International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

DESIGN AND DEVELOPMENT OF PORTABLE FORKLIFT

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Abstract – The paper explores the development and production of a Portable Forklift, emphasizing its role in revolutionizing mechanical industries. Offering improved visibility and scalability, it enables operators to maneuver industrial environments more effectively. Versatile in its applications, it provides flexible and efficient solution for modern industries seeking it's operational optimization. Its implementation promises increased efficiency and accuracy in transporting mechanical tasks and goods within fabrication plants. By enhancing mobility and flexibility, it meets the evolving needs of industrial lines, fostering smoother workflows and higher productivity. With its compact design and adaptable features, the Portable Forklift represents a significant advancement in material handling equipment. Its integration into industrial operations signals a move towards greater efficiency and effectiveness in logistical processes. Overall, the Portable Forklift stands as a transformative solution, set to elevate efficiency and productivity standards across various industrial sectors.

Key Words: development, scalability, optimization, mobility, optimization, implementation, adaptability, logistical.

1.INTRODUCTION

This solution facilitates safe lifting and loading of small equipment or bulky items up to 80kg by a single operator, offering a universal materials handling approach. The project aims to enhance the forklift design to improve functionality and address human factors considerations. It aims to eliminate risky one or two-person lifts, reducing the likelihood of back and other injuries associated with heavy lifting. This unique design enables one person operation to lift and load directly into vehicles (trucks, vans, and cars) or to place equipment and small loads on bench tops.. In this project, we're developing a forklift capable of lifting loads up to 50kg. We'll translate customer requirements into engineering specifications to identify necessary design adjustments and fabrication concepts. Most people are familiar with the basic forklift, which is manually operated. Despite the advancements in automated forklift technology, the basic forklift remains included as standard equipment with the newest automated forklifts.

1.1 LITERATURE REVIEW

Aashishkumar L Sharnangat, M. S. Tufail,(2017)[1], they discussed the creation of a robotic forklift designed to work alongside humans in outdoor storage areas. This forklift operates in partially prepared environments, handling various palletized materials using local sensors and navigating through busy surroundings, interacting with other moving forklifts as it transports cargo.

In Lipan's study from 2017, forklifts are highlighted as crucial tools in industrial handling, playing an essential role in daily operations. Nowadays, to meet the evolving needs of people, the variety of forklift types is continuously expanding.. In this project, based on already the basic parameters of the push The forklift has been introduced into the market with its working mechanism highlighted.

1.2 SCOPE OF WORK

This paper is about the designing and fabricating the forklift. In our paper, we focus on utilizing linear actuator operated forklifts due to their superior reliability and ease of operation. In order to develop a new concept for forklift design, we conducted surveys by discussing with forklift users. The scopes of paper were on the designing 50kg maximum lifting capacity of forklift. To fulfill our new design goals, it's crucial to evaluate the present forklift design and the specific product transport it undertakes. Our survey endeavors are aimed at identifying the inadequacies within current designs. The new design will offer both new features and improvement.

2. METHODOLOGY

1. Data collection of machine dimension collection and their weight.

2. Concept development.
3. Checking design feasibility
4. Checking various stresses that acting on the body due to axial load. Thus, the different parts of forklift are structured, designed and manufactured as per dimensions
5. Design in term of comfort.
6. Experimental calculations & Analyzed using Analysis software for validation. The above said work is in following phases.

Data Collection:

- Forklift Introduction
- Deciding types of lifting mechanism
- Advantages & Disadvantages of forklift
- Research papers regarding forklift design, manufacturing and analysis.
- Technical specifications of forklift components, channel and frame on welding machine.

Requirement of materials:

- Designing each component and validating it based on experimental results involves organizing the data using varied terminology.
- Selection of Steel Material and justification.

Assembly of model in SOLIDWORKS:
- Import each frame, pulley model in the Software.
- Meshing analysis in SOLIDWORKS.
- Finding Stress, Strain analysis with our calculation.
- Identifying critical sections.

Testing:
- Theoretical analysis of forks & comparison.
- Load testing
- Evaluation of Von-Mises stress and strain based on testing calculations. Plotting graphs based on the experimental calculations (such as Load vs. Stress, Stress vs. Strain).

Figure. Actual model

3. MATERIAL SELECTION

The choice of materials relies on the different stress types generated during operation. The material selected should with stand it. Another factor influencing metal selection is the type of load, as machine parts withstand loads more effectively than live loads, and live loads more effectively than shock loads. Material selection is also contingent on the safety factor, which is influenced by the following considerations.

- Reliabilities of properties
- Reliability of applied load
- The certainty as to exact mode of failure
- The extent of simplifying assumptions
- The extent of localized
- The extent of initial stresses set up during Manufacturing.
- The extent loss of life if failure occurs in it.
- The degree of property damage in case of failure.

3.1 Raw materials and Standard Material:

SR. NO	PART NAME	MAT	QTY
1	SQUARE PIPE	MS	20 KG
2	LINEAR ACTUATOR	STD	1 NOS
3	SHAFT DIA 20 MM	MS	10 KG
4	CHAIN	SS	1 SET
5	BATTERY	STD	4 NOS
6	SHEET METAL	MS	1 SQM
7	WHEEL	STD	2 NOS
8	NUT BOLT WASHER M 10	MS	20 NOS
9	HOOK	CI	20 NOS
10	MISCELLANEOUS	-	-

Figure. Raw material chart

Frame: The frame is usually made of mild steel. Availability of the materials. The frame is robust, capable of withstanding various loads during operation, with all other components attached to it. Material selection for engineering purposes is contingent upon several factors, including:

1. Assessing the materials' suitability for the operational environment.
2. The cost of materials.
3. Physical and chemical properties of material
4. Mechanical properties of material.

Linear actuator: Linear actuators generate straight-line motion, differing from the rotational motion of traditional electric motors. They find application in various sectors, including machine tools, industrial machinery, computer peripherals like disk drives and printers, as well as in valves and dampers, fulfilling the need for linear motion.

Motor: The motor is what makes the motion possible, and what interacts with the other parts of an electric linear actuator. The most common type of motor is a 12v DC motor, but for stronger or weaker actuators, this can be switched to a different format.

Lead screw: Lead screw actuators are the most common form of electric actuator. The lead screw is attached inside the cylinder, and it is this part of the actuator that actually turns the rotational motion into linear motion. The lead screw travels up and down the cylinder, creating the motion which is needed.

Cylinder: The cylinder is the part of the actuator which contains the motion created by the motor. It does not move but contains the parts that do move.

Gears: The gears are what attaches the motor to the lead screw, and allow them to move freely.

DC brushes: DC brushes bring current into the actuator by conveying it between stationary wires within the equipment.

Limit switch: A limit switch is incorporated into most (although definitely not all) models of the electric actuator, and acts as a means of limiting the movement of the actuator. When the limit switch is triggered, then all movement stops.

4. DESIGN CALCULATIONS

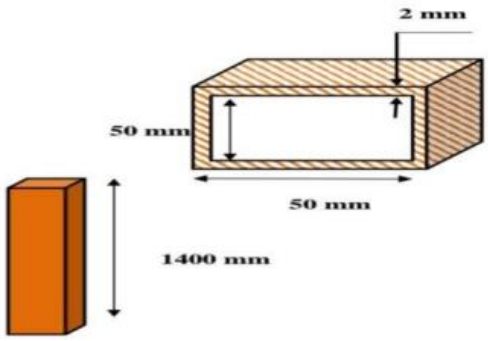
4.1 Why Mild steel C-45 is selected in our project-

- Easily available in all sections
- Welding ability
- Machinability
- Cutting ability
- Cheapest in all other metals.

Material = C 45 (mild steel)
Take fos 2
$\sigma t = \sigma b = 540/fos$
= 270 N/mm2
$\sigma s = 0.5\ \sigma t$
= 0.5 x 270
= 135 N/mm2

4.2 Linear actuator-

A column is constructed using a square pipe with a section measuring 50x50. We will examine its capacity to withstand bending loads. The linear actuator has a maximum load



capacity of 68 kg.
So, load on column is = 68 kg = 680 N
W = 680 N
M = W L / 4 =
680 X 1400/ 4 =238000 N-mm

Z = B^3 – b^3/ 6 = 50^3- 46^3/ 6 = 4610.6 mm^3.
σ b = M / Z
σ b = 238000 / 4610.6
= 51.62 N/mm^2
σ b INDUCED < σ b ALLOWED
36.14 N/mm2 < 270 N/mm^2
Hence our design is safe.

4.3 Design of bolt for sheer stress failure –

The bolt must be securely fastened to bear the load generated by rotation. Stress considerations for C-45 steel are also crucial. The bolt's standard nominal diameter is 9.31 millimeters.. From table in design data book, diameter corresponding to M10 bolt is 8 mm. Let's determine the maximum load capacity the bolt can withstand.

Figure. Nut bolt

P =? N is the value of force
Stress = load/area
$\sigma = P/A$
$A = \pi/4d^2$
$A = \pi/48^2 = 49.98$
$P = 135x49.984$
P = 6747.84 N = 687 kg
The applied load is significantly lower than the calculated load. hence our design is safe.

4.3Design of transverse fillet welded joint –

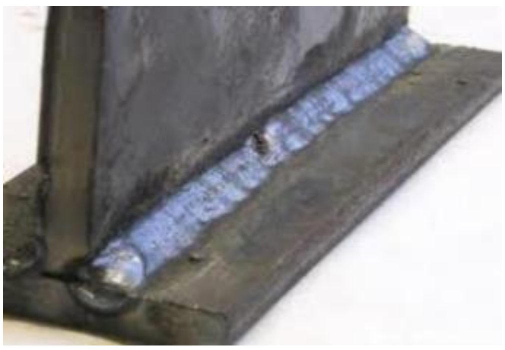


Figure. Transverse fillet weld joint

Selecting weld rod size = 3.2mm
Area of Weld = 0.707 x Weld Size x L
= 0.707 x 3.2 x 25
= 56.56 mm^2
Force exerted = ---N
Stress induced =
Force Exerted / Area of Weld
21 = F / 56.56
F= 1187.76 N = 121.07 kg

The maximum allowable stress for welded joints is 21 Newtons per square millimeter (N/mm²).

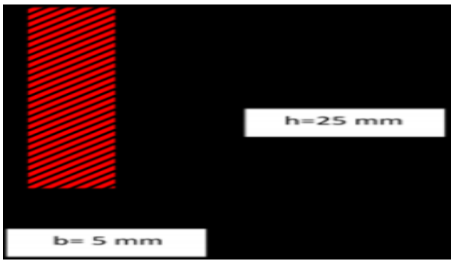
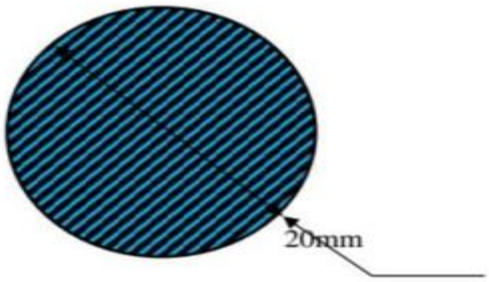


Figure. Welding cross-section

4.4 Design of shaft used as a wheels –

Now, shaft will fail under bending due to weight of forklift and job on it. Let check how much weight shaft can take. The shaft will be directly welded on tube support and will Not rotate Load is cantilever.

W=? kg =? N
M= W × L
The shaft diameter = 20 mm
M = W x 46 = 46 W N-mm
Z= π/32 x d^3
Z= π/32 x 20^3
Z= 785.3 mm^3
σb (allowable)= M/Z
270 = 46W/785.3
W = 4609.3 N
W = 469 kg
The maximum capacity of forklift is 200kg



5.CAD MODEL:

The entire model has been designed using SolidWorks, a designing software.

6.FABRICATION STEPS

1.Design and Planning: Formulate an elaborate plan for the design phase. Including dimensions, materials, and components required for the forklift.

2.Material Acquisition: Source the necessary materials such as steel beams for the frame, hydraulic components for lifting mechanism, wheels, and controls.

3.Frame Construction: Fabricate the frame of the forklift using steel beams and welding equipment. Ensure the frame is sturdy and capable of supporting the weight of the load.

4.Lifting Mechanism: Install the hydraulic lifting mechanism onto the frame. This includes the hydraulic cylinder, pump, and control valves. Test the mechanism for smooth operation and lifting capacity.

5.Fork Assembly: Fabricate the forks using strong steel bars and weld them to the lifting mechanism. Ensure the forks are properly aligned and capable of securely holding loads.

6.Wheel Installation: Attach the wheels to the frame, ensuring they are properly aligned and capable of supporting the weight of the forklift and its load. Consider using heavy-duty caster wheels for easy maneuverability.

7.Control System: Install the control system, including the steering mechanism and hydraulic controls. Verify that the controls function smoothly and precisely during testing.

8.Safety Features: Incorporate safety features such as emergency stop buttons, horn, and warning lights to ensure safe operation of the forklift.

9.Testing and Quality Assurance: Conduct thorough testing of the forklift to ensure all components are functioning properly and the forklift meets safety standards. Make any necessary adjustments or repairs.

10.Finishing Touches: Paint the forklift and apply any decals or branding as desired.

11.User Manual: Prepare a user manual outlining operating instructions, maintenance procedures, and safety guidelines for users.

7.WORKING

The project is made by using the raw material mentioned above, the main raw material of project is mild steel linear actuator battery shaft will and hook project work when the manual operator switch on the linear actuator as soon as the linear actuator motor switch on it rotates the gear inside it and forces the lead screw to push the linear actuator which is the upper arm of the forklift the upper arm of forklift is connected to Chain and hook the operator operating the linear actuator holds the shaft on his hand in the middle one and of linear actuator is connected to hook other and is to lower body where the total weight of a machine is gone to the floor it is operated on 24 volt lead acid dry battery the electrical energy of battery is converted into mechanical energy by using linear actuator the linear actuator which is the upper arm and weight is lifted the capacity of whole machine is around 50 kg.

8.RESULT & ANALYSIS

Functionality: Assess the overall functionality of the portable forklift, including its ability to lift and transport loads efficiently. Evaluate how well it meets the intended purpose and whether it performs as expected under different conditions.

Portability: Consider the ease of transporting the forklift from one location to another. Assess factors such as weight, size, and maneuverability to determine how easily it can be moved around various work environments.

Durability: Evaluate the durability of the forklift components and frame under typical usage conditions. Assess whether it can withstand the rigors of daily operation in industrial or commercial settings without frequent breakdowns or maintenance issues.

Safety: Conduct a thorough analysis of the safety features incorporated into the forklift design. Evaluate how well these features mitigate potential hazards and ensure the safety of operators and bystanders during operation.

Cost-effectiveness: Analyze the cost of materials, labor, and other expenses incurred during the fabrication process compared to the performance and lifespan of the forklift. Determine whether the project was cost-effective and provided value for the investment.

User Feedback: Gather feedback from operators and users who have experience with the portable forklift. Consider their opinions and suggestions for improvement to identify areas where the design or functionality could be enhanced.

Future Improvements: Identify opportunities for future improvements or modifications to enhance the performance, reliability, or functionality of the portable forklift. Consider feedback from users and stakeholders to prioritize areas for further development.

9.CONCLUSION

This project offers significant benefits to small-scale industrialists, providing ease of operation at minimal cost and leading to indirect savings in labor expenses. The cost effectiveness of this machine allows for rapid payback, making it a valuable asset. Additionally, it proves to be a valuable asset in any industry dealing with corroded or unused metals. Researchers have made remarkable strides in trolley design, focusing on enhanced reliability, protection, and robustness, while also achieving cost reduction through adequate design modifications. Trolleys find usage in numerous sectors including the handling of hot rolled products, grain feeding, casting industries, and shopping malls. However, there is still a considerable amount of work required to explore the full potential of trolleys in various other domains.

10.ACKNOWLEDGEMENT

This project on the Portable Forklift has been made possible through the collaborative efforts and support of various individuals whom we would like to acknowledge sincerely. Foremost, our gratitude is extended to Dr. Prathamesh Gorane, Professor at the Department of Mechanical Engineering, GSMCOE, Balewadi, Pune and Dr. S. R. Sandanshiv, Head of Mechanical Department (HOD) at GSMCOE, Balewadi, Pune for their mentorship and guidance throughout the project. Their expertise and encouragement have been invaluable in shaping the direction of our work.We also extend our thanks to the team members Chaitrali Virnak, Namrata Raut, Shweta Chandanshive, Aishwarya Shide for their dedication and hard work in every aspect of the project. Their commitment to excellence and teamwork has been essential to its success.

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