

DESIGN ANALYSIS OF MANUAL FORKLIFT

Dinesh Sunil Bhalerao¹, S. R. Shekokar², Nitin A. Kharche³

^{1,2,3}Department of Mechanical Engineering, Padm. Dr. V. B. Kolte College of Engineering, Malkapur

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ABSTRACT

Material handling is an important part of any production or manufacturing process, encompassing the movement, safeguarding, storage, and control of raw materials, partially finished goods, and final goods during all phases of production and warehousing. Effective material handling systems are required for smooth workflow, shorter production time, and lower labor cost. Among the widely applied equipment in this field, forklifts are an important part in various industries. Forklifts find extensive applications for many purposes like lifting, moving, and safe delivery of materials like big boxes, cylindrical pieces, and raw material.

Usually, forklifts utilize a lead screw and nut system enabling vertical motion of the lifting platform. Though such machinery is highly necessary in large industries, its usage in small industries is mostly restricted by high prices, enormous sizes, and difficulty in maintenance. Most small enterprises continue using manual lifting, which is less efficient, tiresome, and even unsafe.

In order to overcome this problem, the current project aims at designing and developing a low-cost, low-space-occupancy, efficient forklift system specifically for small industries. The suggested forklift system can be used as an alternative to costly material handling machines by incorporating a plain mechanical lifting system combined with robust design elements. It will be able to lift and move moderate loads in a safe and efficient manner within tight spaces, which is perfect for workshops, warehouses, and small production facilities.

This new technique not only increases productivity and safety in the workplace but also helps in the overall objective of mechanizing small-scale industries without placing huge monetary obligations. The forklift designed will be simple to use, low in maintenance costs, and provide a safe solution to material handling needs typically encountered by small businesses.

Keyword: Manual Forklift, Material Handling Equipment, Mechanical Lifting System, Lead Screw and Nut Mechanism, Load Lifting Mechanism, Compact Forklift Design, Small-Scale Industry Equipment

INTRODUCTION

In all manufacturing industries requirement of Portable Machinery is necessary because of rapid development in consumption of manufactured product. Demand of good products within short time frame is necessary in today's scenario. Better quality in products can be obtained by the application of modern technology as well as ancient Technology. We require systems developed by using latest technology in order to simplify our work. For the most part, Manual Forklift are employed to make product of manufacturing or something which could be utilized in life to place specific dimensional products with huge volume or tiny volume. Manual Forklift are that equipment that are not ready-made, therefore they need to be designed and fabricated based on customer's special requirement. They are also referred to as forklift machine. In this project we are only concentrating on the study which simplifies what human beings do along with development of A machine that can lift anything easily.

Material handling process is the transport of raw materials, finished products through different stages of Production and warehousing. Typically, a forklift is utilized in most industries for varied uses like Lifting, delivery of material like giant boxes, Raw materials, etc. The machine that we are going to Manufacture named as "Manual Stacker (Forklift)" is intended for the same operations but is especially developed for small Warehouses or commercial areas. Presently the operation of stacking products in such areas needs to be done manually and also takes much time. To fulfill the increasingly growing demands of the customer, shopping malls Have to make their personnel work overtime in order to make stacking of products feasible. Therefore, such a machine can be utilized in similar Spaces for stacking easily and efficiently. The machine is economical, space-saving, and can be operated by one person and moved through the narrow lanes. A stacker can also be referred to as a manual stacker, which is manually driven equipment, and it is widely utilized in Warehouses, factories, and other industrial environments for lifting and transporting loads.

It has a frame, a lifting Mechanism, and a pair of wheels or casters for transportation. The lifting mechanism of a manual stacker generally Includes a Chain Pulley Block system whereby the operator can lift and lower the load by means of a Chains. The stacker's frame is built to bear the load and also stability, and it can be adjustable To suit various sizes of loads. Manual stackers are available in different sizes and capacities to accommodate various applications. Some units are Designed for light-duty use, while others can handle heavier loads. They also include. Other options such as adjustable forks, straddle legs, or other types of

wheels or casters for Applications. In summary, a manual stacker is a relatively low-cost and highly adaptable lifting solution that can assist in enhancing Efficiency and safety in various industry environments.

2.CLASSIFICATION OF FORKLIFTS

- Electric Hand Lift
- Personnel lifts
- Order pickers
- Hydraulic Lift
- Pneumatic Tire Lift
- Container HandlersLift

2.1.ELECTRIC FORKLIFT

Electric forklifts are now an integral part of contemporary material handling systems, especially within warehouse and manufacturing facilities indoors. Of all the best options in the market today, Hyundai Electric Forklifts can be considered a surefire and effective answer to loading and unloading tasks. Hyundai electric forklifts are engineered to accommodate the needs of high-activity warehouse operations where space is scarce and maneuverability is essential.

One of the major benefits of Hyundai Electric Forklifts is their rugged yet compact and ergonomic body design, enabling them to move safely even on narrow aisles and tight spaces. This is a major driver of operational efficiency and why they are ideal for tightly packed warehouses. Apart from their space-efficient design, these forklifts are also furnished with cutting-edge technology features that enable rapid, safe, and easy use. Hyundai makes available a large selection of electric forklift models with load capacities ranging from 1,500 kg to 4,990 kg. This allows companies to find a model that is specifically suited to their particular needs for material handling. From lightweight products to industrial materials, there is a Hyundai Electric Forklift that can efficiently.

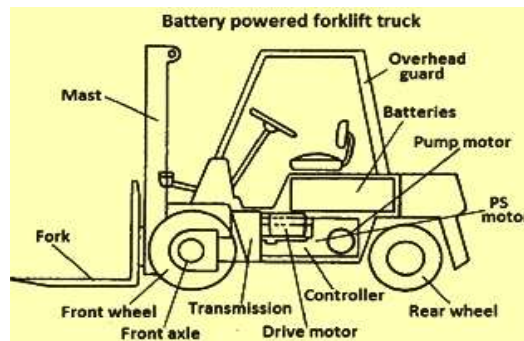


Fig.1.Electric Forklift

The electric nature of these forklifts also contributes to a cleaner and quieter working environment, as they produce no direct emissions and operate with significantly reduced noise compared to internal combustion models. This makes them an eco-friendly and operator-friendly option, aligning with modern sustainability goals.

On the whole, Hyundai Electric Forklifts fuse performance, safety, and environmental stewardship together and are, therefore, a perfect solution for organizations that want to maximize their warehouse operations without sacrificing on quality and efficiency. Their versatility and durable performance make them an important investment for many industries.

2.2.PERSONNEL LIFTS

Personnel lifts are specially designed platforms used for lifting the workers to do work at elevated heights in a controlled and safe way. When combined with forklifts, these lifts are commonly referred to as man baskets or forklift work platforms. They are temporary aerial work platforms and commonly used in warehouse facilities, manufacturing plants, and maintenance work. A forklift personnel lift is typically a steel cage-like unit firmly fixed to the forks of a forklift. It has a safe standing platform for employees, with guardrails, toe boards, and anchorage points for safety harnesses. It can carry one or two employees along with light equipment and has load capacity usually between 200 and 400 kg.

The main benefit of having a forklift-based personnel lift is its versatility and economic advantage, particularly in those facilities that already utilize forklifts to handle materials. It negates the necessity of specialized aerial lift machines such as boom or scissor lifts, which can be expensive for small or medium-sized businesses.

Personnel lifts are best for jobs like overhead maintenance, light installations, inventory checks, and general repairs. Proper safety measures must be observed though. Only trained operators should operate the forklift in lifting people, and fall protection gear should be worn by people on the platform. The platform should be tightly fastened to the forks and never employed on uneven terrain or poor conditions.

Overall, forklift-mounted personnel lifts provide an efficient solution to working at height in the industrial environment. They increase productivity while ensuring employee safety, as long as they are used as per recommended standards and safety protocols like those from OSHA or ISO.

2.3.ORDER PICKERS FORKLIFT

Order pickers are a dedicated class of forklift machines that are used to aid manual order picking activities in warehouses and distribution facilities. As opposed to regular forklifts where pallets and products are raised and the operator remains on the ground, order pickers are engineered to lift the operator as well as the control platform, enabling them to reach products kept at different shelf levels.

These forklifts are especially handy in high-density warehouses where products are placed high on vertical racking systems. Order pickers enable drivers to navigate up and down, as well as in between, in confined aisles, and thus are well-suited to operations in which single item selection is necessary—like in e-commerce, retail, pharmaceutical, and part distribution warehouses. Order pickers are usually equipped with a raised operator platform, anchorage points for safety harnesses, guardrails, and a compartment to store the picked products. The operator travels with the machine to the spot, raises themselves to the desired level, manually picks products, and puts them into bins or totes. The lift reaches a height of 9–12 meters, depending on the model.



Fig 2: Order Pickers Forklift

Key features are electric or hydraulic lifting systems, low-noise operation, energy-saving motors, ergonomic controls, and built-in safety systems like automatic braking, emergency stop switches, and anti-tip designs. Some high-end models are wire-guided or rail-guided to move through very narrow aisles safely. Load capacities typically range from 100 to 1500 kg based on whether the machine is intended for light or medium-duty applications.

In summary, order pickers improve the efficiency of a warehouse through enabling rapid, accurate, and safe picking of individual products. They are particularly efficient in places with many Stock Keeping Units (SKUs) and frequent picking. Through their capacity to drive productivity and minimize operator fatigue, order pickers are critical in contemporary inventory management systems.

2.4.Hydraulic Lift

Hydraulic lift is the central system employed in the majority of forklifts to raise and lower loads. It relies on Pascal's Law that tells us pressure applied to a contained fluid is shared equally in all directions. In a forklift, such a system generally consists of a hydraulic cylinder, pump, fluid reservoir, and control valves.

When the lift controls are activated by the forklift driver, the hydraulic pump displaces fluid from the reservoir into the cylinder. The pressurized fluid forces the piston to move upward, which lifts the mast and the forks with the load. When the load needs to be lowered, a valve is opened to let the fluid back into the reservoir, so the forks slide down smoothly.

Hydraulic lifts are very efficient, providing smooth, powerful, and controlled lifting for even heavy loads. They find extensive applications in material handling, warehousing, and construction because they are reliable and easy to use. The majority of contemporary forklifts, both electric and internal combustion, employ hydraulic systems for handling weights that vary from a few hundred kilos to several tons. Overload valves and controlled descent systems provide safety features that guarantee safe

operation while performing lifting and lowering operations.

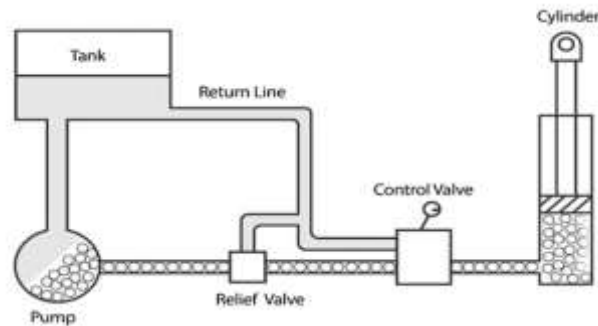


Fig 3. Anatomy Of Hydraulic Lift

2.5 PNEUMATIC TIRE FORKLIFT

A pneumatic tire forklift is a forklift with tires that are meant for rough ground and are meant for outdoor operations. They resemble truck tires and have two primary types: air-filled (pneumatic) inflated tires and solid pneumatic tires. They have improved traction, shock, and ground clearance over cushion tire forklifts and are ideal for uneven or rough ground.

Compressed air-filled pneumatic tires are constructed using heavy-duty rubber and compressed air. They are best suited for traveling over gravel, dirt, and rough outdoor terrain. Pneumatic tires provide superior suspension and operator comfort by damping out shock in travel. They need regular maintenance and are susceptible to puncture. Conversely, solid pneumatic tires consist of pure rubber and are puncture-resistant, hence more durable in nail, scrap, or sharp debris-containing environments. Although they lack the amount of cushioning provided by air-filled tires, they are more appropriate for heavy-duty industrial use where tire wear is a factor.



Fig 4. Pneumatic Tire Forklift

Pneumatic tire forklifts are usually diesel, gasoline, LPG, or electric motor powered, depending on the use. They're available in different load capacities and can be used for both light and heavy material handling duties. First, pneumatic tires are the same as your normal car or truck tires and are used most outdoors. Solid pneumatics and air pneumatics are the two types. The air pneumatics contain air inside, while the solid pneumatics are composed of rubber and more puncture resistant.

Should we be having nails, rocks, or other sharp items lying around the yard or work area, you might prefer to Lean toward the solid pneumatic. One of the greatest advantages of pneumatic tires is their capacity to absorb the unevenness Of terrain. This makes for a smoother ride, and less bumping and shaking. They are also going to have a thicker tread, which offers grip to run over loose and uneven surface.

2.6 CONTAINER HANDLERSLIFT

Container Handler Forklift, or container forklift or heavy-duty forklift, is a heavy-duty industrial truck for lifting and moving giant shipping containers. They are found to be mostly used in ports, terminals, rail yards, and logistics centers for transporting ISO-standard containers safely and efficiently. As opposed to traditional forklifts, container handlers are designed with high-capacity loads usually between 30 and 50 tons to lift 20-foot, 40-foot, and even 45-foot containers. They are fitted with a sturdy boom or telescopic mast and a spreader bar, which locks onto the corner castings of the container through a twist-lock mechanism. This facilitates quick and secure stacking, lifting, and positioning. There are two primary types of container handler forklifts: Top Pick (Top Loader) Picks containers up from the top and stacks them vertically, as high as

Empty Container Handler Specifically made to handle empty (unloaded) containers, which are lighter and usually stacked even higher. Container Handler Forklift, or container forklift or heavy-duty forklift, is a heavy-duty industrial truck for

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Empty Container Handler – Specifically made to handle empty (unloaded) containers, which are lighter and usually stacked even higher.

FABRICATION OF POWER LIFT

The production of a forklift is a synergy of mechanical engineering, precision manufacturing, and quality control to create a machine to lift, move, and stack heavy loads securely. Forklifts are extensively used in warehousing, construction, logistics, and manufacturing industries and need to be produced to certain performance, durability, and safety standards.

Design and Planning: The production of the forklift starts with the design stage, in which engineers establish specifications of the forklift, including its capacity, the height it can lift, tire type (pneumatic or cushion), fuel type (electric, diesel, LPG), and operational setting (indoor/outdoor). CAD (Computer-Aided Design) software is employed to design the forklift structure, the hydraulics, and electrical systems.

Material Selection: The main material for the production of forklifts is high-strength steel, selected for load-carrying capacity and wear resistance. Various types of steel are utilized for different parts:

Chassis and mast: Heavy-duty steel for stability and strength

Forks: Heat-treated alloy steel for bend resistance and durability

Hydraulic parts: Hardened or stainless steel for pressure handling

Frame and Chassis Fabrication: The chassis of the forklift is its backbone. Steel sheets and bars are cut, bent, and welded together to create the base frame in precise manner with the help of CNC (Computer Numerical Control) machines. The mast, which facilitates lifting vertically, is also made at this stage and consists of rails and rollers that direct the forks while lifting.

Fork Manufacturing: Forks are forged or made of alloy steel and heat-treated to enhance their strength. They are subjected to a bending resistance test and dimensional check to guarantee that they have the ability to withstand re-loading.

Hydraulic System Assembly: Forklifts employ hydraulic systems for lifting and tilting loads. Hydraulic cylinders, pumps, valves, and hoses are built and tested for pressure integrity. The systems are essential to ensure smooth and safe operation, as they allow the operator to maneuver the lifting and lowering of the forks with precise control.

Powertrain and Transmission: Depending on the type of forklift, electric motors (for electric forklifts) or internal combustion engines (LPG, petrol, or diesel) are mounted. The transmission system is installed to deliver engine or motor power to the wheels. Electric forklifts also get battery packs and charging systems at this stage.

Tires and Axle Assembly: The front and back axles are mounted with cushion or pneumatic tires, depending on the environment of operation. Alignment of the wheels is properly done to ensure stability and safety.

Electrical and Control Systems: Control systems, such as joysticks, switches, and sensors, are installed in the operator compartment. Electrical wiring for lamps, horns, and warning alarms is linked. New forklifts can also incorporate digital displays and sophisticated diagnostics.

Final Assembly and Testing: After all the major components are installed, the forklift is assembled completely and subjected to extensive testing:

- Load testing
- Brake and steering tests
- Stability and maneuverability checks
- Safety inspections

10. Painting and Finishing

The last process involves surface treatment, painting, branding, and protective coating to avoid corrosion and provide the forklift with its final appearance.

4. OPERATION OF THE MANUAL FORKLIFT

A manual forklift, or hand-operated pallet stacker, is a basic material handling appliance utilized to elevate, push, and place loads without the use of a motor or engine. It is frequently employed in small warehouses, workshops, and retail establishments where lighter loads must be moved for short distances. A manual forklift is a simple material-handling appliance that functions without electricity or hydraulic power. The most effective and budget-friendly version of the manual forklift utilizes the chain block principle, which employs mechanical leverage to raise bulky

loads with minimal human labor. This system comes in handy in small-scale manufacturing units, workshops, and stores where electricity or motorized machinery might not be present or practical.

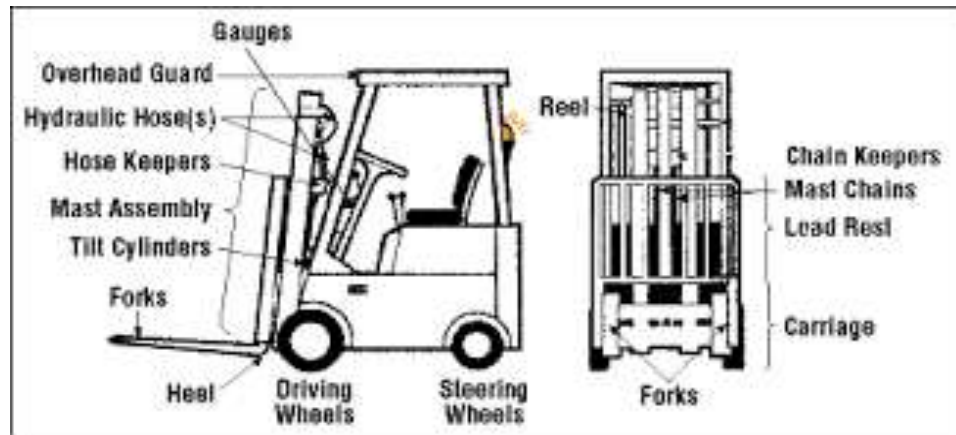


Figure 5: Operation Of The Manual Forklift

The chain block forklift is based on the basic physics of mechanical gear systems and pulleys. The basis of the operation lies in converting a small amount of input force that is applied over a greater distance to a larger output force over a lesser distance. This is made possible by a combination of reduction gears and chain-pulley systems, which lowers the physical effort needed by the operator considerably.

In the center of the chain block forklift is a gear set consisting of one big gear, two small gears, and a main shaft in a two-stage reducer setup. When the hand chain is pulled by the operator, it turns the big gear, which passes the motion to the smaller gears and finally propels the lifting mechanism attached to the load chain and forks. This mechanical configuration achieves a high mechanical advantage and makes it easy to lift heavy loads with high precision. The higher the number of stages of gear reduction employed, the lighter the weight one can lift with less force. This makes it possible for the forklift to transport heavy commodities to different positions or levels with little stress on the driver.

One of the most important factors in the functioning and effectiveness of a chain block forklift is the machining accuracy of its gear set. The more smoothly and accurately the gear teeth are engineered, the less friction is produced when they move, which means smoother lifting and decreased wear. As such, machining quality has a direct influence on the simplicity of use, weight capacity, and longevity of the forklift. To lift or down, the operator will just have to attach the top hook of chain fork lift on frame support, catch the object to be moved, pull down the hand chain blocks based on the up directions noted at the rear side of a chain Pulley Block. While pulling the hand chain, the rotation of the hand wheel will rotate the main shaft and gears will make the load chain wheel rotate, in this manner the chain fork lift will translate along with the rotation of the load wheels, hence the load will be raised. Once the loads are raised to the desired level, simply pull the hand chain from the opposite side or lower down the load.

The major elements of a manual forklift are

- Hydraulic pump
- Lifting forks
- Lead screw or chain mechanism
- Mast/frame
- Handle and wheels

Lifting Mechanism

The operation of a manual forklift is founded upon a hydraulic lift system. When the operator presses the handle, it causes a hydraulic pump to pump fluid into a cylinder. This fluid pressure lifts a piston, which lifts the forks. The forks move along the vertical mast and lift the load placed upon them, typically a pallet or box.

Movement and Steering

Caster wheels are provided on manual forklifts for easy movement. The forklift is pushed or pulled by the operator manually to a desired destination. Steering is carried out by means of a handle attached to the rear wheels. Lead screw and nut mechanisms are utilized by some models to provide mechanical lifting assistance.

Lowering the Load

To decrease the load, the operator releases a release valve close to the handle. This creates a path for the hydraulic fluid to drain back to the reservoir, and the forks lower with the load in a controlled way.

5.CONCLUSION

Manual forklifts are straightforward, effective, and inexpensive material handling machines that are a critical part of small businesses, warehouses, workshops, and stores. They function without the use of fuel or electricity, using mechanical systems—e.g., hydraulic pumps or chain block mechanisms—to lift and transfer loads easily and efficiently. The design is aimed at minimizing manual effort while ensuring control, reliability, and simplicity. One of the most important benefits of manual forklifts is that they have a low cost of operation. Because they don't need any power source except man power, they are especially ideal for small businesses or operations with limited means. They are also lightweight and compact in size, thus being perfect for use in confined spaces where powered forklifts would not be feasible.

Solely manual forklifts, particularly those on the principles of chain block or hydraulic lifting, are constructed for simplicity and for withstanding the wear and tear of time. They provide adequate lifting capacity for moderate to light loads between 500 kg and 2,000 kg. The application of gear reductions or hydraulic pressure makes it easier for operators to lift heavy loads at less effort, contributing to overall productivity at the expense of less physical effort. Still, the point of note here is that manual forklifts are most appropriate for short-distance transport and light to moderate lifting tasks.

In operations that involve continuous or heavy-duty lifting, motorized forklifts would be more suitable. Nevertheless, in small-scale operations, a manual forklift is still a viable and cost-effective alternative. In summary, manual forklifts are a useful resource in material handling with a balance between functionality, price, and simplicity. Their utility in low-volume applications provides them as an economical option for most industries, particularly where ease of maintenance and affordability are considered. Used properly and maintained regularly, manual forklifts will deliver safe, efficient, and durable service.

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