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Design, Development and Modelling of Forklift

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***Abstract*- We describe the development of robotic forklift intended to operate alongside human personnel, handling palletized materials within existing, busy, semi-structured outdoor storage facilities. The main objective of this project is to fabricate a Mechanical forklift for material handling in industries. In this paper a robotic vehicle is fabricated which runs to carry material from one place to another by using Radio Frequency Technology. Nowadays in industries, forklift used with hydraulic system. To use forklift, it requires one spot guide to guide a forklift driver because of less visibility. This paper discusses how to integrate Radio frequency identification (RFID) technology into a forklift truck to make it wireless to increase visibility and human safety.**

Keywords - RFID Technology, forklift trucks, visibility and human safety.

I. INTRODUCTION

A forklift is a vehicle similar to a small truck that has two metal forks on the front used to lift cargo. 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.[1]

Forklift is totally run on electric motors which are control by a remote operator by means of remote will connected with RFID which fix radio frequency transmit and receives to forklift circuits. [1,6,7]With electrical motor it gives the motion to the forklift vehicle like forward, back, left turn, right turn and pallet controlling up down motion, which are controlled with remote and which will be transmitting signals to receiver and receiver will convert signals to operation. It's helpful to operator will be situated at only one position and it will operate the forklift from one position and he we monitoring on the neighbor environment due to that he will avoid the accident and operate with vision cameras.[3,5]

II. FIELD OF USE

Electric forklift have got numerous applications. They are used for transmission of materials from one place to another. Forklifts and fork trucks are used to engage, lift, and transfer palletized loads in warehousing, manufacturing, materials handling, and construction applications.

III. LITERATURE SURVEY [14]

From the reference of the actual forklift named Landoll we had scaled the actual dimensions to prototype model. The mechanical structure of this prototype model is constructed with metal plates, this structure looks like a rectangular frame& the vertical moving mechanism that contains metal forks is assembled over the structure at front side. Since it operates through a remote, it doesn't contain any steering mechanism. The remote technology transfers the data by RFID. All four motors are driven through a single 'H' bridge DC motor drive package. All the four wheels are directly coupled to the motor shafts independently. The DC Motors are having reduction mechanism, there by speed is reduced and torque is increased.

IV. WORKING

The mechanical system is considered as motion converter, this can be created by implementing electro-mechanical techniques. The concept is to transform the motion from one form to some other required form by using suitable mechanical & electrical devices. In this research work the technique of transform the rotational motion in to linear motion is implemented. For this purpose five DC motors are used to create motion in the mechanism that functions as forklift. These motors are constructed with reduction gear mechanism & it is built in with the motor internally. As the machine is designed as prototype module, lowest rating motors are used to drive the mechanism.[8,9]

The name H-bridge sometimes called a "full bridge" is so named because it has four switching elements at the "corners" of the H and the motor forms the cross bar. If the bridge is sufficiently powerful it will absorb that load and your batteries will simply drain quickly.[1]

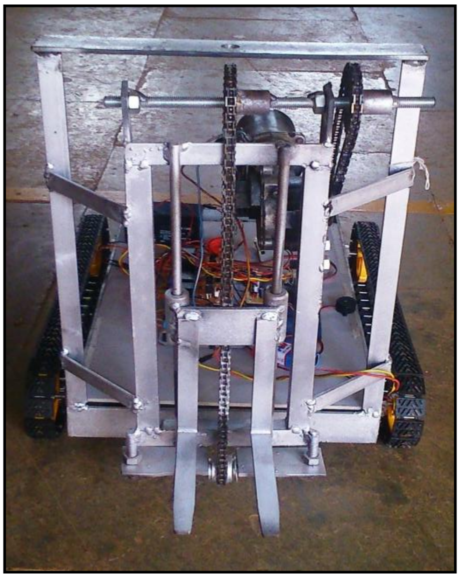

Fig. 1 Working Model

V. COMPONENTS[12]

A. Chain Drive

Chain drive helps to drive the system in both side (one at a time) using electric motor.

Driving chain: Two Sprockets with Diameter 25.07mm and 49.77mm is used which have 12 and 24 teeth on it. Chain of length 480mm and 80 links is convenient.

Lifting chain: Two Sprockets with Diameter 25.07mm and 49.77mm is used which have 12 and 24 teeth on it. Chain of length 660mm and 110 links is convenient.

B. Fork-

The dimension of fork is 125x18x5 mm. The material selected Mild steel. The max load carrying capacity is 50N.

C. Shaft-

The dimension of the shaft is 5mm diameter and 220 mm length.The material selected is Mild steel. It is an interconnection between primary and secondary chain drive

D. Geared Motor

It drives the primary chain drive at 24rpm. The torque is about 5 kg-cm and the power input is 12V DC.

E. Tensioner

It is used to maintain the tension in secondary chain drive.

F. Bearing

SKF 618/6 bearing is selected which is having I.D. 6 mm and O.D. 13 mm.

G. Wheel motor

It function is to travel to and fro. There are 4 no of motor of 30rpm each.

H. Guided Belt Drive

It is connected between two wheels at 350mm to provide better traction in worst industrial floor condition. The track width is 330mm.

VI. DESIGN [12,13]

The design of the mechanical assembly is derived from the scaled dimension the forklift named Landoll forklift truck of the Japanese company. The material selected to prepare the prototype model is Mild Steel due to its properties like malleability as it can be hammered and pressed into any shape, ductility as it can be bent easily and versatile and in the last is most common, cheap, strong and stiff. [2]

For the electrical point of view, we had used an AT89C2051 microcontroller; the output of this controller is fed to the RF transmitter. This transmitter is designed to generate a very high frequency of 433 MHz & it is used as carrier frequency.[3,10]

1. Design of driving chain and sprocket:

Speed of motor=24 rpm

Torque of motor= 5kg-cm

Power (P) $=\frac{2\pi NT}{60}$

$=\frac{2\pi\times24\times5\times10}{60}$

=1.232 W

KW Rating of the chain,

$=\frac{KW\ to\ be\ transmit\ \times k_s}{k_1\times k_2}$

$=\frac{1.232\times10^3\times1}{1\times0.72}$ = 1.71× 10^{-3} kW

$k_s = Service\ factor = 1$

$k_1 = mutiple\ strand\ factor = 1$

$k_2 = tooth\ correction\ factor = 0.72$

Select chain no. 04-1

Specification:

Pitch – 6mm

Roller dia – 4mm

Width – 2.8mm

Weight – 0.12kgf/m

Dia. of driving sprocket,

$D_1=\frac{p}{\sin(\frac{180}{z_1})}$

$=\frac{6}{\sin(\frac{180}{13})}$

$= 25.07mm$

For driven sprocket,

$\therefore \frac{z_1}{z_2}=\frac{N_2}{N_1}$ $\therefore \frac{13}{26}=\frac{N_2}{24}$

$\therefore N_2 = 12rpm$

Dia. of driven sprocket,

$D_2=\frac{p}{\sin(\frac{180}{z_2})}$

$=\frac{6}{\sin(\frac{180}{26})}$

$= 49.77mm$

Centre distance between the sprockets should be between 30p to 50p,

Assume a = 30p=30× 6 $= 180mm$

Calculation of no. of links in chain,

$$L_n = \frac{2a}{p} + \left(\frac{z_1+z_2}{2}\right) + \left(\frac{z_2-z_1}{2\pi}\right)^2 \times \frac{p}{a}$$

L_n = 80links

Exact center distance,

$$a = \frac{p}{4}\{[L_n - \left(\frac{z_1+z_2}{2}\right) + \sqrt{[L_n - \left(\frac{z_1+z_2}{2}\right)]^2 - 8\left(\frac{z_2-z_1}{2\pi}\right)^2}\}$$

=181.07mm

Length of chain,

L = $L_n \times p$

=80 × 6

$= 480mm$

Avg. velocity of chain,

V = $\frac{\pi D_1 N_1}{60}$

$=\frac{\pi\times25.07\times24}{60}$

$= 31.50\, mm/sec$

Tangential force due to power transmission,

$P_{t1} = \frac{102 \times P}{V}$

$= \frac{102 \times 1.71 \times 10^{-3}}{31.50 \times 10^{-3}}$ ……. P in KW

= 5.53 Kgf = 55.37 N

Tension due to sagging of chain,

$P_{s1} = k \times w \times a$

$= 2 \times 0.12 \times 181.07 \times 10^{-3}$

$= 0.043 Kgf = 0.43 N$

K = coefficient of slag (for $\theta > 40°$) = 2

w =weight of chain

a =central distance

2. Design of lifting Chain and Sprocket:

Dia. of driving sprocket,

$D_1 = \frac{p}{\sin(\frac{180}{z_1})}$

$= \frac{6}{\sin(\frac{180}{26})} = 49.77 mm$

Dia. of driven sprocket,

$D_2 = \frac{p}{\sin(\frac{180}{z_2})}$

$= \frac{6}{\sin(\frac{180}{13})} = 25.07 mm$

Centre distance between the sprocket should be between 30p to 50p,

Assume a = 45p=45× 6 = 270mm

Calculation of no. of links in chain,

$L_n = \frac{2a}{p} + \left(\frac{z_1 + z_2}{2}\right) + (\frac{z_2 - z_1}{2\pi})^2 \times \frac{p}{a}$

L_n=110 links

Exact center distance:

$a = \frac{p}{4}\{[L_n - \left(\frac{z_1+z_2}{2}\right) + \sqrt{[L_n - \left(\frac{z_1+z_2}{2}\right)]^2 - 8\left(\frac{z_2-z_1}{2\pi}\right)^2}$

a=271.21mm

Length of chain,

L = $L_n \times p$ =110× 6 = 660mm

Avg. velocity of chain,

V = $\frac{\pi D_1 N_1}{60} = \frac{\pi \times 49.77 \times 12}{60} = 31.27\, mm/sec$

Tangential force due to power transmission,

$P_{t3} = \frac{102 \times P}{V} = \frac{102 \times 1.71 \times 10^{-3}}{31.27 \times 10^{-3}}$ ……. P in KW

=5.57Kgf = 55.7N

Tension due to sagging of chain,

$P_{s3} = k \times w \times a$

$= 1 \times 0.12 \times 271.27 \times 10^{-3} = 0.032 Kgf$

$= 0.324 N$

K = coefficient of slag (for $vertical$) = 1

w =weight of chain

a =central distance

3. Design of shaft:[2,11,12,17]

Material: - 30C8; $S_{yt} = 400 N/mm^2$

From fig. 3,

For vertical plane,

$R_2 + R_4 = 78.32$

$R_2 \times 1.7 - 86.094 \times 9.2 + R_4 \times 16.7 = 0$

$\therefore R_2 = 34.39N R_4 = 43.92N$

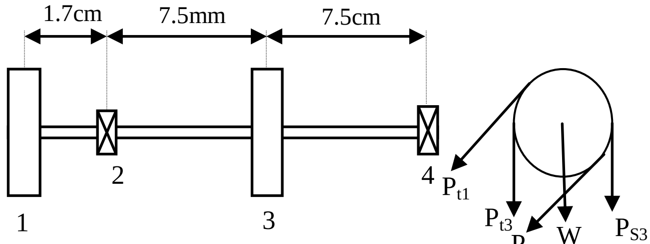

Fig. 2 Support Shaft layout

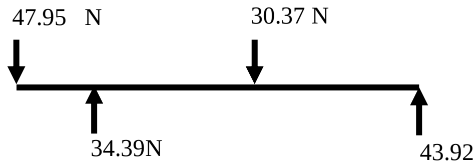

Fig. 3 Forces in vertical plane

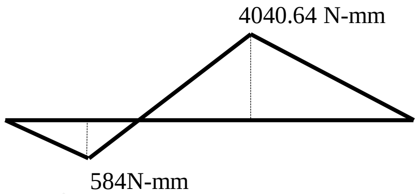

Fig. 4 Bending Moment Diagram

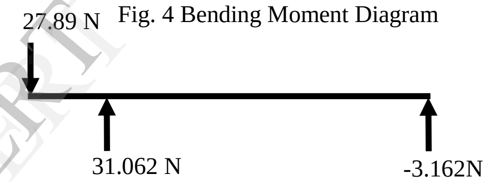

Fig. 5 Forces in horizontal plane

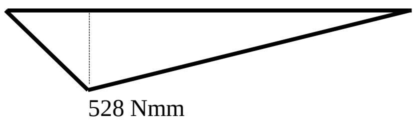

Fig. 6 Bending Moment Diagram

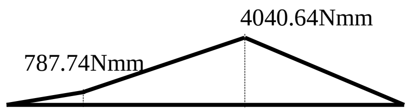

Fig. 7 Resultant Bending Moment Diagram

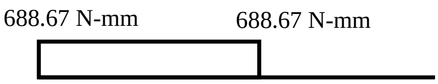

Fig. 8 Torsional Moment Diagram

Form fig. 4,

Bending Moment,

M_1=0

$M_2 = -34.39 \times 1.7 = -58.4 N\, cm$

$= -584 N\, mm$

$M_3 = 43.92\,(7.5 + 1.7) = 404.064 N\, cm$

$= 4040.6 N\, mm$

M_4= 0

From fig. 5,
For horizontal plane,

$R_2 + R_4 = 27.9$

$R_2 \times 1.7 + R_4 \times 16.7 = 0$

$\therefore R_2 = 31.06N R_4 = -3.162N$

From fig. 6,
Bending Moment, (+ve)

M_1=0

$M_2 = -31.062 \times 1.7 \ \times 10 = -528N\ mm$

M_4=0

From fig. 7,
Resultant Bending moment,

$M_2 = \sqrt{(-584.6)^2 + (-528)^2}$

M_2= 787.74N mm

$M_3 = \sqrt{(4040.6)^2 + 0}$ =4040.64 N mm

Now,

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{(M_b)^2 + (M_t)^2}$$

And

$$\tau_{permissible} = \frac{S_{sy}}{FOS} = \frac{0.5\times400}{1.5} = 133.33N/mm^2$$

From fig. 8,

$M_t=(P_{t1}\text{-}P_{s1}) \times R = (55.37 - 0.43) \times 12.53$
=688.67N mm

From, $\tau_{max} = \frac{16}{\pi d^3}\sqrt{(M_b)^2 + (M_t)^2}$

$\therefore d = 5.38 = 6mm$

4. Design of Fork: [4]

Case 1:- By considering fork as a cantilever beam with point loading.

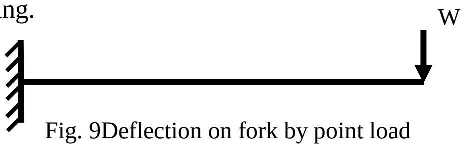

Fig. 9Deflection on fork by point load

W=3kg
By point load,

$M_x = -W \times L$

$=-3\times9.81\times 12.5 \times 10^{-3}$

=-0.367Nm

Deflection,

$$y_{max} = \frac{WL^3}{3EI} = \frac{3 \times 9.81 \times (12.5)^3}{3 \times 2.1 \times\times 10^5 \left(\frac{16 \times 3^3}{12}\right)}$$

$= 2.5344 \times 10^{-3}\ mm$

Case 2:- By considering fork as a cantilever beam with uniform distributed load

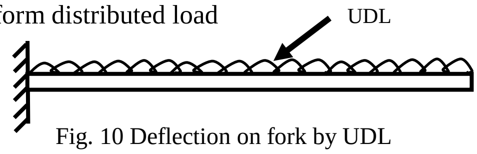

Fig. 10 Deflection on fork by UDL

Now $M_x = -\frac{W\times L^2}{2}$

$=\frac{-3\times9.81\times\left(12.5\times10^{-3}\right)^3}{2}$

=-0.0022Nm

Deflection,

$$y_{max} = \frac{WL^4}{8EI} = \frac{3 \times 9.81 \times (12.5)^4}{8 \times 2.1 \times\times 10^5 \left(\frac{16 \times 3^3}{12}\right)}$$

$= 0.0188\ mm$

5. Design of Bearing: [15,16]

Axial load, F_a = 0N
Radial load, F_r = 30N

$P = (X\,F_r + Y\,F_a)$

P = 30N

N = 24rpm

Assuming life of bearing is 5000 hrs.

L_{10h} = 800 hrs.

Life in million revolutions

$L_{10mr} = \frac{L_{10h}\ x\ 60\ x\ h}{10^6}$

$= \frac{3000\ x\ 60\ x\ 24}{10^6}$

= 4.32 million revolution

Dynamic load carrying capacity,

$C = P\ x\ (L_{10mr})^{1/k}$

Where, k = 3 for ball bearing

$C = 30\ x\ (4.32)^{1/3}$

= 48.85 N

∴ Selected bearing is SKF 618/6

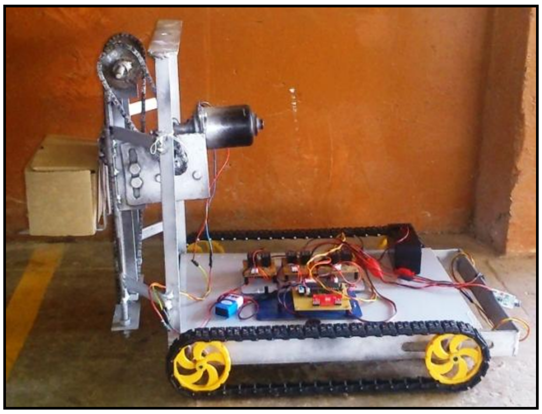

Fig. 11Prototype Model

VII. CONCLUSION

The main advantage of using this technology is to increase the safety of operator by operating the forklift from certain distance. This increases the efficiency of the productivity, because human errors due to the poor visibility can be minimized. During the trail run we have tested the range & we found that the transmitter is able control the forklift from a distance of 15feet.

VIII. FUTURE SCOPE

As per the present situation considering the casualty rates we had come up with an enhanced system of fork lifting mechanism which emphasizes over the safety features along with more precise working. Web-cam conciliated with sensors will reduce exertion on operator and reduce the casualties.

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