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

\[
\text{From Fig.3, reaction at A and C} \quad \sum M_C = 0
\]
\[
\sum F_Y = 0
\]
\[
R_A + R_C = 500
\]
\[
250 + R_C = 500
\]

3.2. Power and torque calculations:

We know that, Torque required to be given by,
\[
T = F \cdot r
\]

Where, \( F = \text{Net load in N} \)
\[
\therefore T = 500 \times 0.046
\]
\[
T = 12\text{Nm (Fig.10)}
\]

Power required to transmit,
\[
P = T \cdot \omega (W)
\]

Where, \( \omega = \text{angular velocity in rad/sec} \)

Required Conveyor belt speed, \( V = 0.12\text{m/s} \)

We know that,
\[
V = \frac{r \cdot \omega}{\pi}
\]
\[
\therefore \omega = \frac{V \cdot \pi}{r} = 5 \text{ rad/sec}
\]
\[
\therefore P = 12 \times 5 = 60\text{W}
\]

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 = \( P_T + P_S \)

\[
P_T = \text{Power transmitted (in watts)} = \frac{P}{V}
\]
\[
V = \frac{\pi DN}{60} = \frac{\pi \times 0.077 \times 50}{60} = 0.2 \text{ m/s}
\]
\[
\therefore P_T = \frac{60 \times 300}{0.2} = 300 \text{ N}
\]
\[
P_S = k \cdot m \cdot g \cdot x
\]

Where, \( k = \text{constant} = 2 \text{ to 6} \)

\( m = \text{mass of chain} = 2\text{kg} \)
\( x = \text{centre distance} = 0.5\text{m} \)
\( F_S = 4 \times 2 \times 10 \times 0.5 = 40 \text{ N} \)
\( P_A = P_T + P_S \)
\[
= 300 + 40 = 340 \text{ N}
\]
Torsional moment on shaft, 
\[ M_T = \text{Torque required} = 12 \text{ Nm} \]

From Fig.5, reaction at B & D point
\[ \sum M_B = 0 \]
\[ R_{DV} x 0.6 = 500 \times 0.3 \]
\[ R_{DV} = 250 \text{ N} \]
\[ \sum F_Y = 0 \]
\[ R_{BV} + R_{DV} = 500 \]
\[ R_{BV} = 250 \text{ N} \]

Bending Moment at each point (\( +ve \))
\[ M_{DV} = R_{BV} x 0.6 - 500 x 0.3 = 0 \text{ Nm} \]
\[ M_{BV} = 0 \text{ Nm} \]
\[ M_{CV} = R_{BV} x 0.3 = 75 \text{ Nm} \]

From Fig.7, \( \sum X = 0 \)
\[ R_{BH} + R_{DBH} = 340 \]
Taking moment about point B,
\[ -340 \times 0.05 - R_{BH} \times 0.6 = 0 \]
\[ R_{BH} = 28.33 \text{ N} \]
\[ R_{BH} = 340 + 28.33 = 368.33 \text{ N} \]

From Fig.8, bending moment at each point (\( +ve \))
\[ M_{AB} = 0 \text{ Nm} \]
\[ M_{BH} = -340 \times 0.05 = -17 \text{ Nm} \]
\[ M_{CH} = -340 \times 0.35 + R_{BH} \times 0.3 = -8.50 \text{ Nm} \]

From Fig.9, resultant Bending moment at B and C
\[ M_B = \sqrt{M_{BH}^2 + M_{BV}^2} \]
\[ M_B = 17 \text{ Nm} \]
\[ M_C = \sqrt{M_{CH}^2 + M_{CV}^2} \]
\[ M_C = 75.48 \text{ Nm} \]

Therefore maximum bending moment,
\[ M_B = 75.48 \text{ Nm} \]
\[ \tau_{max} = \frac{16}{\pi do^3(1-\sigma_y)} \sqrt{Mt^2 + Mb^2} \]

Material used GI pipe (M.S.)
\[ S_y = 0.5 \text{ S}_{yt} = 0.5 x 100 = 50 \text{ Mpa} \]

By using maximum shear stress theory,
\[ \tau_{max} = \frac{S_{yt}}{FOS} = \frac{50}{3} = 16.67 \text{ Mpa} \]

\[ \tau_{max} = \frac{\pi x 0.040^4 x (1-0.945)}{\sqrt{12^2 + 75.48^2}} = 16.05 \text{ MPa} \]

\[ \therefore \tau_{max} > \tau_{cal} \]

Design is safe.

3.4. Bearing design

Axial load \( F_a = 500 \text{ N} \)
Radial load \( F_r = 0 \)
\[ P = (XF_r + YF_a) \]
\[ P = F_a = 500 \text{ N} \]
\[ n = 50 \text{ rpm} \]
Assuming life of bearing 800 hrs.
\[ L_{10h} = 800 \text{ hrs} \]
In million revolutions,
\[ L_{10mr} = \frac{L_{10h} x 10^6}{800 x 60 x 50} = 2.4 \times 10^6 \text{ revolutions} \]

Dynamic load carrying capacity,
\[ C = P \left( L_{10mr}\right)^{\frac{1}{k}} \]
\[ = 500 \times 3^{\frac{1}{3}} \text{ N} \]
\[ k = 3 \text{ for Ball bearing} \]
\[ C = 721.12 \text{ N} \]

Selecting SKF 6010 for which \( d = 50 \text{ mm} \)
\[ D = 80 \text{ mm} \]

3.5. Design of chain and sprocket

kW rating of chain \( \frac{kW}{\text{to be transmitted x ks}} \)
Power required to transmit \( = 60 \text{ kW} \)
As there are 5 rollers
Total power required \( = 60 \times 5 = 300 \text{ W} = 0.3 \text{ kW} \)
\[ k_s = \text{service factor} = 1.2 \]
\[ k_t = \text{multiple strand factor} \]
As no. of strands \( = 1 \)
\[ k_t = 1 \]
\[ k_s = 2 \text{ tooth correction factor} \]
For no. of teeth on sprocket \( = 16 \)
\[ k_2 = 0.92 \]
kW rating of chain = \( \frac{0.3 \times 1.2}{1 \times 0.92} = 0.4 \) kW
Sprocket speed = N = 50 rpm
:\( k \) = 10A
This gives following data:
- Pitch \( p = 15.875 \) mm
- Roller diameter \( d_1 = 10.16 \) mm
Sprocket specification,
PCD of sprocket,
\[
D = \frac{p}{\sin\left(\frac{\pi}{2}\right)}
\]
Where, \( z = \) no. of teeth on sprocket = 16
\[
D = \frac{15.875}{\sin\left(\frac{\pi}{16}\right)} = 81.37 \text{ mm}
\]
\( D \approx 82 \) mm
Top diameter,
\[
D_t = D + 1.25P - d_1
\]
\( = 82 + 1.25 \times 15.875 - 10.16 \)
\( = 91.68 \text{ mm} \)
\( D_t \approx 92 \text{ mm} \)
Root diameter,
\[
D_f = D - 2r_i
\]
Where, \( r_i = \) Roller seating radius
\( = 0.505d_1 = 5.1308 \) mm
\( \therefore D_r = 82 - 2 \times 5.1308 = 71.73 \) mm
\( D_r \approx 72 \text{ mm} \)
Approximate center distance (\( a_0 \)) = 500 mm = 0.5 m
\[
a = \left( \frac{p}{2\pi} \right) P \text{ & } e = l_p - \frac{z_1 + z_2}{2} \text{ & }
\]
\[
m = \left( \frac{z_2 - z_1}{2\pi} \right)^2
\]
\( l_p = \) no. of links in chain
\[
l_p = 2a_0 + \frac{z_1 + z_2}{2} + \left[ \frac{z_2 - z_1}{2\pi} \right]^2 / a_p
\]
\( = 2 \times 31.5 + \frac{16}{2} = 79 \approx 80 \)
\( \therefore e = 80 - 16 = 64 \)
\( \therefore a = 64 + \sqrt{64^2 - 8 x 0} \times 15.875 \)
\( a = 508 \text{ mm} = 0.508 \text{ m} \)
Length of Chain,
\[
l = l_p \times p
\]
\( = 80 \times 15.875 \)
\( = 1270 \text{ mm} = 1.27 \text{ m} \)

3.6. **Hydraulic cylinder specifications** [10]
- Working pressure(\( p \)) = 16 MPa
- Cylinder bore or piston head diameter(\( d \)) = 40 mm

\[
p = \frac{F}{A}
\]
Where, \( F = \) load to be lifted in N
\( A = \) area in mm² = \( \pi / 4 d^2 \)
\( \therefore F = p x (\pi/4)d^2 \)
\( = 20 \text{ kN} \)
- Stroke length = 165 mm

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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°.

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**REFERENCES**


