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Design and Fabrication of Three Way Tipper Mechanism

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Abstract- Tipper has lots of applications in today's world. In industrial and domestic considerations, tippers can haul a variety of products including gravel, potatoes, grain, sand, compost, heavy rocks, etc. By considering wide scope of the topic, it is necessary to do study and research on the topic of tipper mechanism in order to make it more economical and efficient. In existing system, tipper can unload only in one side by using hydraulic jack or conveyor mechanism. By this research it is easy for the driver to unload the trailer and also it reduces time and fuel consumption. For making tipper mechanism with such above conditions both mechanisms namely hydraulic jack and conveyor mechanism can be used. But eventually it comes with question that how both systems can arrange in single set up? Answer to this question is nothing but this research work.

Index Terms- *Tipper; hydraulic jack; conveyor mechanism.*

1. INTRODUCTION

This tipper mechanism can do a great job by unloading the goods in three direction as nowadays trailers unloads in only one direction. Existing trailers requires more space, time and fuel so to overcome these problems we want to introduce the three way tipper mechanism so that the device is economical and efficient etc.[1]

This tipper mechanism generally relates to conveyor equipment and in a particular use of a conveyor mechanism for unloading material from trailer in left/right side and use of hydraulic jack for unloading in back side. [2, 3, 4]

A conveyor mechanism is provided for transporting objects. The conveyor mechanism, in particular, includes a single continuous belt member wrapped around rollers. A lever is connected to the first roller for driving the rollers and the surrounding belt member. This will unload tipper in left/right side. A hydraulic jack is a powerful lifting or pushing tool designed to provide effective lift over greater distance than basic mechanical jack. Hydraulic jacks use a plunger mechanism and non compressible fluid, typically a hydraulic oil to create required pressure and resulting lifting capability. In this project hydraulic jack is attached below whole setup to lift the trolley for backside unloading. [7, 8, 9]

This tipper mechanism can be applied to both domestic and industrial use. Whatever the application, the choice of equipment, it's safe use and correct maintenance is vital if the job is to be done safely, cost effectively and efficiently.

1.1. *Field of use and benefits* [5, 6]

Tipper is having lots of applications in today's world. In industrial and domestic considerations, Tippers can haul a variety of products including gravel, potatoes, top soil, grain, carrots, sand, lime, peat moss, asphalt, compost, heavy rocks, etc. By considering wide scope of the topic, it is necessary to do study and research on the topic of tipper mechanism in order to make it more economical and efficient. This mechanism is useful in dumping vehicles like tractor, trucks etc. This mechanism can provide faster work rate, less human interaction. In existing system, tipper can unload only in one side by using hydraulic jack or conveyor mechanism. That's why in case of two trailer truck, it is difficult for the driver to unload it at only one place and also it consumes more fuel, time, space etc. Wide area is available for research in this topic in order to make it easy for the driver to unload and reduce time and fuel consumption. It is easy to operate, does not required any special skill of driver, rapid, safe operation and simple maintenance.

1.2. *Traditional tipper trailers*

There are many different methods of unloading goods followed by industries. Some of those methods are described below.

1.2.1. *Single trolley trailer*

These type of trailers can unload goods in only back side direction, for this type of unloading either hydraulic or conveyor system is used. Trailers with conveyor system are quite effective than trailers with hydraulic jack but these both systems can unload the goods in only back side direction, therefore more space and time required.

1.2.2. *Two trolley trailer*

These types of trailers are used to carry more goods at single time. To unload two trolleys skilled driver is required also it requires more space, time and thereby fuel requirement increases.

2. COMPONENTS OF MECHANISM [11, 12]

2.1. *Roller conveyor*

48mm pipes are used as rollers and conveyor belt is wrapped around that pipes. Lever is attached to the first pipe for input power. Chain mechanism is used for power transmission from one shaft to another.

2.2. *Bearing*

SKF 6010 bearing is selected which is having I.D. 50 mm and O.D. 80 mm.

2.3. *Chain Drive*

Sprocket with I.D. 50 mm is used which have 16 teeth. Chain of length 1.24 m and 82 links is convenient. Chain drive helps to drive the system in both side (one at a time) using lever on one side roller only.

3. DESIGN [11, 12]

3.1. *Design of supporting rollers on strength basis*

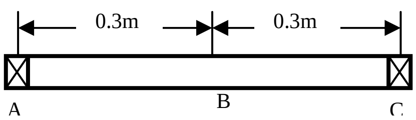

Fig.1. Support Shaft layout

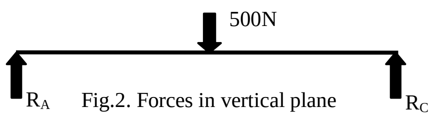

Fig.2. Forces in vertical plane

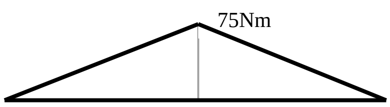

Fig.3. Bending Moment Diagram

From Fig.2, reaction at A and C

$\sum M_C = 0$

$R_A \times 0.6 - 500 \times 0.3 = 0$

$R_A = 250$ N

$\sum F_Y = 0$

$R_A + R_C = 500$

$250 + R_C = 500$

$\therefore R_C = 250$ N

From Fig.3, maximum bending moment at point B

$M_B = R_A \times 0.3$

$= 250 \times 0.3 = 75$ Nm

Material used for shaft is GI pipe (MS)

Yield strength $S_{yt} = 100$ MPa

FOS = 3

Maximum allowable stress

$\sigma_b = S_{yt}/FOS = 100/3$

$\sigma_b = 34$ MPa

For hollow shaft assuming $d_i/d_o = 0.94\sigma_b$

By bending equation,

$$\frac{\sigma b}{y} = \frac{Mb}{I}$$

$$\frac{\sigma b}{\frac{do}{2}} = \frac{Mb}{\frac{\pi}{64}(do^4 - di^4)}$$

$C = d_i/d_o = 0.94$

$$d_0^3 = \frac{32\,Mb}{\sigma b\,(1-C^4)\pi}$$

$$d_o^3 = \frac{32 \,X\, 75}{34 \,X\, 10^6 \,X\, (1-0.94^4)\pi}$$

$d_o = 0.0467$

$d_o = 48$ mm

$d_i = 45$ mm

3.2. *Power and torque calculations:*

We know that, Torque required to be given by,

$T = F.r$

Where, F = Net load in N

$$\therefore T = 500 \text{ x } \frac{0.048}{2}$$

T = 12Nm (Fig.10)

Power required to transmit,

$P = T.\ \omega$ (W)

Where, ω = angular velocity in rad/sec

Required Conveyor belt speed, V = 0.12m/s

We know that,

$V = r.\ \omega$

$$\therefore \omega = \frac{V}{r} = \frac{0.12}{(\frac{0.048}{2})} = 5 \text{ rad/sec}$$

$\therefore P = 12 \text{ x } 5 = 60$W

3.3. *Checking of driving rollers against shear stress*

At point A,

Load on sprocket = tangential force acting on chain + tension in chain due to sagging = $P_T + P_S$

$$P_T = \frac{\text{Power transmitted (in watts)}}{\text{Speed of chain }(\frac{m}{s})} = \frac{P}{V}$$

$$V = \frac{\pi DN}{60} = \frac{\pi \text{ x } 0.077 \text{ x } 50}{60} = 0.2 \text{ m/s}$$

$$\therefore \quad P_T = \frac{60}{0.2} = 300 \text{ N}$$

$P_S = k.m.g.x$

Where, k = constant = 2 to 6

m = mass of chain = 2kg

x = centre distance = 0.5m

$F_S = 4 \text{ x } 2 \text{ x } 10 \text{ x } 0.5 = 40$ N

$P_A = P_T + P_S$

$= 300 + 40 = 340$ N

Torsional moment on shaft,

M_T = Torque required = 12 Nm

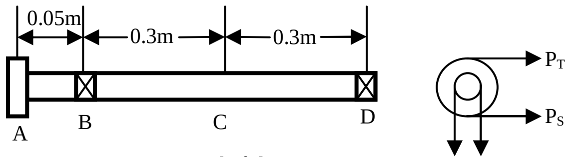

Fig.4. Driving Shaft layout

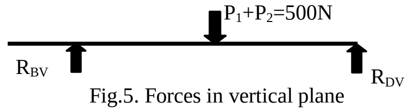

Fig.5. Forces in vertical plane

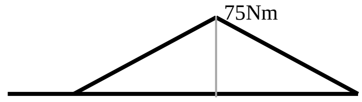

Fig.6. Bending moment diagram

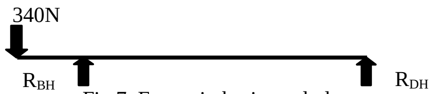

Fig.7. Forces in horizontal plane

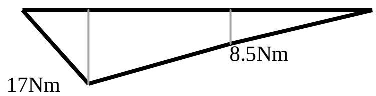

Fig.8. Bending moment diagram

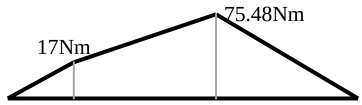

Fig.9. Combined bending moment diagram

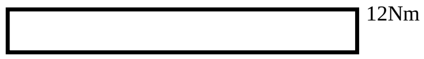

Fig.10. Torsional moment diagram

From Fig.5, reaction at B & D point

$\sum M_B = 0$

R_{DV} x 0.6 = 500 x 0.3

R_{DV} = 250N

$\sum F_Y = 0$

$R_{BV} + R_{DV} = 500$

R_{BV} = 250N

From Fig. 6,bending Moment at each point(+ve)

∴ $M_{DV} = R_{BV}$ x 0.6 - 500 x 0.3= 0Nm

M_{BV} = 0Nm

$M_{CV} = R_{BV}$ x 0.3= 75Nm

From Fig. 7,

$\sum F_X = 0$

$R_{BH} + R_{DH} = 340$

Taking moment about point B,

-340 x 0.05 - R_{DH} x 0.6 = 0

R_{DH} = -28.33N

R_{BH} = 340 + 28.33 = 368.33N

From Fig.8,bending moment at each point (+ve)

M_{AH} = 0Nm

M_{BH} = -340 x 0.05 = -17Nm

M_{CH} = -340 x 0.35 + R_{BH} x 0.3

= -8.50Nm

M_{DH} = -340 x 0.65 + R_{BH} x 0.6

= 0.002Nm ≈ 0Nm

From Fig.9, resultant Bending moment at B and C

$M_B = \sqrt{M_{BH}^2 + M_{BV}^2}$

M_B = 17Nm

$M_C = \sqrt{M_{CH}^2 + M_{CV}^2}$

M_C = 75.48Nm

Therefore maximum bending moment,

M_B =75.48Nm

$\tau_{max} = \frac{16}{\pi do^3(1-C^4)}[\sqrt{Mt^2 + Mb^2}]$

Material used GI pipe (M.S.)

$S_{sy} = 0.5\ S_{yt}$ = 0.5 x 100 = 50Mpa

FOS = 3

By using maximum shear stress theory,

∴Maximum Allowable shear stress,

$\tau_{max} = \frac{Ssy}{FOS}$ = 50/3=16.67MPa

$\tau_{max} = \frac{16}{\pi \ x\ 0.048^3\ x\ (1-0.94^4)}\sqrt{12^2 + 75.48^2}$

= 16.05 MPa

∴ $\tau_{max} > \tau_{cal}$

Design is safe.

3.4. *Bearing design*

Axial load F_a = 500 N

Radial load F_r = 0

$P = (XF_r + YF_a)$

$P = F_a$ =500 N

n = 50 rpm

Assuming life of bearing 800 hrs.

L_{10h} = 800 hrs

In million revolutions,

$L_{10mr} = \frac{L10h\ X\ 60\ X\ n}{10^6}$

$= \frac{800\ X\ 60\ x\ 50}{10^6}$

= 2.4 = 3 million revolutions

Dynamic load carrying capacity,

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

= 500 × 3^(1/k)

k = 3 for Ball bearing

C = 721.12 N

Selecting SKF 6010 for which d = 50 mm,

D = 80 mm.

3.5. *Design of chain and sprocket*

kW rating of chain $= \frac{\text{kW to be transmitted x ks}}{k1\ x\ k2}$

Power required to transmit = 60W

As there are 5 rollers

Total power required = 60 x 5=300W = 0.3kW

k_s = service factor = 1.2

k_1= multiple strand factor

As no. of strands = 1

k_1 = 1

k_2 = tooth correction factor

For no. of teeth on sprocket = 16

k_2 = 0.92

$\therefore$kW rating of chain = $\frac{0.3 \times 1.2}{1 \times 0.92}$ = 0.4kW
Sprocket speed = N = 50rpm
$\therefore$ chain no. = 10A
This gives following data:
Pitch p = 15.875mm
Roller diameter d_1 = 10.16mm
Sprocket specification,
PCD of sprocket,

$$D = \frac{p}{\sin(\frac{180}{z})}$$

Where, z = no. of teeth on sprocket = 16

$$D = \frac{15.875}{\sin(\frac{180}{16})} = 81.37mm$$

$D \approx 82mm$
Top diameter,

$$D_a = D + 1.25P - d_1$$
$$= 82 + 1.25 \times 15.875 - 10.16$$
$$= 91.68mm$$
$$D_a \approx 92mm$$

Root diameter,

$$D_f = D - 2r_i$$

Where, r_i = Roller seating radius
$= 0.505d_1 = 5.1308mm$

$$\therefore \quad D_f = 82 - 2 \times 5.1308 = 71.73mm$$
$$D_f \approx 72mm$$

Approximate center distance (a_0) = 500mm = 0.5m

$$a_p = \frac{a0}{p} = \frac{0.5}{15.875 \times 10^{-3}} = 31.49m$$

$a = \frac{e+\sqrt{e^2 - 8m}}{4}$ P & $e = l_p - \frac{z1+z2}{2}$ &

$m = (\frac{z2-z1}{2\pi})$^2

l_p = no. of links in chain

$$l_p = 2a_p + \frac{z1+z2}{2} +[(\frac{z2-z1}{2\pi})^2 / a_p]$$
$$= 2 \times 31.5 + \frac{16+16}{2}$$
$$= 79 \approx 80$$
$$\therefore \quad e = 80 - \frac{16+16}{2} = 64$$
$$\therefore \quad a = \frac{64+\sqrt{64^2 - 8 \times 0}}{4} \times 15.875$$
$$a = 508mm = 0.508m$$

Length of Chain,

$$l = l_p \times p$$
$$= 80 \times 15.875$$
$$= 1270mm = 1.27m$$

3.6. *Hydraulic cylinder specifications* [10]

- Working pressure(p) = 16MPa
- Cylinder bore or
  piston head diameter(d) = 40mm

p = F/A
Where, F = load to be lifted in N
A = area in $mm^2 = (\pi/4)d^2$
$\therefore F = p \times (\pi/4)$ d2
= 20kN

- Stroke length = 165mm

Fig.11. Prototype of tipper mechanism

4. CONCLUSION

After carrying out the testing of our project we got positive output. We have obtained most of the objectives and goals that we set for ourselves at the start of our project. We have been able to increase the easiness in unloading trolley. Problems occurred at the time of unloading the trolley in critical areas are eliminated. And thereby reducing overall time and fuel required for unloading the trailer.

5. FUTURE SCOPE

The process of unloading the trailer trolley in left and right direction can be made easier by implementing electric motor system instead of hand lever. Electric motor can be attached underneath the conveyor system and input power can be given to the roller with help of belt and pulley arrangement.

Hydraulic jack can be implemented for backside unloading instead of hydraulic cylinder. This implementation will increase the trolley lifting angle up to 45 to 50°.

ACKNOWLEDGMENT

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