A design of compact weight lifting machine using linear actuator

Mr. S. D. Nikam[1], Mr. Sachin Badhe[2], Mr. Rohan Kalshetty[3], Mr. Vinayak S. Kumbhar[4], Mr. Sachin K. Ovhal[5]

[1,2,3,4,5]*Suman Ramesh Tulsiani Technical Campus, Khamshet, Pune*

***Abstract*— The present work is concerned with design and manufacturing of a compact weight lifting machine i.e. forklift which can be used for various purpose in domestic as well as industrial places. Improvement in forklift is really needed to make it more efficient, user friendly, and practical to use, & most importantly high safety features.**

The in-plant goods carrier system is user friendly as designed. The device finds greater use in the industrial lines for transport of the machined jobs, carrying goods internally in the fabrication plant. Forklift is an industrial power truck used for lifting and transport materials. Through the steel fork under the load, the lifting and transportation have been done. At present, different kinds of forklift is available, according to the lifting weight of forklift is divided into small tonnage (0.5t) and (1t), middle tonnage (2t and 3t) and large tonnage (5t and above).

The sort of compact weight lifting machine that we used in this project is linear actuator operated forklift as it is more reliable to operate. To develop new concept of the forklift design, we have done some survey by discussing with the forklift user. The scopes of project were on the designing 50kg maximum lifting capacity of forklift. To realize our new design goals, we would like to do some work on the existing forklift design and what kind of product transportation is using. supported that work, we would like to find what the shortcomings of existing designs are. The new design offers both new and improvised features, over what is currently available.

***Index Terms*— Frame, Linear actuator, Design Process, CAD data & Calculations.**

METHODOLOGY

1. Data collection regarding machine dimension and their weights.
2. Concept development.
3. Checking design feasibility
4. Checking of various stresses acting on the body due to axial load. Thus, the different parts of forklift are designed, manufactured as per dimensions.
5. Design trolley in term of comfort.
6. Experimental calculations & Analysed using Analysis software for validation.

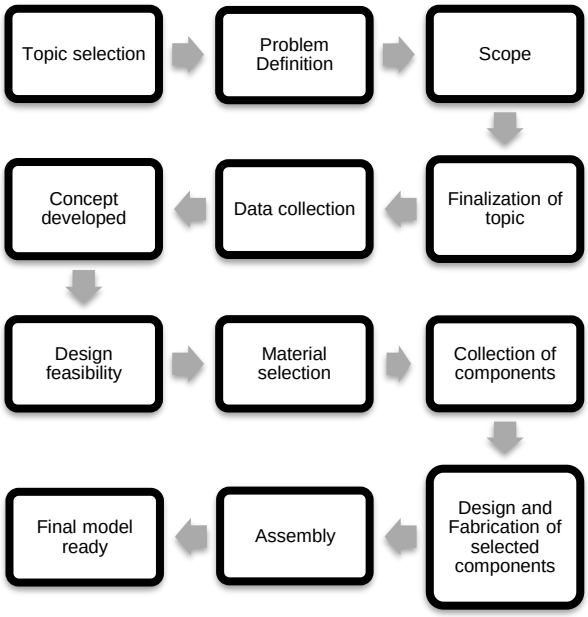


Figure: Methodology

The above said work is planned in following phases.

Data Collection:

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

Material Selection:

- ➢ Design of each component and validation as per experimental results.

➢ Selection of Steel Material and justification. Section selection, deciding modelling strategy, property definition.

Assembly of model in Ansys:

➢ Import each frame and pulley model in ANSYS Software.

➢ Meshing analysis in ANSYS.

➢ Finding Stress, Strain analysis with our calculation.

➢ Identifying critical sections.

Testing:

➢ Theoretical analysis of forks & comparison.

➢ Load testing.

➢ Von-Mises Stress, Strain evaluation and calculations based upon testing calculation.

➢ As per experimental calculation, plotting graphs (Load vs. Stress, Stress vs.).

CONSTRUCTION

1. Frame

The proper selection of material for the different part of a machine is the main objective in the fabrication of machine. For a design engineer it is must that he be familiar with the effect, which the manufacturing process and heat treatment have on the properties of materials. The Choice of material for engineering purposes depends upon the following factors:

- Availability of the materials.
- Suitability of materials for the working condition in service.
- The cost of materials.
- Physical and chemical properties of material.
- Mechanical properties of material.

In engineering practice, the machine parts are subjected to various forces, which may be due to either one or more of the following.

- Energy transmitted
- Weight of machine
- Frictional resistance
- Inertia of reciprocating parts
- Change of temperature
- Lack of balance of moving parts

The selection of the materials depends upon the various types of stresses that are set up during operation. The material selected should with stand it. Another criterion for selection of metal depends upon the type of load because a machine part resist load more easily than a live load and live load more easily than a shock load.

Selection of the material depends upon factor of safety, which in turn depends upon the following factors.

- 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
- The extent of loss of property if failure occurs

2. Linear actuator

A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor. Linear actuators are used in machine tools and industrial machinery, in computer peripherals such as disk drives and printers, in valves and dampers, and in many other places where linear motion is required. Hydraulic or pneumatic cylinders inherently produce linear motion. Many other mechanisms are used to generate linear motion from a rotating motor.

Inside a linear actuator is several different components, all of which work together to form the movements that are needed from the equipment. While electric screw actuators were specifically designed to have fewer moving parts, both to reduce the potential for breakdowns and maintenance, and to make the actuators lighter and easier to use, there are many parts that are integral to its overall functioning.

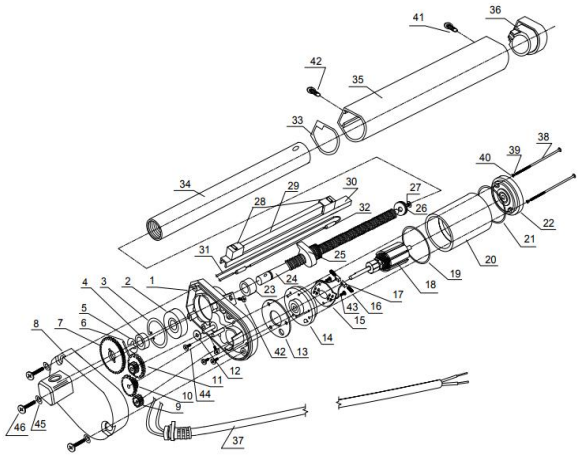


Figure: Electric Linear Actuator Parts

Item	Description	Qty
1	Actuator base	1
2	Shaft Bearing	1
3	Shaft Bearing Lock	1
4	Shaft Base Spacer	1
5	Shaft Base Spacer Lock	1
6	Shaft Gear Wheel Holder	1
7	Shaft Gear Wheel	1
8	Base Cover with Mounting Support	1
9	Electric Motor Gear Wheel	1
10	Small Intermediate Gear Wheel	1
11	Medium Intermediate Gear Wheel	1
12	Teflon Washer	1
13	Electric Motor Base Washer	1
14	Electric Motor Base	1
15	Brush Holder PCB	1
16	Electric Motor Brush	2
17	Electric Motor Brush Spring	2
18	Electric Motor Rotor	1
19	Motor Enclosure Bottom Washer	1
20	Electric Motor Encloser with Stator	1
21	Motor Enclosure Top Washer	1
22	Electric Motor Cap with Rotor Bearing	1
23	Shaft Spacer	1
24	Treaded Shaft Drive / Lead Screw	1
25	Shaft Base with Limit Switches Arm	1
26	Shaft Drive End Support	1
27	Shaft Drive End Support Screw	1
28	Limit Switch	2
29	Limit Switches Spacer	1
30	Limit Switches Base	1
31	Limit Switches Wiring	1
32	Diode	2
33	Shaft Encloser Bottom Washer	1
34	Shaft with Mounting Hole	1
35	Shaft Encloser	1
36	Shaft Enclosure Top Cap	1
37	Power Cable	1
38	Motor Enclosure Screw	2
39	Motor Screw Spring Washer	2
40	Motor Screw Washer	2
41	Shaft Eclosure Top Cap Screw	1
42	Shaft Enclosure Base Screw	3
43	Brush Holder PCB Screw	2
44	Motor Base Screw	3
45	Base Cover Washer	3
46	Base Cover Screw	3

Table: Linear actuator description

CAD MODEL

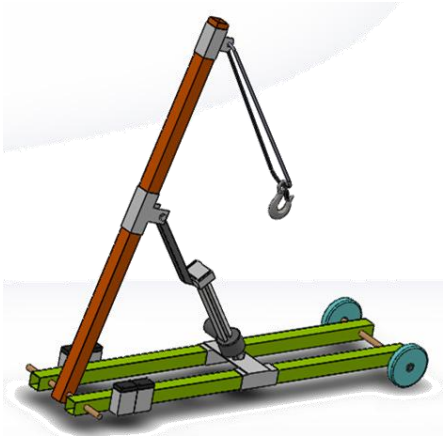


Figure: Assembly

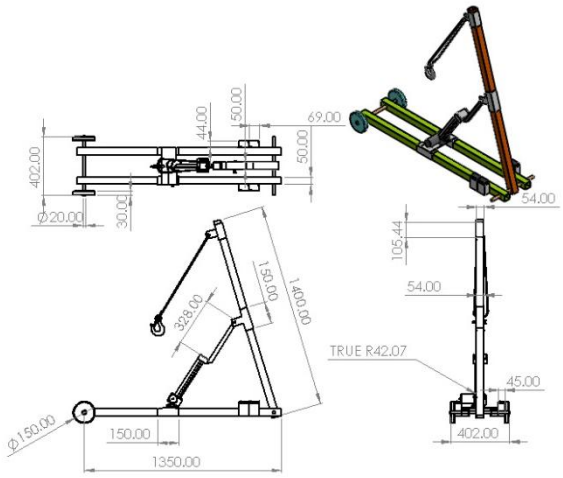


Figure: Drafting

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 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

CALCULATIONS

Material = C 45 (mild steel)

Take fos 2

$\sigma_t = \sigma_b = 540/fos = 270\ N/mm^2$

$\sigma_s = 0.5\ \sigma_t$

$= 0.5 \times 270$

$= 135\ N/mm^2$

Square pipe of 50x50 section is used as a column, we will check for its bending load.

Let the maximum load applied by linear actuator be 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

$Z = B^3 – b^3 / 6 = 50^3 - 46^3 / 6 = 4610.6\ mm^3$

$\sigma_b = M / Z$

$\sigma_b = 238000 / 4610.6 = 51.62\ N/mm^2$

$\sigma_{b\ INDUCED} < \sigma_{b\ ALLOWED}$

$36.14\ N/mm^2 < 270\ N/mm^2$

Hence our design is safe.

Design of bolt for sheer stress failure

Bolt is to be fastened tightly also it will take load due to rotation. Stress for C-45 steel. Standard nominal diameter of bolt is 9.31 mm. From table in design data book, diameter corresponding to M10 bolt is 8 mm.
Let us check how much load bolt can sustain -
P =? N is the value of force
Stress = load/area

$$\sigma = \frac{P}{A}$$

$$A = \frac{\pi}{4}d^2$$

$$A = \frac{\pi}{4}8^2 = 49.98$$

$$P = 135\ X\ 49.984$$

P = 6747.84 N = 687 kg

The calculated load is much higher than any applied load, hence our design is safe.
Design of transverse fillet welded joint
Hence, 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
Maximum Allowable Stress for Welded Joints = 21 N/mm^2

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 X L
The shaft diameter = 20 mm
M = W x 46 = 46 W N-mm

$Z = \pi/32 \times d^3$
$Z = \pi/32 \times 20^3$

$Z = 785.3\ mm^3$

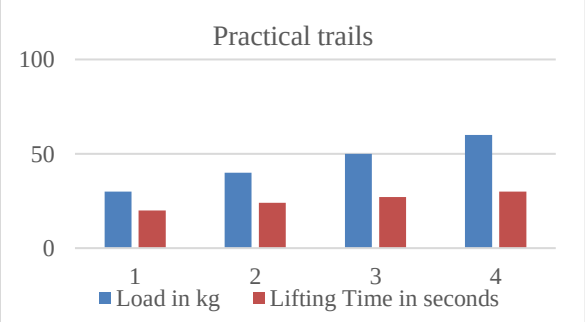
σ_b (allowable)= M/Z
270 = 46W/785.3
W = 4609.3 N
W = 469 kg

The maximum capacity of forklift is 68 kg.
As induced bending load is less then allowable load, so design is safe.

RESULTS

Sr no	Load in kg	Lifting Time in seconds
1	30	20
2	40	24
3	50	27
4	60	30

Table: Practical trails



CONCLUSION

We conclude that, compact weight lifting machine will helpful for small scale industries as it is easy to operate with less cost and indirectly it will save the labor cost. Savings resulting from the utilization of this machine will make it pay for itself with in short period of time and it can be a great companion in any field dealing with rusted and unused metals. It is mechanical device, does not required electricity as well as any external source of battery. The event of mechanical forklift assures the ergonomically comfort to the operator or worker and to reduces time required for manual lifting and handling. This increases efficiency of productivity and it provide safety of operator while handling of the fabric.

FUTURE SCOPE

The standard market for forklift is mainly focused on heavy loads and many big corporate companies are selling products for that, but their product has main disadvantage of big size, weight, and high cost. Whereas portable forklift is lighter small size and low cost. Also, it can be operated by unskilled user. Normal forklift cannot be made portable and cannot be used in rooms and office for lifting load hence there is a big market gap for our product. Based on end users, forklift market size is categorized into food, electrical, retail & wholesale, chemical, logistics and automotive. Wholesale & retail distribution segment is projected to witness high demands owing to increased transportation activities across different regions and surplus goods stocking generating the requirement for distributors to increasingly deploy forklifts. Battery operated for are highly used in retail segment due to its high efficiency.

REFERENCES

[1] Mr. V.B. Bhandari, "Design of machine element," Tata Mc- Graw Hill Publication, 3rd Edition 2010.

[2] Mr. P.S. Gill, "Design Data Book," 3rd Edition.

[3] Sharnangat, A. L., & Tufail, M. S. (2013). Design of Wireless Operated (On RFID) Forklift in Warehouse. *The International Journal of Engineering and Science (IJES)*, *2*(4), 64-67.

[4] Liai Pan, Qiulei Du, Yanli Wu, Design research on working device of 3 tons balanced and internal combustion forklift, OJME 2017

[5] P. S. Thakare, P. G. Mehar, Dr. A. V. Vanalkarand Dr. C. C. Handa, "Productivity Analysis of Manually Operated and Power Operated Sheet Bending Machine: A Comparative Study", International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 2, Issue 2, Mar-Apr 2012, PP.111-114.

[6] Failure of Forklift Forks, Juan M. Massone and Roberto E. Boeri, Engineering Failure Analysis 17 (2010) 1062–1068

[7] Michael G. Kay, Material Handling Equipment (McGraw-Hill, 2nd Edition, 2012).

[8] P. Jey Praveen Raj, P. M. Mohamed Fuge, R. Paul Caleb, G. Natarajan, Design and Fabrication of Stair Climbing Trolley, International Journal for Scientific Research and Development,6(2), 2016, 50 - 53.

[9] S. R. Kulkarni, T. S. Vandali, and S. A. Goudadi, Prototype of Collapsible Trolley, International Journal for Scientific Research and Development, 4(5), 2016, 18 - 25.

[10] Mulik Shriniwas, Salunkhe Rohit, Shaikh Shahrukh, Waghmode Dada, and Swipnil Gaikwad (2016), Advance material handling trolley using tri-wheel mechanism, International Journal of Recent Research in Civil and Mechanical Engineering, ISSN 2393-8471, Vol. 2, Issue 2, pp: (160-165). M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[11] Roshan Alas pure, Chaitali Barmase, Snehal Chambhare, Manish Mandhre, and Prof. Yogesh G. Joshi (2016), Fabrication of Stair Climbing Wheel Mechanism: Alternate for lifting goods, International Research Journal of Engineering and Technology, e-ISSN: 2395 -0056, Volume: 03 Issue: 05, pp: (553-555).

[12] Hsueh-Er, C., "Stair-climbing forklift, 2008, "Patent No. US2008164665 (A1)", Jan 24.

[13] VegimImeri, 2013, Studying dynamic effects on warehouse forklift during forward movement with full loading, 16th International Research / Expert Conference, TMT 2012.

[14] Swagat Kelkar, 2015, Virtual Stability of Forklift Truck in CAD. International Journal of Research in Aeronautical and Mechanical Engineering. February 2015 Vol 3, Issue 2 ISSN 2321-3051.

[15] Ben T Railsback, 2014, Stand-Up Forklift Egress Times as a Function of Operator Compartment Guarding. International Mechanical Engineering Congress and Exposition. November 2014. Vol 14, Issue 7.

[16] Muthukumar K, Sankaranarayanasamy, and A.K. Ganguli. (2014). "Analysis of Frequency, Intensity, and Interference of Discomfort in Computerized Numeric Control Machine Operations," Human Factors and Ergonomics in Manufacturing & Service Industries, 24 (2), pp.131-138.

[17] Mr. Sachin Badhe, Mr. Rohan Kalshetty, Mr. Vinayak S. Kumbhar, and Mr. Sachin K. Ovhal, A review for design of compact weight lifting machine using linear actuator, © November 2024 | IJIRT | Volume 6 Issue 12 | ISSN: 2349-6002

[18] https://www.alloysteelplates.com/c45-plates.html