reservoir as a hydraulic pressure source for lifting operations.
- To minimize driver effort and reduce tyre replacement time by eliminating the need for external jacking tools, also minimize efforts while washing and during vehicle maintenance.
- To incorporate safety mechanisms such as check valves and mechanical locks to ensure operational isolation from the braking system.
- To evaluate the feasibility and effectiveness of the proposed system through design validation and functional analysis.

III. DESIGN AND DEVELOPMENT

Fig 1 Pin

Fig 2 Cylinder

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IV. WORKING PRINCIPLE

Fig 3 Clamp

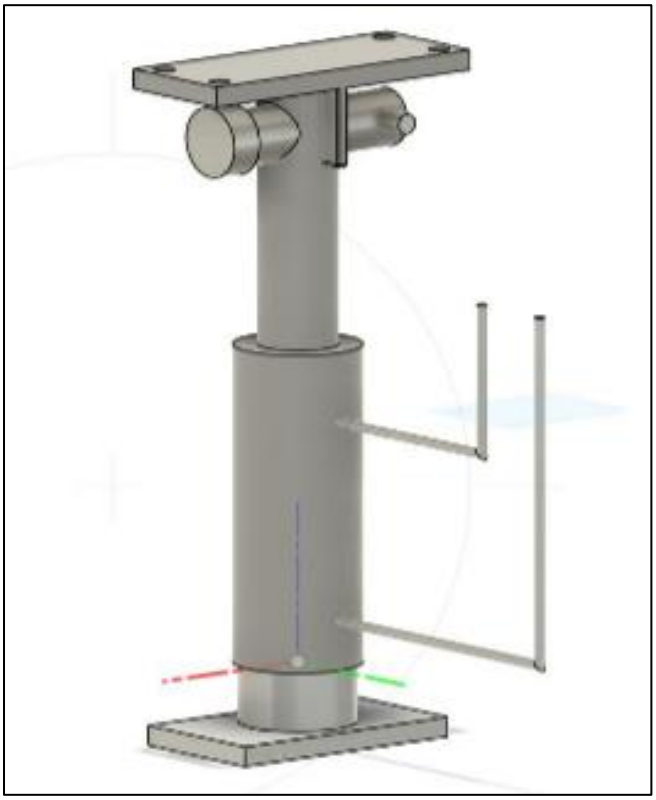

Fig 4 Assembly of Inbuilt Jack System

The inbuilt hydraulic jack system was conceptualized to integrate directly into the vehicle chassis, utilizing the existing brake oil pressure for lifting operations. The design aims to reduce driver effort and eliminate the need for external jacks, while maintaining the vehicle's safety and stability during tyre maintenance.

The system comprises several key components, including a hydraulic lifting cylinder, a pressure inlet from the brake oil reservoir, a directional control valve, and mounting supports. Each of these parts was carefully modelled to ensure structural compatibility and effective operation.

The hydraulic cylinder is designed to exert a lifting force on the vehicle chassis when brake fluid is pressurized and directed through the control valve. This valve governs the flow and direction of hydraulic fluid, allowing for controlled lifting and lowering actions. A set of mounting brackets and support frames ensures that the cylinder remains securely fixed to the vehicle's underside. Safety features such as check valves and mechanical locks are considered in the design to ensure stability during the lift and to isolate the lifting system from the braking function.

The 3D model was developed using CAD software to simulate real-world applications and ensure precise alignment with the chassis structure.

The proposed inbuilt hydraulic jack system operates by utilizing hydraulic pressure from the vehicle's brake oil reservoir to raise the chassis during tyre maintenance or replacement. When the control switch is activated, hydraulic fluid from the dil sump is directed through a control valve to the hydraulic lifting cylinders mounted on the vehicle frame.

As the pressurized fluid enters the cylinder chamber, it exerts force on the piston, causing a linear upward movement. This movement lifts the corresponding section of the vehicle, enabling easy and efficient tyre removal, vehicle maintenance, and vehicle washing without external jacking equipment. The system functions smoothly due to the incompressibility of hydraulic fluid, which allows for consistent force transmission and reliable lifting action.

To ensure safe operation, the design includes check valves to prevent reverse flow and mechanical locks to secure the vehicle in the lifted position. Additionally, the lifting circuit is isolated from the primary braking system to avoid any interference with vehicle safety during normal operation. Once maintenance is completed, the control valve is returned to its original position, allowing fluid to return to the reservoir and the piston to retract, gently lowering the vehicle.

V. RESULT AND OBSERVATION

The developed design of the inbuilt hydraulic jack system was evaluated primarily through CAD modeling and theoretical analysis. The model demonstrates the feasibility of lifting a vehicle chassis using hydraulic pressure sourced directly from the brake oil reservoir without affecting the primary braking function.

The 3D model illustrates that the lifting mechanism can be compactly installed on the vehicle frame without requiring significant structural modifications. Based on component alignment and fluid path simulation, the system can achieve sufficient lift height for tyre removal, vehicle washing, and vehicle maintenance, ensuring operational convenience.

➢ *Initial Observations from the Design Include:*

- The system allows for quick and controlled elevation of the vehicle using a simple switch-based control system.
- Integration with the brake oil circuit is achievable without compromising braking efficiency, owing to the inclusion of isolation valves.

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- The addition of safety locks and check valves enhances stability and prevents unintentional lowering.
- The design offers ergonomic advantages by eliminating the need to manually place and operate a jack, especially in emergency conditions.

VI. APPLICATIONS

The proposed inbuilt hydraulic jack system is designed to enhance the ease and safety of tyre maintenance. Its compact and integrated design makes it suitable for a variety of automobile platforms and service environments. The key applications include:

- Use in personal and commercial vehicles to simplify roadside tyre replacement, vehicle washing, and vehicle maintenance.
- Integration in passenger cars, SUVs, and light-duty trucks to reduce dependency on external jacking tools.
- Deployment in emergency service vehicles to improve response efficiency in the field.
- Application in automobile manufacturing as a factory-fitted feature for modern vehicles.
- Use in educational institutions and research labs as a prototype for understanding hydraulic systems and vehicle automation.

VII. FUTURE SCOPE

The current design presents a promising solution for vehicle tyre maintenance, but several improvements and extensions can be considered for future development:

- Integration of a microcontroller-based control unit for fully automated lifting and lowering.
- Implementation of pressure sensors to monitor hydraulic fluid levels and enhance system safety.
- Structural optimization for compatibility with a wider range of vehicle types, including heavy-duty models.
- Incorporation of wireless or mobile app-based control for remote operation and diagnostics.
- Prototyping and real-world testing to validate performance under varied load and road conditions.

VIII. CONCLUSION

This project presents the design and development of an inbuilt hydraulic jack system aimed at simplifying the process of vehicle maintenance, vehicle washing, and tyre removal. By utilizing the existing brake oil reservoir as a hydraulic pressure source, the system eliminates the need for external jacking tools, thereby reducing driver effort and increasing operational convenience. The design ensures minimal structural modification to the vehicle while maintaining full safety through the inclusion of check valves and mechanical locking features.

The CAD-based modeling confirms that the system is compact, structurally feasible, and adaptable to different vehicle types. In addition to improving roadside serviceability, the mechanism has the potential to enhance driver safety and reduce the time required for tyre replacement. With further optimization, sensor integration, and physical prototyping, this system can be developed into a commercially viable product for modern vehicles.

ACKNOLEDGEMENT

This project was successfully completed through the collective effort, coordination, and dedication of the student team. Every stage, from conceptualization and design to modeling and documentation, was carried out through collaborative teamwork and shared responsibilities. We extend our sincere thanks to the Department of Mechanical Engineering at SVERI's College of Engineering, Pandharpur, for providing the necessary resources and a supportive environment that enabled us to bring this concept to life. Lastly, we are grateful to our families and friends for their cooperation, dedication, and moral support, which contributed significantly to the successful completion of this work.

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