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Design of Electric Forklift used in Small industrial Warehouses and Workshops

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Abstract **- We describe forklift powered by an electric motor instead of the IC engine using rechargeable batteries the main objective of this project is to design electrically powered forklift for material handling in industrial warehouses and workshops. Nowadays in industries, the forklift operates on an IC engine for transportation and hydraulic system for lifting and lowering of materials. Due to this mode of operation, there are many adverse environmental impacts such as emission of carbon dioxide and leakage of hydraulic fluid. This paper discusses how to integrate the electric system into a forklift truck to make it electrically powered which lift to 200 kg and elevate up to 6 feet.**

Keywords - Forklift, Rechargeable Batteries, Electric Motor, IC Engine

1. INTRODUCTION

In general the forklift can be defined as a tool capable of lifting hundreds of kilograms. A forklift has two metal forks on the front used to lift cargo. Forklifts have revolutionized warehouse work. The forklift operator drives the forklift forward until the forks push under the cargo, and can then lift the cargo several feet in the air by operating the forks. The forks, also known as blades or tines, are usually made out of steel and can lift up to tons.

2. MARKET SURVEY

The market survey lets to understand and realize the real demand and potential for the product under consideration. First and foremost, it is necessary to establish that the proposed product will fulfill the required specifications, what is supposed to do, and the service it can offer to the consumers.

We surveyed in our institute and small industrial workshop where we found that the educational engineering apparatus and industrial equipment up to 200 Kg is not easy to move from one place to another place. So the miniature forklift is required to design that can utilized for lifting load up to 150Kg.

3. FIELD OF USE

Forklifts are also immensely essential in warehouse operations. Forklifts are mainly used for loading and unloading trucks and for carrying goods. They can be used to stack material both the small and the more massive ones in places that cannot easily be accessed by humans. Aside from carrying goods and materials, forklifts can also be used to transport large and hefty equipment. They're used as a substitute tool to aerial lifts and cranes to hoist people to higher places, especially when these people need to perform a variety of tasks, such as: Inventory of stocks, and Maintenance purposes.

4. LITERATURE SURVEY

From the references actual Industrial forklift we have designed our miniature and cost effective forklift. The structure is constructed by using square tubes, C-channels, Metal frames, Chain- sprocket, bearings, etc.(1) These materials are easily available into market. From literature survey we got important information regarding design procedures and manufacturing of Forklift. It provides information related to design consideration and battery selection methods.(6) The advantage of using this technology is to increase productivity in small scale industries by better material handling availability and enhancing safety majors.(3)

5. WORKING

Electric Forklifts derive power from Lead Acid Batteries. The carriage serves as the base to the forklift. The Carriage is fixed on mast rails so that it can be easily moved upward and downward. The Mast is a vertical part that lifts up and pushes down the loads. A motor is a device that converts electro-chemical energy, provided by an industrial rechargeable battery, into mechanical energy. The Electric motors are attached to the two main vertical structures called the "masts." However, the actual forks that carry the load are attached to the main body of the forklift through a pair of roller chain pulleys whose fulcrum is a gear at the top of the mast. Thus, the Electric motor pushes the masts up, the gears on the masts push against the roller chain.

Forklifts have two sets of controls: one for steering and one for lifting. The steering controls work much like those of a golf cart: acceleration pedal, brake, steering wheel, forward gear and reverse gear. Front-wheel steering allows the driver a greater degree of rotation and precision when handling a load.

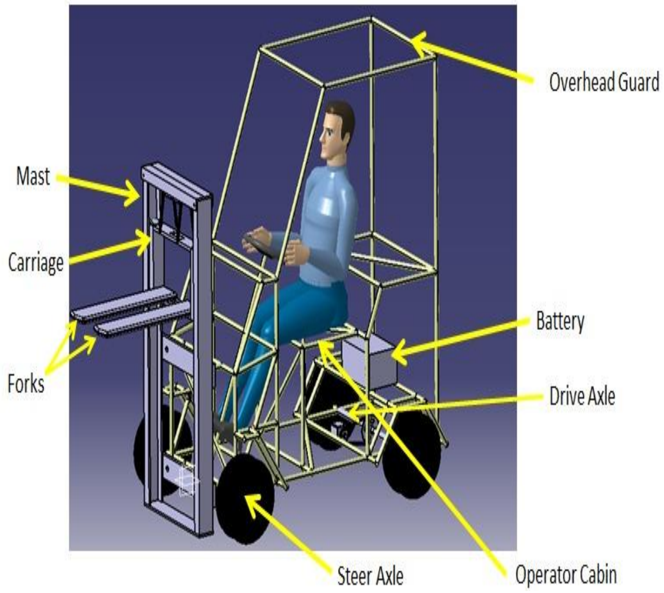

Fig 1 – Detailed design of electric forklift.

6. COMPONENTS

A. Chain drive
   It helps to drive the system in both side (one at a time) using electric motor. Standard chain of no. 6B is selected.

B. Lifting D.C. Motor
   The D.C. motor is act as prime mover which drives the sprocket to raise the load. We select 12V, 2.5A, 100 rpm, and 6Nm motor

C. Driving D.C. Motor
   The D.C. motor is act as prime mover which drives the sprocket for transportation purpose. We select 12V, 2.5A, 300 rpm, and 120Nm motor

D. Wheels
   R8 wheels are used. The wheels rolls and moves the forklift from one place to another place. We use four wheels two at front side attached at bottom at support legs and two are at rear side.

E. Battery
   The battery acts as power source for driving of motor. We use two batteries of capacities 12V, 7.2 Ah

F. Lifting Forks
   The dimensions of lifting fork L600, A=40x40x10mm. The lifting fork directly lifts the load from its position.

7. DESIGN

Selection of Driving Motor –

Mass of forklift vehicle with driver = 270 kg
Acceleration assumed as = 1G F= 270*9.81 = 2648.7N
F(normal) = 1324.35N
F (frictional) = 0.75*1324.35 = 993.26N
Now, Torque required for moving forklift vehicle
T = F* Radius of wheel
= 993.26*120
= 119191.5Nmm = 119.19 Nm

Selection of Lifting Motor –

Total Load (W) = Mass (m) × Acceleration due to gravity (g) = 150 ×9.81 = 1471.5 N
Required torque of motor (M_t) = 5668.96 Nmm
Required motor specification N=100 rpm
Torque required raising maximum load in Kg-cm
$= \frac{M_{tRaise}}{9.81\times10} = \frac{5668.96}{9.81\times10}$=57.787 kg-cm=5.88Nm
Required speed of motor shaft in rpm = 100 rpm

Chain design -

Selecting standard chain used in cycle as Chain - 06 B
From V.B.Bhandari page no. 14.3
Pitch -9.525mm
Roller diameter,d1=6.35 mm
Transverse pitch p_t=10.24 mm
Width' b1=5.72 mm
Z1= 18, Z2= 18
Approximate centre distance,
a = 40×P ----------------nominal
a = 40×9.525
a = 381 mm
No of links

$L_n=2(\frac{a}{p}) + (\frac{Z1+Z2}{2}) + (\frac{Z1-Z2}{2\pi})^2 \times (\frac{p}{a})$

$= 2(\frac{381}{9.525}) + (\frac{18+18}{2}) + (\frac{18-18}{2\times\pi})^2 \times (\frac{9.525}{381})$

= 98

Corrected centre distance

$a= \frac{p}{4}\{[Ln - ((Z1+Z2)/2)] + ([Ln - ((Z1+Z2)/2)]^2 - 8\times\left(\frac{Z1-Z2}{2\pi}\right)^2)\}^{1\div2}$

a=191.68 mm
a = 192 mm
Length of the chain
L = L_n×p = 98×9.525 = 933.45 mm

Design of sprocket -

Used chain no.06B
For Z = 18
Pitch, P = 9.525 mm
Width between inner plates, b1 = 5.72 mm
Roller diameter, d1 = 6.35 mm
Transverse pitch p_t = 10.24 mm
Pitch circle diameter

$D_1 = \frac{p}{\sin(180/z1)} = \frac{9.525}{\sin(\frac{180}{18})}$ $\qquad$ $D_2 = \frac{p}{\sin(180/z2)} = \frac{9.525}{\sin(\frac{180}{18})}$

D_1 = 54.85 mm $\qquad$ D_2 = 54.85 mm

Roller seating radius (r_i)
$r_{imax} = 0.505d_1 + 0.069\times(d_1)^{1/3}$
r_{imax} = 3.33mm
$r_{imin} = 0.505\,d_1 = 3.2$mm
Tooth Flank Radius (r_e)

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r_{emax} = 0.008× (z^2+180) =16.928mm
r_{emin} = 0.12×d_1(z+2) = 15.24mm
Root Diameter (D_f)
D_f = D – 2× r_i = 88.47mm
Tooth height above pitch polygon (h_a)
h_{amax} = 0.625×p – 0.5×d_1 +0.8× $\frac{p}{z}$ = 2.9513mm
h_{amin} = 0.5× (p-d_1) = 1.5875mm
Tooth Width (b_f)
b_f = 0.93 ×b_1 = 5.3196mm
Tooth Side Relief (b_a)
b_a = 0.1p to 0.15p = 1.1907mm

Design of Fork –
Outer face height (D) = 50.8 mm
Outer face width (B) = 50.8 mm
Inner ace height (d) = 44.8 mm
Inner face width (b) = 44.8 mm
Length of fork (L) = 600 mm
Moment of Inertia of fork (I) –

$$I = \frac{1}{12}[BD^3 - bd^3]$$

$$I = \frac{1}{12}[6659702.81 - 4028209.56]$$

$$I = 219291.10 \ mm^4$$

1] Consider Two Fork with Point Load
Moment of Inertia for two fork (I) –
I = I1+I2 = 219291.10 + 219291.10
I = 438582.2 mm^4
Bending Moment (M_A) –
M_A= -W × L = -1470 × 600 M_A
= - 882000 N-mm
3. Deflection (Y_{max}) –

$$Y_{max} = \frac{(WL^3)}{3EI} = \frac{1470\times600^3}{3\times210\times10^3 438582.2} \qquad Y_{max} = 1.149 \text{ mm}$$

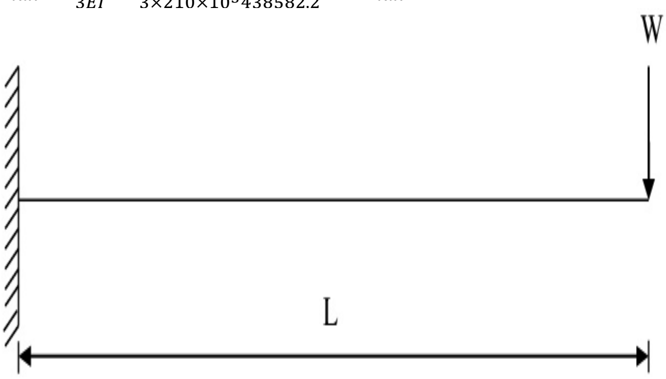

Fig 2- Point load

II] Consider Two Fork with Uniform Distributed Load
Moment of Inertia for two fork (I) –
I = I1+I2 = 219291.10 + 219291.10
I = 438582.2 mm^4
Find W/mm –
W/mm = $\frac{W}{L} = \frac{1470}{600}$
W/mm = 2.45 N/mm
Bending Moment (M_A) –
$M_A = -\frac{W\times L^2}{2} = -\frac{2.45\times600^2}{2}$
M_A = - 441000 Nmm
Deflection(Y_{max}) –

$$Y_{max} = \frac{(WL^4)}{8EI} = \frac{(2.45\times600^4)}{8\times210\times10^3}$$

Y_{max} = 0.43 mm

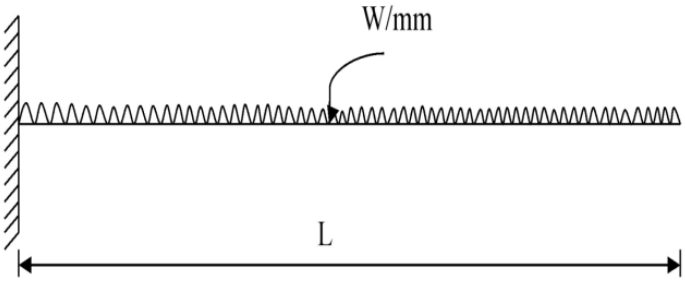

Fig 3- Uniformly distributed load

Selection of bearing –
Bearing life = 12000-20000 Hrs.
Radial load (P) = 2450 N
Speed (n) = 50 rpm
Assume L_10h = 12000 hrs.

Bearing life (L_10) –
L_10= (60 × n × L_10h)/ 〖10〗 ^6
L_10=(60 ×50×12000)/ 〖10〗 ^6
L_10 = 36 million rev.

Load capacity (C) –
C = P 〖(L_10)〗 ^(1/3)
C = 2450 〖(36)〗 ^(1/3)
C = 8089.72 N
Using standard table of bearing selection,
C = 9950 N
C_0 = 4150 N
d = 12mm, D = 37mm, B = 12mm
But, from available bearing range in market, we are assuming suitable bearing –
d = 12mm, D = 28mm, B = 8mm
Designation – DGBB 60012 Z

8. CONCLUSION

The main boon of using the technology is to reduce the impact of fuel-based forklift also it lessons human efforts and their misconceptions. It's not only user friendly but also environment friendly. It is highly affordable at a lower cost.

9. FUTURE SCOPE

In the era of interconnectivity every device, machine and person will start talking to each other, and this includes lift trucks. The introduction of automated decision-making into forklift technology will make operations safer. Next generation of environmentally friendly Forklift has an electric-powered core which combines with rechargeable battery-capacity technology to clear even the strictest environmental standards. By removing unnecessary processes and extended routes, forklift operators around the world can reduce man hours, emissions and costs significantly.

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