International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 10 | Oct - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Design and Development of a Manually Operated Low-Cost Forklift for Short-Distance Material Handling Applications

Soham Kale[1], Om Awari[1]

[1]Jhulelal Institute of Technology, Nagpur

Abstract - Manual material handling is an important activity in small workshops, warehouses, fabrication units and other industrial environments. When materials are repeatedly lifted, moved and positioned by workers, considerable physical effort may be required and unsafe handling practices can increase the possibility of strain or accidents. The present project focuses on the development of a manually operated mini forklift intended for lifting and transporting moderate loads over short distances. The concept is based on a simple mechanical arrangement that can operate without electricity or fuel.

The proposed forklift provides a practical approach to material handling where a powered forklift may be unnecessary or economically unsuitable. Its main purpose is to reduce direct human effort during lifting and movement while maintaining a relatively simple construction and operation. The system can be useful in workshops, small warehouses, stores and similar environments where loads need to be raised to a convenient height or shifted over a limited distance.

The project emphasizes simplicity, low operating complexity, ease of maintenance and suitability for small-scale applications. Because the machine is manually operated, it does not depend on a battery, electric motor or internal-combustion engine for its basic operation. The project therefore demonstrates how mechanical principles can be used to develop an economical material-handling device for moderate loads.

Key Words: Manual forklift, material handling, mechanical lifting, low-cost machine, workshop equipment, load lifting, mechanical advantage, safety.

1.INTRODUCTION

Material handling is the movement, storage, protection and control of materials during manufacturing, storage and other industrial activities. In many small-scale industries, a significant amount of material movement is still performed manually. Workers may have to lift components from the floor, move them between workstations, load or unload materials, and place them on platforms or racks. Repetitive manual handling can require substantial physical effort and may reduce productivity.

Forklifts are widely associated with industrial material handling because they can lift and transport loads efficiently. However, conventional powered forklifts can involve comparatively high purchase cost, energy requirements, maintenance requirements and operating-space requirements. For small workshops or low-volume operations, the complete capabilities of a powered forklift may not always be necessary.

The manually operated forklift considered in this project addresses this situation by using a mechanical lifting arrangement operated by the user. The project described in the supplied brief specifically aims to provide a low-cost mini forklift capable of lifting and transporting moderate loads without electricity or fuel. The design is intended for short-distance material handling and focuses on reducing human effort and improving safety.

The basic engineering idea is to use mechanical advantage so that the force applied by the operator is converted into a controlled lifting action. A suitable lifting mechanism, supporting frame, forks and wheels can work together to provide stability and controlled movement. The design must consider load distribution, structural strength, stability, ease of operation and safe handling.

2. PROBLEM STATEMENT

Small workshops and storage areas frequently require movement of materials that are too heavy or inconvenient to lift repeatedly by hand. Depending entirely on manual lifting can increase physical workload and can create unsafe working conditions. At the same time, a powered forklift may be excessive for small loads, short travel distances or locations where electricity or fuel-based equipment is not convenient.

Therefore, there is a need for a simple, economical and manually operated material-handling device that can lift and move moderate loads over short distances. The proposed manually operated forklift attempts to address this requirement through a compact mechanical design that does not require an external power source.

3. OBJECTIVES

The major objectives of the project are:

- To develop a manually operated mini forklift for material handling.
- To reduce the physical effort required for lifting moderate loads.
- To provide a simple and economical alternative for short-distance material movement.
- To operate the lifting system without electricity or fuel.
- To improve handling safety compared with direct manual lifting.
- To develop a mechanism that is understandable, maintainable and suitable for small workshops and warehouses.
- To demonstrate the practical application of mechanical advantage in material-handling equipment.

4. LITERATURE REVIEW

Material-handling equipment ranges from simple manually operated devices to powered and automated systems. The selection of equipment depends on load, lifting height, travel distance, operating environment, required productivity and available resources. Machine-design literature emphasizes that components carrying loads must be selected and proportioned according to the forces, moments, material properties and operating conditions involved [1,2].

Mechanical advantage is central to manually operated lifting equipment. In an ideal mechanism, the ratio of load force to applied effort indicates the force multiplication available to the operator. Actual performance is lower because of friction, deformation, misalignment and other mechanical losses. Consequently, experimental verification is necessary when evaluating a prototype rather than relying only on ideal calculations [1,4].

Strength and stability are equally important. Structural members must resist excessive bending and deformation, while the complete machine must remain stable as the load is raised and transported. Strength-of-materials principles provide the basis for evaluating bending stress and related structural conditions [3]. Production and fabrication considerations also influence the quality, alignment, durability and maintainability of the finished machine [5].

The present project applies these established engineering principles to a small manually operated forklift. The supplied project brief does not specify a single lifting mechanism, exact dimensions, material grades, rated capacity or experimental results; therefore, these parameters are treated as prototype-specific values to be established through design documentation and testing.

5. PROPOSED SYSTEM

The proposed system consists of a structural frame, fork assembly, manual lifting mechanism, wheels or rollers, axles/shafts, bearings or bushings, operating handle or lever, fasteners and load-supporting members. The frame carries the loads generated during lifting and movement, while the forks directly support the material. The lifting mechanism converts operator input into vertical movement of the fork assembly.

Subsystem	Primary function	Important design requirement
Main frame	Supports lifting mechanism and load	Strength, rigidity and alignment
Fork assembly	Supports the material	Adequate bending strength and secure attachment
Lifting mechanism	Raises and lowers forks	Mechanical advantage and controlled motion
Wheels/rollers	Permit movement	Load capacity, rolling resistance and stability
Axles/shafts	Support rotating elements	Strength and proper alignment
Bearings/bushings	Facilitate relative motion	Low friction and durability

Handle/lever	Provides operator input	Ergonomic and controlled operation
Fasteners/joints	Connect components	Secure attachment and serviceability

Table 1. Major subsystems and their design functions.

6. METHODOLOGY

The project methodology is organized into the following stages:

1. Requirement identification: Define the intended load range, lifting requirement, travel distance, floor condition and operating environment.
2. Concept development: Select a suitable manually actuated lifting arrangement and establish the preliminary frame, fork and wheel layout.
3. Engineering design: Determine loads, forces, moments, stability conditions and required structural dimensions using appropriate machine-design principles.
4. Component selection: Select structural members, wheels, shafts, bearings, fasteners and other components according to the calculated requirements.
5. Fabrication: Cut, drill, machine and join the components using suitable workshop processes while maintaining dimensional accuracy and alignment.
6. Assembly: Install the fork assembly, lifting mechanism, wheels and operating controls, followed by inspection of all joints and moving parts.
7. Functional testing: Operate the machine without load to verify free movement, alignment, lifting and lowering.
8. Load testing: Increase the load gradually under controlled conditions and record lifting effort, time, height, stability and movement performance.
9. Evaluation: Calculate mechanical advantage and efficiency where adequate measurements are available and identify areas requiring improvement.

7. WORKING PRINCIPLE

The working principle of the manually operated forklift is based on mechanical advantage. Instead of requiring the operator to directly lift the complete load, the operator applies force to a mechanical input. The lifting mechanism transfers this input through its components and produces upward movement at the forks.

When the operator applies force, the lifting mechanism begins to raise the fork assembly. As the forks rise, the load supported by them is also raised. The mechanism should be designed so that the movement is controlled and the load remains supported throughout the lifting operation.

After the required height is reached, the operator can move the forklift using its wheels. The frame transfers the load to the wheel-support system and maintains the relative position of the load. At the destination, the lifting mechanism is operated in the reverse direction so that the forks descend gradually and the load is placed on the supporting surface.

The efficiency of the system depends on the mechanical design, friction at joints and wheels, alignment, mass of the structure and characteristics of the lifting mechanism. Consequently, the prototype should be tested rather than relying only on theoretical calculations.

8. MAJOR COMPONENTS

The principal components of a manually operated forklift generally include:

1. Main frame – supports the lifting mechanism and carries the overall structural load.
2. Forks – directly support the material being lifted.
3. Lifting mechanism – converts manual input into vertical fork movement.
4. Wheels or rollers – allow movement of the machine.
5. Axles and shafts – support rotating components and transmit forces.
6. Bearings or bushings – facilitate relative movement at appropriate joints.
7. Handles or operating lever – provide the operator interface for manual control.
8. Fasteners and joints – connect the structural and mechanical elements.
9. Load-supporting members – distribute load forces from the forks into the frame.

The exact component dimensions, material grades and mechanism type should be taken from the fabricated prototype. The project brief supplied for this paper does not provide those specifications.

9. DESIGN AND ENGINEERING ANALYSIS

9.1 Mechanical Advantage

For an ideal lifting mechanism:

Mechanical Advantage (MA) = Load Force / Effort Force

For a measured prototype, MA should be calculated using the actual load force and operator effort recorded during testing.

9.2 Mechanical Efficiency

The mechanical efficiency can be expressed as:

Efficiency (%) = (Useful Output Work / Input Work) × 100

Where output work is associated with raising the load through the measured vertical distance, and input work is based on the measured operator force and corresponding input displacement, subject to the actual mechanism geometry.

9.3 Lever Equilibrium

If the lifting mechanism operates as a lever, the static moment relationship can be expressed as:

Effort × Effort Arm = Load × Load Arm

The arm lengths must be measured from the relevant pivot to the lines of action of the effort and load.

9.4 Bending Stress

For a structural member subjected to bending:

$\sigma = M / Z$

where σ is bending stress, M is bending moment and Z is the section modulus. The calculated stress should be compared with the allowable stress for the selected material and design condition.

9.5 Stability

Stability is critical because raising a load can change the combined centre of gravity of the machine and load. The load should remain within the effective support region formed by the wheel and support arrangement during lifting and movement. The actual stability assessment should use the prototype wheelbase, load position, machine mass and load mass.

10. FABRICATION AND ASSEMBLY

Fabrication begins with preparation of the structural members according to the selected design. Material is cut to the required dimensions and joined using suitable fabrication methods. The frame should be checked for squareness and alignment because misalignment can affect lifting motion and stability.

The fork assembly is then connected to the lifting structure. Moving joints are checked to ensure that they can operate smoothly without excessive play. Wheels are mounted securely on their axles, and the complete structure is assembled.

After assembly, the mechanism should be inspected for loose fasteners, sharp edges, weld defects, interference between moving components and abnormal friction. The lifting mechanism should first be operated without a load. If movement is smooth and the structure remains stable, controlled load testing can be performed gradually.

11. TESTING AND PERFORMANCE EVALUATION

Testing is necessary to determine whether the prototype performs its intended function. The first stage should be an unloaded functional test. This verifies that the forks can move through the intended range and that the wheels rotate correctly.

The next stage is a controlled low-load test. The load is increased gradually while observing frame deformation, lifting effort, stability and movement. The operator should never exceed the experimentally established safe capacity.

Useful performance parameters include lifting time, maximum verified load, operator effort, lifting height, movement distance, stability and lowering control. If suitable instruments are available, the applied effort can be measured using a force gauge or spring balance. Repeated trials can then be used to calculate average values.

A sample test table can be completed from actual experimental data:

Parameter	Trial 1	Trial 2	Trial 3	Average
Load lifted	___	___	___	___
Lifting time	___	___	___	___
Operator effort	___	___	___	___
Lifting height	___	___	___	___
Travel distance	___	___	___	___

These values should be filled from the team's prototype testing.

12. ADVANTAGES

The proposed manually operated forklift offers several potential advantages for small-scale material handling:

• Does not require electricity or fuel for its basic operation.
• Can reduce direct manual lifting effort.
• Has a relatively simple operating concept.
• Can be suitable for short-distance material movement.
• Can be useful in small workshops and storage areas.
• Potentially has lower operating complexity than powered equipment.
• Demonstrates practical application of mechanical engineering principles.
• Can be maintained using basic mechanical inspection and servicing.

13. LIMITATIONS

The manually operated forklift also has limitations. Its performance depends on the physical effort available from the operator. It is therefore not intended to replace powered equipment for very heavy loads or long-distance transportation. Movement may also be influenced by floor condition and wheel design.

Because the project brief does not provide a numerical load capacity or lifting height, these parameters must be established experimentally for the completed prototype. The machine should not be treated as a commercial industrial forklift unless it has undergone the appropriate engineering validation, testing and certification.

14. APPLICATIONS

Potential applications include small mechanical workshops, fabrication workshops, storage rooms, educational laboratories, small warehouses, maintenance areas and other locations requiring short-distance movement of moderate loads.

The machine can also be useful as an educational demonstration of mechanical advantage, structural design, fabrication, force transmission and basic material-handling principles. Its manually operated nature makes it suitable for demonstrating how mechanical systems can perform useful work without an external power source.

15. SAFETY CONSIDERATIONS

Safety should be treated as a primary requirement during operation. The load should be positioned centrally and securely on the forks. Operators should avoid placing hands or feet beneath raised loads. The machine should be operated on a suitable and reasonably level surface.

The rated or experimentally verified load should never be exceeded. Sudden lifting or lowering should be avoided because dynamic effects can increase forces. The frame, forks, wheels, axles, joints and lifting mechanism should be inspected regularly.

Before each use, the operator should check for loose fasteners, cracks, excessive wear, wheel damage and abnormal movement. If any structural or mechanical defect is identified, the machine should be removed from service until the defect is corrected.

16. COST AND ECONOMIC CONSIDERATION

One of the major motivations for a manually operated forklift is the possibility of developing a low-cost material-handling solution. The absence of an electric motor, battery or fuel system can reduce system complexity and eliminate the associated energy requirements during operation.

17. ENVIRONMENTAL CONSIDERATION

The manually operated concept does not require fuel combustion or electrical energy during normal lifting operation. This can reduce direct operational energy consumption compared with powered alternatives. The environmental impact of the complete project still depends on the materials used, manufacturing processes, maintenance and eventual disposal or recycling of components.

Using durable structural materials and designing components for repair and replacement can extend service life. At the end of the product life, metallic components may be separated and recycled where suitable facilities are available.

18. RESULTS AND DISCUSSION

The project demonstrates the feasibility of using a manually operated mechanical system for moderate-load, short-distance material handling. The key functional objective is to provide controlled lifting and movement while reducing the need for direct manual lifting.

The performance of the final prototype should be discussed using measured test results. Particular attention should be given to lifting effort, stability, lifting height, ease of movement and reliability of the mechanism. If the measured effort is significantly lower than direct lifting effort, the mechanical advantage of the system can be considered beneficial for the intended application.

The absence of numerical experimental results in the supplied project brief means that this paper does not claim specific load capacity, lifting speed or efficiency.

Such values should be added after testing the actual prototype.

19. FUTURE SCOPE

The manually operated forklift can be further developed in several ways. The lifting mechanism could be optimized to reduce operator effort and improve lifting smoothness. Improved wheel selection could make movement easier on different floor surfaces. A locking or braking arrangement could provide additional control during loading and unloading.

Future versions could incorporate an adjustable fork width to accommodate different load sizes. A mechanical or hydraulic assist mechanism could also be investigated while retaining a low-energy design philosophy. Additional structural analysis using CAD and finite element analysis could be performed to optimize frame dimensions and reduce unnecessary weight.

Instrumentation could be added to measure load, applied effort, lifting height and cycle time. These measurements would allow a more detailed performance comparison and provide experimental evidence for design optimization.

20. CONCLUSION

The manually operated forklift provides a simple approach to material handling in environments where moderate loads must be lifted and transported over short distances. The project addresses the physical effort associated with manual material handling by applying mechanical principles to create a controlled lifting action.

The concept is particularly relevant to small workshops and warehouses where a powered forklift may not be necessary or convenient. Its operation without electricity or fuel is a key feature, while its simple construction can support economical fabrication and maintenance.

The successful development of the prototype depends on correct structural design, stable load support, reliable mechanical joints and controlled operation. Actual load capacity, efficiency and lifting performance must be established through prototype testing. With further optimization, the concept can serve as a useful low-cost material-handling solution as well as a practical demonstration of mechanical engineering design principles.

21. DESIGN DRAWINGS AND PROTOTYPE REFERENCE

The following images show the reference manually operated forklift, the preliminary hand-drawn concept layout, and the dimensioned CAD drawing used to communicate the proposed frame and fork arrangement.



Figure 1. Reference image of a manually operated forklift.

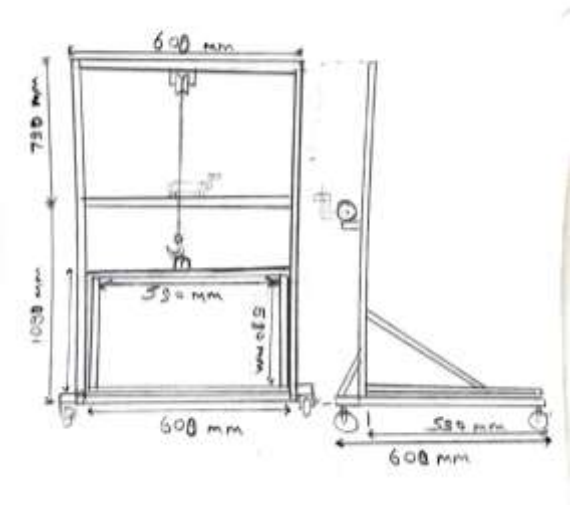


Figure 2. Preliminary hand-drawn design of the manually operated forklift.

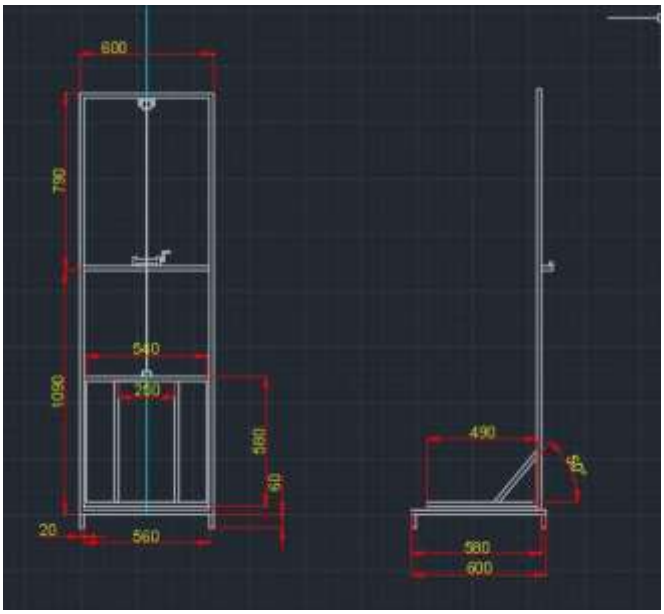


Figure 3. Dimensioned CAD drawing showing the front and side views of the proposed design.

REFERENCES

1. R. S. Khurmi and J. K. Gupta, A Textbook of Machine Design, S. Chand Publishing.
2. V. B. Bhandari, Design of Machine Elements, McGraw Hill Education.
3. S. Ramamrutham and R. Narayanan, Strength of Materials, Dhanpat Rai Publishing.
4. S. S. Rattan, Theory of Machines, McGraw Hill Education.
5. R. K. Jain, Production Technology, Khanna Publishers.
6. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson.
7. Project brief supplied by the project team: “Manually Operated Forklift,” including the stated objective of developing a low-cost manually operated mini forklift for moderate-load, short-distance material handling.