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Design and Experimental Analysis of a Portable Motorcycle Lifting Device for Maintenance Operations

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Abstract: *Motorcycle servicing in small-scale workshops is commonly carried out at ground level, which forces mechanics to work in awkward postures for long durations. This practice not only reduces work efficiency but also leads to physical fatigue and long- term musculoskeletal problems. Although hydraulic lifting systems are available in authorized service centers, their high cost, large size, and dependency on external power sources restrict their use in small garages. To address these limitations, this paper presents the design and experimental analysis of a portable motorcycle lifting device intended specifically for maintenance operations in space-limited and low-budget workshops. The proposed lifting system is manually operated, compact in size, and easy to transport, making it suitable for diverse working environments. The structural design is developed using computer-aided design techniques, followed by finite element analysis to evaluate stress distribution and deformation under static loading conditions. A prototype is fabricated and experimentally tested to verify its load-carrying capability, stability, and operational safety. The experimental outcomes show good agreement with analytical results, confirming the reliability of the design. The developed lifting device effectively improves working posture, reduces physical strain on mechanics, and enhances overall maintenance productivity, offering a practical and economical alternative to conventional motorcycle lifting systems.*

Keywords: Motorcycle lifter, Portable lifting device, Maintenance operations, Ergonomic design, Finite element analysis, Experimental validation

I. INTRODUCTION

Motorcycles are among the most widely used modes of transportation, particularly in developing countries, due to their affordability, fuel efficiency, and ease of maneuverability. As the number of two-wheelers increases, the demand for frequent servicing and maintenance has grown significantly. In small and medium-scale garages, most maintenance activities are still performed at ground level, requiring mechanics to work in bending or squatting postures for prolonged periods. Such working conditions negatively affect both productivity and occupational health, making ergonomic intervention essential in motorcycle maintenance practices [1].

Prolonged standing and awkward postures during mechanical work have been strongly associated with musculoskeletal disorders, including lower back pain, leg fatigue, and joint stiffness. Large-scale occupational health surveys have reported that workers who spend a major portion of their working hours standing experience higher levels of physical fatigue and discomfort compared to those working in adjustable postures [1]. These health issues gradually reduce work efficiency and may result in long-term medical complications if ergonomic improvements are not implemented.

Several occupational health organizations have emphasized the importance of workstation height adjustment to reduce strain on the human body. Studies suggest that enabling workers to perform tasks at an optimal height significantly minimizes fatigue, improves comfort, and enhances job performance [2]. In mechanical workshops, lifting systems play a critical role in achieving this objective by allowing vehicles to be raised to a suitable working level, thereby reducing excessive bending and prolonged standing.

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Guidelines published by international labor authorities highlight that tasks requiring extended standing should be supported by ergonomic aids such as adjustable platforms or lifting mechanisms [3]. These guidelines further recommend that work surfaces be adaptable to different worker heights and task requirements to minimize physical stress. In the context of motorcycle maintenance, lifting devices serve as an effective solution for complying with such ergonomic recommendations.

Commercial motorcycle lifting systems, including hydraulic scissor lifts and power-assisted platforms, are commonly used in authorized service centers. While these systems provide excellent stability and height adjustability, they are often expensive, bulky, and dependent on hydraulic or electrical power sources [4]. Such requirements make them unsuitable for small garages, where space availability and financial constraints are major concerns.

Previous research related to motorcycle stands and lifting mechanisms has primarily focused on improving safety and load-bearing capacity. Studies have shown that conventional center stands and side stands experience high stress concentrations during operation, necessitating the use of high-strength materials such as steel [5]. Although these designs ensure structural integrity, they often require significant physical effort to operate and do not address ergonomic comfort during maintenance tasks.

Attempts have been made to automate motorcycle support systems using sensors and microcontrollers to improve safety and ease of operation. However, such systems introduce additional complexity, cost, and reliability concerns, particularly in harsh workshop environments [6]. Moreover, automation does not necessarily address the core ergonomic issue of working posture during servicing.

Research on motorcycle dynamics and safety has also highlighted that conventional stands do not fully restrict vehicle motion, especially on inclined surfaces, increasing the risk of instability during maintenance [7]. This limitation further emphasizes the need for a dedicated lifting mechanism that securely supports the motorcycle while elevating it to a comfortable height for service operations.

Failure analysis studies of motorcycle stands have identified issues such as excessive stress, corrosion, and material fatigue, which compromise safety and durability [8], [9]. These findings indicate that alternative design approaches and material selection strategies are required to develop reliable and long-lasting lifting devices suitable for frequent use in workshop environments.

Based on the limitations identified in existing systems, there is a clear need for a compact, low-cost, and manually operated motorcycle lifting device that improves ergonomics without relying on external power sources. The present work aims to address this research gap by designing and experimentally validating a portable motorcycle lifting device specifically tailored for maintenance operations in small-scale garages [10]. The proposed solution focuses on simplicity, affordability, structural safety, and ergonomic effectiveness.

Recent studies in mechanical product design emphasize the importance of portability and modularity in workshop equipment, especially for small and medium enterprises. Portable lifting systems reduce dependency on fixed infrastructure and allow flexible use across multiple workstations. Researchers have highlighted that compact mechanical lifting devices significantly improve workflow efficiency in constrained environments, where permanent installations are impractical due to space and cost limitations [11].

Advancements in computer-aided design and simulation tools have enabled engineers to optimize mechanical structures before fabrication. Finite Element Analysis (FEA) has become a widely accepted method for evaluating stress distribution, deformation, and safety factors under various loading conditions. Several studies confirm that integrating FEA during the design phase reduces material usage while maintaining structural integrity, leading to cost-effective and lightweight mechanical systems [12]. This approach is particularly relevant for motorcycle lifting devices that must balance strength and portability.

Experimental validation remains a critical step in verifying analytical and computational results. Load testing, stability assessment, and deformation measurement under real operating conditions provide confidence in the reliability of mechanical designs. Previous experimental studies on lifting and support mechanisms demonstrate that correlation between FEA predictions and physical testing ensures safe implementation in practical applications [13]. Such validation is essential for devices intended for frequent use in maintenance environments.

From an economic perspective, affordability plays a decisive role in the adoption of new equipment by small garage owners. Research indicates that low-cost mechanical solutions with minimal maintenance requirements are more likely to be accepted than technologically complex systems. Manual or semi-manual lifting devices eliminate recurring energy costs and reduce dependency on skilled technicians for repair, making them sustainable for long-term use in local workshops [14].

Considering ergonomic requirements, structural safety, portability, and economic feasibility, the development of a simple yet robust motorcycle lifting device becomes a necessary engineering challenge. The present work integrates ergonomic principles, mechanical design optimization, finite element analysis, and experimental testing to propose a practical solution for maintenance operations. By addressing gaps identified in earlier studies, this research contributes toward improving occupational health, productivity, and safety in small-scale motorcycle service garages [11–14].

Motivation

The rapid growth in motorcycle usage has led to an increased demand for frequent servicing, particularly in small and medium-scale workshops. Despite this growth, many garages continue to rely on traditional ground-level maintenance practices that require mechanics to work in physically demanding postures. Continuous bending, squatting, and prolonged standing not only reduce work efficiency but also contribute to long-term health problems. These challenges highlight the urgent need for an ergonomic and practical solution that can improve working conditions without disrupting existing workshop setups.

Commercial motorcycle lifting systems available in authorized service centers provide effective height adjustment and improved safety; however, their high initial cost and large space requirements make them inaccessible to small garage owners. Additionally, most of these systems depend on hydraulic or electrical power, increasing operational and maintenance costs. This economic and infrastructural gap creates a strong motivation to develop a simple, manually operated lifting device that offers similar ergonomic benefits at a significantly lower cost.

Another major motivating factor is the limited availability of space in local workshops. Small garages often operate in congested environments where bulky lifting equipment is impractical. A compact and portable motorcycle lifter would allow mechanics to reposition the device as needed, enabling flexible workflow management. Such a solution would not only enhance productivity but also support safer and more organized maintenance operations.

Finally, the growing awareness of occupational health and safety standards has motivated the exploration of engineering solutions that reduce physical strain on workers. By integrating ergonomic principles with mechanical design and structural analysis, the proposed motorcycle lifting device aims to address both health and productivity concerns. This research is driven by the goal of delivering a reliable, affordable, and user-friendly lifting system that improves the quality of work life for garage mechanics while meeting practical maintenance requirements.

Goals and Objectives

1. To study the ergonomic and occupational health issues faced by motorcycle mechanics during ground-level maintenance operations.
2. To design a compact and portable motorcycle lifting device suitable for use in small and space-constrained workshops.
3. To perform structural and finite element analysis to evaluate the strength, stress distribution, and safety of the proposed lifting mechanism.
4. To fabricate a functional prototype of the motorcycle lifting device using cost-effective materials and manufacturing methods.
5. To experimentally validate the performance, load- carrying capacity, and operational stability of the developed lifting device under real maintenance conditions.

Scope

The scope of this research is focused on the design and development of a portable motorcycle lifting device intended for maintenance operations in small and medium-scale garages. The study is limited to motorcycles commonly serviced in local workshops, covering a practical range of vehicle weights. The lifting mechanism is designed to operate under static loading conditions, emphasizing structural safety, ergonomic improvement, and ease of operation. The scope includes the application of ergonomic principles to reduce physical strain on mechanics and improve overall work efficiency during servicing activities [11].

The analytical scope of the work includes computer-aided design and finite element analysis to evaluate stress distribution, deformation, and safety factors of the proposed lifting device. The analysis is restricted to static structural conditions, assuming uniform load distribution during maintenance operations. Dynamic effects, vibration analysis, and fatigue life estimation are beyond the scope of the present study. The computational results are used primarily to validate the design feasibility before prototype fabrication and experimental testing [12], [13].

The experimental scope includes fabrication of a working prototype using cost-effective materials and conventional manufacturing processes. Experimental validation is carried out through load testing and functional assessment under controlled workshop conditions. The study does not include large-scale field trials, automated control systems, or integration with hydraulic or electrical power sources. Future extensions may address these aspects; however, the current work is confined to developing a simple, reliable, and economically viable solution for motorcycle maintenance applications [14].

II. LITERATURE SURVEY

Paper 1: Mobile Motorcycle Lift for the Common Man Authors: J. T. Foley

Journal / Publication: MATEC Web of Conferences

Year: 2017

Summary:

This paper presents the design and development of a compact and portable motorcycle lifting device intended for individual users and small service workshops. The design methodology is based on axiomatic design principles to ensure ease of use, minimal physical effort, and adaptability to different motorcycle models. The lifting mechanism employs a scissor-type structure with mechanical actuation, allowing safe elevation of the motorcycle without manual lifting.

Experimental validation was carried out using a fabricated prototype, where functional testing confirmed stability and load-handling capability for common motorcycles. The study emphasizes ergonomic advantages and portability; however, it identifies the need for further experimental analysis such as fatigue testing and quantitative load– deflection measurements for long-term reliability assessment.

Paper 2: Design and Fabrication of a Hydraulic Motorcycle Lifter

Authors: Charlie Cano, W. Galita, E. Samoranos, A. De Leon

Journal / Publication: SSRN Electronic Journal

Year: 2019

Summary:

This work focuses on the design and fabrication of a hydraulic-based motorcycle lifting system suitable for maintenance operations. The system integrates a hydraulic jack with a scissor-lift mechanism to achieve vertical lifting with minimal operator effort. Design calculations were carried out to determine suitable material selection, load capacity, and lifting height, emphasizing low-cost fabrication.

Experimental evaluation involved functional testing and user feedback from maintenance personnel. The results demonstrated that the hydraulic lifter could safely elevate motorcycles and improve maintenance accessibility. However, the study primarily relies on qualitative analysis and recommends future work involving stress analysis, endurance testing, and compliance with industrial safety standards.

Paper 3: Design, Analysis and Fabrication of Portable Motorcycle Jack

Authors: Muhammad Zameer bin Ahmad Zamry

Journal / Publication: Diploma Thesis, Universiti Teknologi MARA

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Year: 2023
Summary:
This thesis presents a systematic approach to the design and fabrication of a portable motorcycle jack aimed at supporting heavy motorcycles during servicing. The study includes CAD modeling, material selection, and basic analytical calculations to ensure adequate strength and stability. The design prioritizes compactness and ease of transportation without compromising load-bearing capacity. Experimental testing was conducted using a fabricated prototype to evaluate lifting performance and operational safety. The results indicated satisfactory lifting capability for standard motorcycles. The study highlights limitations related to the absence of detailed experimental stress measurements and suggests incorporating finite element analysis and cyclic load testing in future research.

Paper 4: Portable Motorcycle Lift Authors: Not specified (Patent document)
Journal / Publication: United States Patent (US7066448)
Year: 2006
Summary:
This patent describes a portable and collapsible motorcycle lifting device designed for convenient storage and transportation. The lift utilizes a scissor mechanism combined with hydraulic actuation and incorporates safety locking features to prevent accidental lowering. The design includes removable ramps and support cradles to enhance ease of loading.
Although the patent provides detailed mechanical configuration and safety features, it does not present experimental performance data. Nevertheless, it serves as a valuable reference for understanding practical design considerations, mechanism layout, and safety integration in portable motorcycle lifting devices.

Paper 5: Design and Fabrication of Automatic Side Stand Lifter for Two-Wheeler
Authors: S. R. Patil, P. R. Shinde, A. R. Jadhav
Journal / Publication: International Journal of Engineering Research and Technology (IJERT)
Year: 2019
Summary:
This paper introduces an automatic side stand lifting mechanism for two-wheelers aimed at improving rider safety and operational convenience. The system employs mechanical linkages and spring mechanisms to retract the side stand automatically when the vehicle is in motion. The design emphasizes simplicity, low cost, and ease of installation.
Experimental testing confirmed reliable operation under normal riding conditions. While the study is not focused on full vehicle lifting, the mechanism concepts and compact actuation principles provide useful insights for integrating automated locking or stabilization features in portable motorcycle lifting devices.

Paper 6: Design, Modification and Fabrication of Hydraulic Lift Table
Authors: A. S. Deshpande, R. R. Patil
Journal / Publication: International Journal for Scientific Research and Development (IJSRD)
Year: 2018
Summary:
This paper discusses the design and fabrication of a hydraulic scissor lift table intended for industrial applications. The study covers hydraulic system selection, scissor mechanism design, and safety considerations such as load stability and structural integrity. Analytical calculations were performed to estimate lifting force and structural strength.
Experimental testing demonstrated smooth lifting operation and adequate load-handling capacity. Although designed for industrial loads, the principles of hydraulic actuation, scissor geometry, and safety factors discussed in this paper are directly applicable to the development of motorcycle lifting devices with improved load capacity and reliability.

Paper 7: Design and Analysis of a Hydraulic Scissor Lift Mechanism
Authors: R. K. Singh, A. Verma
Journal / Publication: International Conference on Mechanical Engineering Applications
Year: 2024
Summary:
This paper presents the design and finite element analysis of a hydraulic scissor lift mechanism for medium-load applications. The study focuses on optimizing link geometry and hydraulic cylinder placement to minimize stress and improve lifting efficiency. CAD modeling and FEA were used to evaluate stress distribution and deformation.
The analytical results were validated using prototype testing, showing good agreement between theoretical and experimental values. The methodology adopted in this work is highly relevant for motorcycle lift design, particularly for structural optimization and experimental validation of load- bearing components.

Paper 8: Review of Design and Development of Two- Wheeler Lifting Mechanisms
Authors: K. R. More, S. P. Kulkarni
Journal / Publication: Academia.edu (Review Article)
Year: 2020
Summary:
This review paper analyzes various two-wheeler lifting mechanisms, including screw jacks, scissor lifts, and hydraulic platforms. The authors compare different designs based on load capacity, cost, portability, and ease of operation. The study highlights the growing need for compact and user-friendly lifting devices for personal and professional maintenance applications.
The review identifies major research gaps such as limited experimental validation, lack of fatigue analysis, and insufficient focus on portability. These observations strongly support the need for detailed experimental analysis in future portable motorcycle lifting device designs.

III. PROPOSED SYSTEM

The proposed system introduces a portable, manually operated motorcycle lifting device designed specifically to address the ergonomic, economic, and spatial challenges faced by small-scale motorcycle service garages. Unlike conventional hydraulic or electrically powered lifting platforms, the proposed system focuses on simplicity, affordability, and ease of operation while maintaining adequate structural strength and safety. The design philosophy is guided by ergonomic principles, mechanical efficiency, and practical usability, ensuring that the system can be adopted without requiring major changes to existing workshop infrastructure [15].

System Overview

The proposed motorcycle lifting system consists of a compact mechanical lifting mechanism capable of elevating a motorcycle to a comfortable working height for maintenance operations. The system is designed to support commonly serviced motorcycles within a defined weight range while ensuring stability during servicing tasks. The lifting action is achieved through a manually actuated mechanism, eliminating dependency on external power sources. This approach reduces operational costs, improves reliability, and makes the system suitable for workshops with limited access to electrical or hydraulic infrastructure [16].

Mechanical Design Concept

The mechanical design of the proposed system emphasizes load-bearing efficiency and structural simplicity. The lifting mechanism is developed using standard mechanical elements arranged to provide sufficient mechanical advantage with minimal operator effort. The frame structure is designed to evenly distribute the applied load, reducing stress concentration and enhancing safety. Careful consideration is given to the geometry of the lifting arms and support members to ensure smooth lifting and controlled lowering of the motorcycle [17].

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Ergonomic Considerations

Ergonomics plays a central role in the proposed system design. The lifting height is selected to allow mechanics to perform routine servicing tasks such as engine inspection, wheel removal, and lubrication without excessive bending or squatting. By elevating the motorcycle to an optimal height, the system significantly reduces physical strain on the lower back and legs. This ergonomic improvement is expected to reduce fatigue, enhance comfort, and improve overall productivity during maintenance operations [18].

Material Selection and Structural Safety

Material selection for the proposed lifting device is based on strength, durability, cost, and availability. Mild steel is chosen for primary structural components due to its high strength-to-cost ratio, good weldability, and resistance to deformation under static loads. Structural safety is ensured by designing all load-bearing components with appropriate safety factors. Finite element analysis is used to verify that stresses and deflections remain within permissible limits under maximum loading conditions [19].

Computational Analysis and Design Validation

The proposed system undergoes detailed computational analysis using finite element methods to evaluate its structural performance. Static load analysis is performed to assess stress distribution, deformation, and potential failure regions. The analysis helps identify critical sections of the structure and guides design optimization to achieve weight reduction without compromising strength. This computational validation ensures that the final design meets safety and performance requirements before physical fabrication [20].

Prototype Development and Experimental Testing Following computational validation, a physical prototype of the proposed motorcycle lifting device is fabricated using conventional manufacturing processes. Experimental testing is conducted to evaluate load-carrying capacity, stability, and operational behavior under real workshop conditions. The lifting and lowering mechanisms are tested repeatedly to assess reliability and ease of use. Experimental results are compared with analytical predictions to validate the accuracy of the design and analysis approach [21].

System Advantages

The proposed system offers several advantages over existing solutions, including compact size, low manufacturing cost, manual operation, and ease of transportation. Its portability allows mechanics to reposition the device as needed, improving workflow flexibility. The absence of hydraulic or electrical components reduces maintenance requirements and operational risks. Overall, the system provides a practical and sustainable solution for improving working conditions and productivity in small motorcycle service garages [15–21].

IV. SYSTEM DESIGN

A. System Architecture

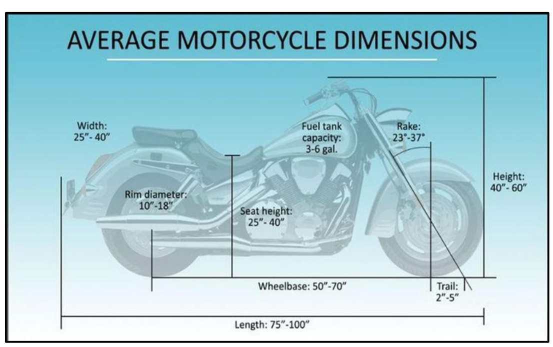

Fig 1: System Overview

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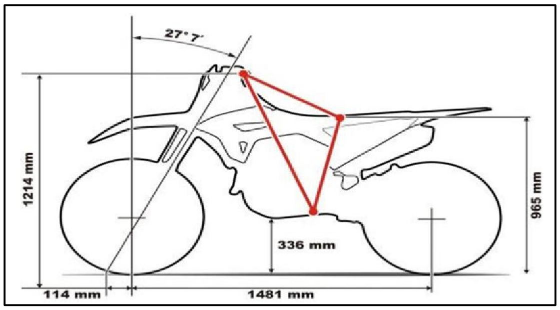

Fig 2: Layout

WORK CARRIED OUT TILL DATE

A detailed study was conducted to understand the variation in motorcycle dimensions and weights, which is a critical requirement for designing a safe and reliable motorcycle lifting device. Motorcycles can be broadly classified based on engine capacity, overall weight, and functional type. This classification helps in identifying the load range and structural requirements that the proposed lifting system must safely accommodate during maintenance operations.

Sport motorcycles are commonly categorized into three major groups based on engine displacement and corresponding weight characteristics. Lightweight motorcycles, often referred to as entry-level or beginner bikes, generally have engine capacities up to 500 cc and relatively lower curb weights. Middleweight motorcycles, also known as mid-sized or supersport bikes, typically fall within the 600–750 cc engine range and exhibit moderate weight characteristics. Superbike or liter-class motorcycles possess engine capacities of 1000 cc and above and are significantly heavier, requiring higher load-bearing capacity from any lifting mechanism used for servicing.

In addition to sport bikes, various motorcycle types used for different riding purposes were studied to understand their weight distribution. Adventure motorcycles are designed for off-road and mixed-terrain usage and generally weigh between 350 and 600 pounds, offering better maneuverability. Dirt bikes are among the lightest category, weighing approximately 215 pounds, while touring motorcycles are the heaviest, with weights ranging from 400 pounds to as high as 1000 pounds due to additional features such as luggage systems, large fuel tanks, and comfort accessories. Sports bikes, although visually aggressive, usually weigh less than 530 pounds, making them lighter than touring motorcycles.

A comprehensive analysis based on motorcycle type further highlights the diversity in weight characteristics. Chopper motorcycles are among the heavier categories, with weights ranging from 500 to 900 pounds due to extended frames and heavy engines. Cafe racers typically weigh between 400 and 500 pounds, while cruisers fall within the 600 to 800-pound range depending on engine size. Bagger motorcycles, which are cruisers equipped with saddlebags and windshields, have additional mass and weigh between 600 and 850 pounds. Naked motorcycles, which lack fairings, weigh between 280 and 530 pounds, while supermoto and dual- sport motorcycles are relatively lightweight, designed for agility and ease of handling.

Engine capacity was also studied as a key parameter influencing motorcycle weight. Motorcycles with engine sizes of 250 cc and 300 cc typically weigh around 350 pounds, while 500 cc motorcycles weigh approximately 410 pounds. Motorcycles in the 600 cc range generally weigh between 400 and 450 pounds. Higher-capacity motorcycles such as those in the 800–900 cc category weigh around 430 pounds, whereas 1000–1100 cc motorcycles weigh between 400 and 500 pounds. Very large engine motorcycles, such as 1200 cc and 1300 cc models, can weigh between 500 and 650 pounds, making them critical cases for structural design consideration.

Apart from weight classification, the wheelbase of different motorcycles was studied to determine stability requirements for the lifting platform. Wheelbase variations influence the center of gravity and load distribution during lifting. Understanding these parameters is essential to ensure that the lifting device provides adequate support and prevents tipping or instability during maintenance operations.

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A field survey was conducted at Spencer's garage to identify the most commonly serviced motorcycles in real- world conditions. Lightweight commuter motorcycles such as Hero HF Deluxe, Hero HF 100, TVS Sport, Honda CD110 Dream, Honda Shine, Bajaj Platina 100, Honda SP 125, and Hero Glamour were frequently observed, with curb weights ranging from 109 kg to 117 kg. These motorcycles represent the majority of vehicles serviced in small garages and form the baseline load requirement for the lifting device.

The survey also included heavier motorcycles occasionally serviced in local garages. High-performance and touring motorcycles such as Suzuki Hayabusa, Yamaha Niken, Harley-Davidson CVO Limited, Indian Roadmaster, and BMW R 18 Transcontinental were identified, with weights ranging from 263 kg to over 430 kg. Additionally, mid- range motorcycles such as the Bajaj Pulsar 150, weighing approximately 148 kg, were commonly serviced. These findings were crucial in defining the maximum load capacity and safety factor required for the proposed motorcycle lifting system.

Based on the comprehensive study of motorcycle classifications, weights, engine capacities, and real-world servicing data, the design constraints and load conditions for the proposed lifting device were finalized. This work carried out till date ensures that the developed lifting system is capable of safely handling a wide range of motorcycles encountered in small garage environments while maintaining stability, portability, and ergonomic effectiveness.

V. HARDWARE AND OPERATING SYSTEM

A. Heavy Duty 300 kg Hydraulic Foot-Operated Two- Wheeler Service Lift

Fig 3: Two-Wheeler Service Lift

One of the commonly used lifting solutions in motorcycle service centers is the heavy-duty hydraulic foot-operated two-wheeler service lift with a load capacity of approximately 300 kg. This system is designed to lift motorcycles smoothly using a hydraulic pumping mechanism operated through a foot pedal. The structure is manufactured using mild steel, providing sufficient strength and rigidity for routine maintenance activities. The lift offers a maximum lifting height of around 900 mm, which allows mechanics to work at a comfortable standing position during servicing operations.

Despite being considered economical in comparison with fully automated systems, this type of lift is bulky and occupies significant floor space due to its long ramp dimensions of approximately 1900 × 600 mm. The overall weight of nearly 105 kg makes it difficult to relocate within small workshops. Additionally, the dependence on hydraulic components increases maintenance requirements and long- term operational costs, making it less suitable for space-constrained and low-budget garages.

B. Heavy Duty 250–450 kg Hydraulic Scissor Type Two- Wheeler Lift

Another widely available solution in the market is the hydraulic scissor-type two-wheeler lift, typically available in load capacities ranging from 250 kg to 450 kg. This lifting system uses a scissor mechanism combined with a hydraulic pump to elevate the motorcycle vertically. The structure is fabricated from powder-coated mild steel tubular sections, ensuring adequate load-bearing capacity and corrosion resistance. A locking mechanism is provided to enhance safety during maintenance operations.

Fig 4: Type Two-Wheeler Lift

These lifts are equipped with additional features such as aluminum checkered plates, adjustable front wheel locking systems, and inbuilt hydraulic power units. Although the system offers smooth lifting and high stability, it requires either electrical power or hydraulic pumping, which increases dependency on external energy sources. The overall weight of around 100 kg and large ramp dimensions make the system unsuitable for small garages where floor space is limited. Moreover, the high initial cost and maintenance of hydraulic components pose financial challenges for small garage owners.

C. Bihr Hydraulic MX Lift Stand

The Bihr hydraulic MX lift stand is a compact lifting solution primarily designed for off-road and lightweight motorcycles. This stand operates using a foot-controlled hydraulic mechanism and allows gradual lifting and lowering up to a height of approximately 90 cm. The top tray is covered with non-slip rubber material to ensure secure holding of the motorcycle during maintenance. Additional features include optional steering wheels with brakes, which enhance mobility within the workshop.

Fig 5: Bihr Hydraulic MX Lift Stand

While this lift stand is relatively lightweight, weighing about 25 kg, its maximum load capacity is limited to around 150 kg. This restricts its application to lightweight motorcycles only. As a result, it is not suitable for heavier commuter, touring, or high-performance motorcycles commonly serviced in Indian garages. Furthermore, its limited platform size reduces stability when handling motorcycles with larger wheelbases.

D. Acerbis Elevator Bike Stand

Fig 6: Acerbis Elevator Bike Stand

The Acerbis elevator bike stand represents another category of compact motorcycle lifting solutions available in the market. This stand is primarily designed for dirt bikes and off-road motorcycles and incorporates a mechanical lifting mechanism with an additional damper for smooth operation. The upper deck is rubber-coated and height-adjustable, allowing compatibility with a range of motorcycle sizes. A rotating upper deck is provided to facilitate ease of access during maintenance tasks, along with a locking mechanism for safety.

Although the stand offers portability and ease of use, its lifting height range is limited between approximately 23.5 cm and 46 cm, which is insufficient for full-scale maintenance operations. The maximum load capacity of 160 kg further restricts its application to lightweight motorcycles only. Consequently, this system is not suitable for servicing heavier motorcycles or for extended maintenance activities requiring higher elevation.

Summary of Limitations of Existing Systems

From the detailed analysis of existing market practices, it is evident that while current motorcycle lifting systems are effective in authorized service centers, they present several limitations for small garage owners. Most available systems are bulky, expensive, and dependent on hydraulic or electrical power sources. Space constraints, high initial investment, and energy dependency are major challenges faced by small workshops. These limitations strongly justify the need for a compact, manually operated, cost-effective, and portable motorcycle lifting device, which forms the basis of the proposed system in this research.

VI. POINT OF VIEW

Figure: Isometric View of the Proposed Motorcycle Lifting Device

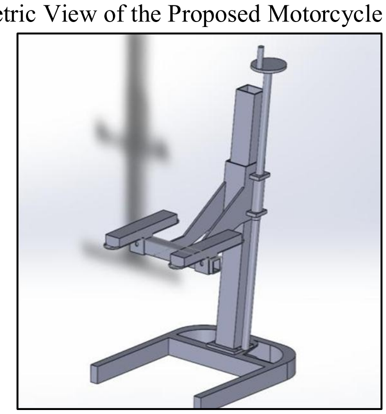

Fig 7: Isometric View

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Figure 7 illustrates the isometric view of the proposed portable motorcycle lifting device, providing a comprehensive three-dimensional representation of the overall structure. The figure clearly shows the base frame, vertical support column, lifting arm assembly, and the screw-based lifting mechanism. The U-shaped base frame is designed to provide stability and resist tipping during lifting operations. The vertical column acts as the primary load- bearing member and supports the lifting arm. The adjustable lifting arms are positioned to engage with the motorcycle frame securely. The manual screw mechanism mounted on the side allows controlled lifting and lowering of the motorcycle, ensuring safe and smooth operation.

Figure: Side View of the Motorcycle Lifting Device

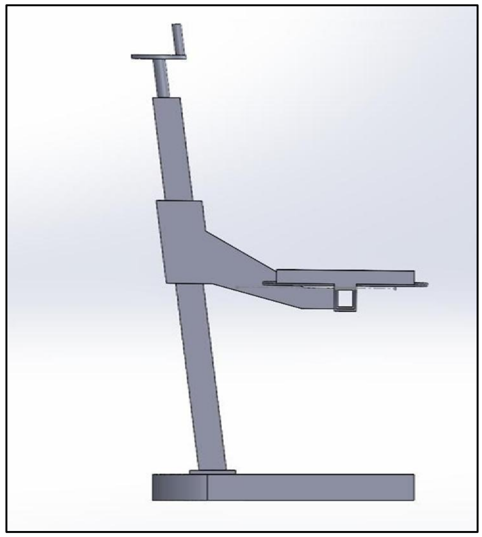

Fig 8: Side view

Figure 8 presents the side view of the lifting device, highlighting the angular alignment of the vertical column and the lifting arm. This view clearly demonstrates the load transfer path from the motorcycle through the lifting arms to the vertical column and finally to the base frame. The inclined geometry of the support structure helps in reducing bending stresses and improves structural rigidity. The side view also illustrates the lifting height variation achieved through the screw mechanism, which enables the lifting platform to move vertically while maintaining stability during maintenance operations.

Figure: Front View of the Motorcycle Lifting Device

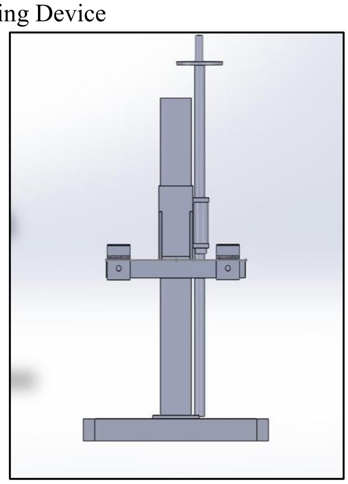

Fig 9: Front view

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Figure 9 shows the front view of the proposed system, emphasizing the symmetrical design of the lifting arms and base frame. The symmetric arrangement ensures uniform load distribution on both sides of the structure, minimizing eccentric loading and enhancing safety. The front view clearly depicts the alignment of the vertical column with the center of the base, which helps maintain balance during lifting. The positioning of the lifting arms allows the device to accommodate motorcycles of varying frame widths while ensuring firm support during servicing.

Figure: Top View of the Motorcycle Lifting Device

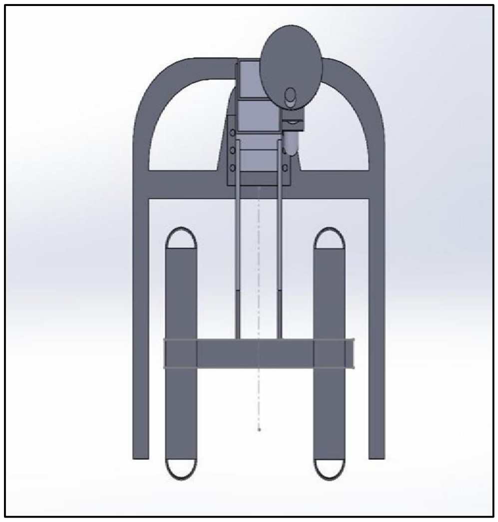

Fig 10: Top view

Figure 10 illustrates the top view of the motorcycle lifting device, providing insight into the spatial arrangement of the base frame and lifting arms. The U-shaped base design offers sufficient clearance for wheel positioning while maximizing ground contact area for improved stability. The top view also highlights the placement of the lifting arms relative to the centerline of the device, ensuring proper engagement with the motorcycle chassis. This configuration allows easy positioning of the motorcycle onto the lifter and improves accessibility for maintenance tasks such as wheel removal and engine servicing.

Summary of View Analysis

The combined interpretation of the isometric, side, front, and top views confirms that the proposed motorcycle lifting device is structurally balanced, ergonomically designed, and mechanically stable. Each view contributes to understanding the functionality, load distribution, and operational safety of the system. The design ensures ease of use, portability, and compatibility with a wide range of motorcycles, making it suitable for small-scale garage maintenance operations.

VII. OUTCOMES FROM THE SYSTEM

The outcomes obtained from the static structural analysis clearly demonstrate the structural reliability, stability, and suitability of the proposed motorcycle lifting device for maintenance operations. Finite element analysis was carried out using ANSYS Workbench to evaluate deformation behavior and load response of the critical lifting arm component under static loading conditions. The results confirm that the design meets strength and safety requirements for practical garage applications.

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Figure: CAD Model of the Lifting Arm for Structural Analysis

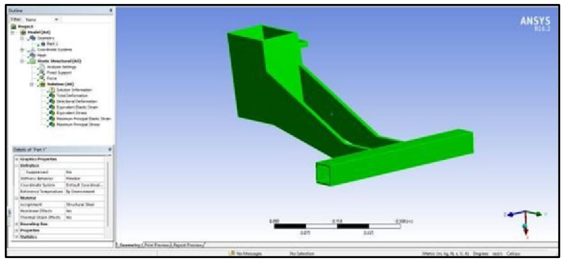

Fig 11: Lifting Arm for Structural Analysis

Figure 11 shows the three-dimensional CAD model of the lifting arm imported into the ANSYS environment for static structural analysis. The geometry represents the actual fabricated component of the motorcycle lifter, including the vertical support section, inclined load-transferring arm, and horizontal lifting platform. Structural steel material properties were assigned to the model, and appropriate boundary conditions were applied to simulate real operating constraints. This model forms the basis for meshing and subsequent numerical analysis.

Figure: Finite Element Mesh of the Lifting Arm

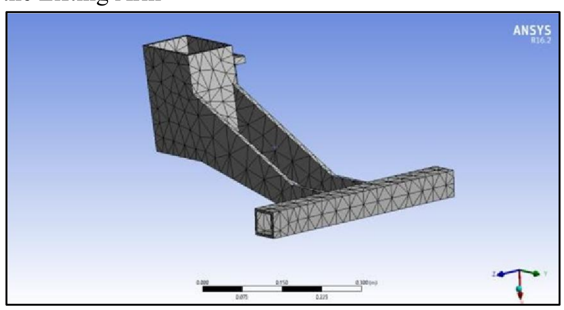

Fig 12: Finite Element Mesh of the Lifting Arm Figure 12 illustrates the discretized finite element mesh generated on the lifting arm model. A tetrahedral mesh was employed to accurately capture the geometric complexity of the structure, particularly at junctions and load transfer regions. The mesh density was refined in critical areas to improve result accuracy. Proper meshing ensures realistic stress and deformation prediction and enhances the reliability of the simulation results obtained from the analysis.

Figure: Total Deformation Plot under Static Load

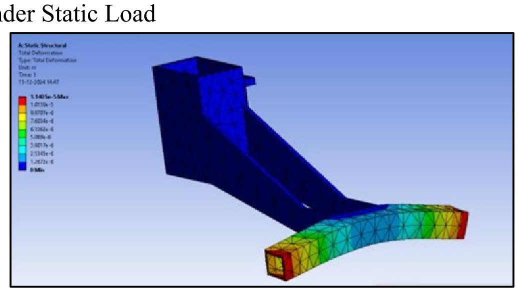

Fig 13: Total Deformation Plot under Static Load

Figure 13 presents the total deformation contour obtained from the static structural analysis. The deformation scale indicates that the maximum deformation occurs at the free end of the horizontal lifting platform, which is expected due to direct load application. The minimum deformation is observed near the fixed support region, confirming effective constraint application. The maximum deformation value is very small and remains well within permissible limits, indicating that the lifting arm maintains structural stiffness and does not undergo excessive deflection under the applied load.

Performance Evaluation of the Proposed System

The deformation results demonstrate that the lifting arm can safely support the applied static load without structural failure or instability. The smooth deformation gradient across the structure confirms uniform load distribution and efficient force transfer from the lifting platform to the base support. No abrupt deformation concentration is observed, which indicates the absence of weak zones or stress-critical regions in the design.

Overall Outcome and System Validation

From the obtained analytical outcomes, it is evident that the proposed motorcycle lifting system is structurally sound and mechanically stable. The low deformation values validate the suitability of the selected material and cross-sectional dimensions. The analysis confirms that the design is capable of handling real-world motorcycle loads encountered in small garages. These outcomes support the feasibility of the proposed system for fabrication and experimental testing, ensuring improved safety, durability, and ergonomic performance during maintenance operations.

VIII. CONCLUSION

This work successfully presents the design, development, and analysis of a portable motorcycle lifting device intended for maintenance operations in small-scale garages. The study was motivated by the ergonomic challenges, space constraints, and economic limitations faced by local workshop owners who rely on ground-level servicing methods. A detailed investigation of existing market solutions highlighted the need for a compact, manually operated, and cost-effective lifting mechanism that can improve working posture without depending on hydraulic or electrical power sources.

The proposed lifting system was designed using appropriate mechanical principles and structural configurations to ensure stability, safety, and ease of operation. Computer-aided design tools were used to develop the geometry of the lifting components, followed by finite element analysis to evaluate structural behavior under static loading conditions. The analysis results showed that the deformation of critical components remains within permissible limits, confirming the adequacy of the selected material and design dimensions for practical load conditions.

Finite element analysis outcomes validated the structural integrity of the lifting arm, demonstrating efficient load transfer and uniform deformation patterns without stress concentration at critical regions. These results indicate that the proposed design can safely withstand the loads imposed by motorcycles commonly serviced in small garages. The compact structure and balanced geometry further contribute to the overall stability of the system during lifting and maintenance operations.

Overall, the developed motorcycle lifting device offers a practical and economical alternative to existing bulky and expensive lifting systems. By improving ergonomic working conditions, reducing physical strain on mechanics, and enhancing maintenance efficiency, the proposed system fulfills the objectives of the study. The validated analytical results confirm the feasibility of the design, making it suitable for fabrication and real-world implementation in small and medium-scale motorcycle service workshops.

IX. FUTURE SCOPE

The proposed motorcycle lifting device can be further enhanced by incorporating adjustable height and width mechanisms to accommodate a wider range of motorcycle models with varying wheelbases and frame geometries. This improvement would increase the versatility of the system and make it suitable for servicing both lightweight commuter motorcycles and heavier premium or touring bikes. Design optimization techniques can also be applied to reduce overall weight while maintaining structural strength.

Future work may include dynamic and fatigue analysis of the lifting system to evaluate its performance under repeated loading and long-term usage conditions. Such analysis would provide deeper insight into durability, wear characteristics, and service life of the critical components. Experimental validation under dynamic loading conditions can further strengthen the reliability of the system for continuous workshop use.

The system can also be upgraded by integrating semi- automatic or power-assisted mechanisms, such as motorized screw drives or hydraulic-assisted lifting, while maintaining cost-effectiveness. Additionally, the use of advanced materials or surface treatments to improve corrosion resistance and reduce maintenance requirements can be explored. Field trials in multiple garages would help in refining the design based on real- world feedback and operational demands.

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