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Design and Manufacturing of Three direction Dumping Trolley

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Abstract - *The idea behind the need of three direction dumping trolley is by detecting the difficulty in unloading the material in congested area. This paper mainly focuses on this difficulty. With the study of different books & information some difficult methods were adopted to unload the method. We developed turning table mechanism for that. The direction of the mechanism can be control with the help of turn table with cylinder by providing the rotary movement which could be very useful where there arrangement has been designed. The materials can be unloaded from the trailer in three axes.*

This mechanism prevents blocking of the road which saves the time and enhances the productivity. This concept saves time & energy which leads to efficient working. This paper proposes a model of three directional dumping systems. In several industrial purposes, revealed the facts that mostly some difficult methods were adopted in unloading the materials from the trailer. Now the trailer has mainly concentrated on this difficulty, and hence a suitable arrangement has been designed.

Key Words: turning table mechanism, bearings, trolley, hydraulic cylinder, pins.

1. INTRODUCTION

In industrial and domestic considerations, trolleys can pull a variety of products including gravel, grain, sand, fertilizer, heavy rocks, etc. By study of the older dumping trolley mechanism & by observing the difficulty in unloading the materials in congested area need of three direction trolley is generated. By considering wide scope of the topic, it is necessary to do study and research on the topic of the trolley mechanism in order to make it more economical and efficient. The trolley mechanism can do the great job by unloading the materials in three directions as now day's trolley unloads in one direction.

Existing trailers requires more extra space, time and fuel so to overcome these problem the three directions trolley mechanism is introduced so that the device is economical and efficient. The trolley working is relates to telescopic cylinder mounted on chassis frame with turning table at base frame and trolley frame for unloading the material in left or right direction and in back side. The single acting telescopic cylinder is used to provide motion in three directions. In this working the turning table allow cylinder to rotate in any direction i.e. also allow to tilt in left and right direction. To deliver the material in right side and left side, we have fixed sides of trolley by hinge joint using pin. The proposed mechanism used for unloading purpose is safe and efficient and can be used the safely in different areas. Hydraulic cylinder used unload loose material on back side, left side and right side of trolley respectively. Some design modification is needed in existing system to work on multisided trolley tilting mechanism

1.1 Design objective:

1. To provide the users with a user friendly mechanism for dumping material.
2. System should be developed with minimum vehicle components.
3. Design must give the user the option to control direction of tilting trolley.
4. Less fuel consumption, less time requirement and efficient working.

2. Related work

2.1. Problem statement

The present material handling automobiles are having the trolley which has the lifting system to dump the material towards one side i.e. rear side. For dumping the material at a particular point, the vehicle has to be positioned properly to affect the exact dumping point. At some places it will not be possible to position the vehicle according to the dumping point. Since the roads or the space might be congested. So the material is not dumped in a required place which again needs some manpower to shift it. We are proposing to make the hydraulic

Cylinder rotating trolley which can rotate to any required angle (0-180) and lift it to dump the material in that position. All the hydraulic actuations are by the hydraulic pump operated by hand lever and in actual the hydraulic pump is operated by the engine. This mechanism can provide faster work rate, less human interaction and makes easy for the driver unload and reduce time and fuel consumption.

2.2 Conceptual Design

In this type of system, single acting telescopic cylinder of 1 Ton capacity and turn table at two ends of

cylinder play very vital role. The hydraulic pump will pump the hydraulic oil at very high pressure. Due to oil pressure the piston start rising in the cylinder. The end portion of the piston is attached to turn table of trolley frame and other end of cylinder is attached to turn table of chassis frame. Both ends are easily able to rotate in any directions. Hinge pin will be provided at the each corner of the frame and on the chassis also. If we want to unload the goods on left side then, fixed left side hinge with pin and remove the pins of other two sides and start the raising the single acting telescopic cylinder. Similarly for other two operation.

3. Working:

This concept generally relates to single acting cylinder and turning table mechanism for unloading material from trolley in left side, right side and back side. A hydraulic cylinder is a powerful lifting or pushing tool designed to provide effective lift over greater distance than basic mechanical jack. Hydraulic cylinder use a plunger mechanism and non-compressible fluid, typically a hydraulic oil, to create required pressure and thus resulting in greater lifting capability. In this type of system, hydraulic cylinder of 1 Tone capacity and turn table plays very vital role. The turn table is able to rotate in 360 degree direction. The plunger of cylinder will pump the hydraulic oil at very high pressure. Due to oil pressure the piston start rising in the cylinder. The end portion of the piston is attached to U joint. Hinge pin will be provided at the each corner of the frame and on the chassis also. If we want to unload the goods on left side then, fixed left side hinge with pin and remove the pins of other two sides and start the raising the hydraulic cylinder. During this process, the end of the piston which is in contact in the socket start turning to the left side. Same process is done in case of tilting of trolley to right side by fixing the right side hinges and removing the pins of other two sides to unload the goods. If we want to unload the carrier in backward side, simply remove the pins fixed on right & left hand sides and fixed the hinge with the pin at backside and raise the hydraulic cylinder.

4. Components and construction

4.1 Roller bearing

Fig 4.1 ball bearing

A **ball bearing** is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least two races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other.

Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races.

4.2 Hydraulic cylinder with turn table

Fig.4.2 Cylinder with turn table

Single-acting telescopic cylinders extend under hydraulic pressure and rely on gravity or some external mechanical force for retraction. Single-acting cylinders are used in applications where some form of load is always on the cylinders. The classic single-acting telescopic applications are dump trucks and dump trailers. Pressurized oil extends the telescopic cylinder to raise one end of the dump body. When pressure is released, the weight the dump body forces oil out of the cylinder, it retracts.

Turn table is a motorized or manual device, usually installed in a trolley or on a garage floor that rotates a motor vehicle in garage And to give turning to the hydraulic cylinder of trolley. Turn table used in this system is to rotate cylinder for tilting of trolley in three axes.

5. Design calculations

Design of bearing:

Time for rotation of cylinder through 90 ° = 15 sec. (Assume)

$W = \theta/t = (90\times\pi)/(180\times15) = 0.1047$ rad/sec.

N= W/2π = 0.1047/2π = 0.0166 rpm
Hence, we select 10 rpm
Forces acting on bearing
Radial force = 1000 cos 42 = 743.14 N
Axial force = (0.5×743.14)/1.5 = 247.71... (Assume y=1.5)
(f_a/f_r) = 247.71/743.14 = 0.33
As we know, P= f_r
$(f_a/f_r) \leq e$
Life L_{10}= 10000 revolution.
Capacity $C = P (L_{10})^{1/3}$
$= 743.14(10000)^{1/3}$
= 15526.39
So selected bearing is 3210
Dimensions of the bearing
D= 75mm
d = 45mm
B = 20mm

Design of plate:

Bending of circular plate, Material for plate is Mild steel.
S_{ut} =440 MPa
S_{yt} =370 MPa
E=205 GPa
Standard bending stress
F_y =248 Mpa
Hence, bending stress=248×0.66=163.68 N/mm²
This is allowable stress
Principle Stress:
Support at centre of plate over circular area of radius b and udl W
$\sigma_{max}=(3\times W\times a^2)/2\times t\{(1+\mu)\ln(a/b)+1/4(1-\mu)(1-b^2/a^2)\}$
Where,
a=Radius of plate
b=Radius of circular area
W=load/area and t=thickness of plate
μ=Poisson ratio=0.303
$\sigma_{max}=(3\times1000\times9.81\times0.225^2)/(2\times6\times10^3\times2\times\pi\times a)\{(1+0.303)\ln(0.225/0.0725)+1/4(1-0.303)(1-(0.0125/0.225^2)$
$=7006319.32 N/m^2$
Consider the plate as beam
d = 8 mm b= 80 mm or 120 mm
To find bending stress:
W = 9810N
For b= 80 mm
$I = bd^3/12 = (80\times8^3)/12 = 3413.33 mm^4$
For b = 120 mm, I = 5120 mm⁴
P=w sin 42 =9810sin 42=6514.17 N
M=P×L=6564.17×20=131283.4N.m
Bending stress = (M.Y)/I
= (131283.4×4)/3413.33=153.84 N/mm²
OR = 162.5 N/mm²
The bending stress for plate with conspiring plate as beam is 162.5N/mm²

Design of pin:

1) Bending failure:
Given, d=2.3cm
M_b=PD/8
M_b = (9810×2.3)/8
=282037.5N.cm
$I = (\pi/64)\times d^4 = (3.14/64)\times2.3^4$
$=13736.66 mm^4$
Y=d/2=23/2=11.5mm
$\sigma_b = (M_b.y)/I = (28203.75\times11.5)/13736.66$
$=23.611 N/mm^2$
$(\sigma_b)_{allowable} \geq 23.623$
Hence, Design is safe for bending
2) Shear failure:
Shear stress (Ƭ) $=P/2\times[(\pi/4)\times d^2] = 9810/[(\pi/20\times23^2]$
$=11.80 N/mm^2$
Design is safe.
3) Crushing failure of pin:
σ_c = Force /Area
=P/L×d=9810/23×6.4
$\sigma_c = 66.64 N/mm^2$

Design of cylinder:

Weight in trolley=1000 kg
Force acting on the cylinder=m × g
=1000×9.81
=9810 N
For this capacity we select 1 ton capacity telescopic cylinder,
From market survey the diameter of cylinder is = 60 mm
Now, the pressure in the cylinder=P=F/A
Where A=Area of Piston = $A = \frac{\pi}{4}D^2$
$=\frac{\pi}{4}\times60^2$
$=2827.43\ mm^2$
Pressure in the Cylinder=F/A
=9810/2827.43
$=3.46 N/mm^2$
The material used for cylinder is cast steel
The yield strength for cast steel is 72 N/mm^2
(σ) Allowable=72/1.5 = 48 M Pa
Poisson's ratio is 0.26
Therefore by Clavarino's Equation for closed cylinder of ductile material for thickness of cylinder
$t = \frac{di}{2}\times(\sqrt{\frac{\sigma+pi(1-2U)}{\sigma-pi(1+U)}}-1)$
$= \frac{78}{2}\times(\sqrt{\frac{48+3.46(1-2\times0.26)}{48-3.46(1+0.26)}}-1)$
= 2 mm
t = 10 mm standard
Outer diameter of cylinder = di+2t
= 78+2(10)
= 80 mm

We have, $\frac{di}{t} = \frac{78}{5}$ =15.6 ≤ 20 Therefore it is a thick cylinder.

Principal stresses at inner surface of cylinder:-

(σ) Tensile = $\frac{pi(do^2+di^2)}{(do^2-di^2)}$

= $\frac{3.46(80^2+60^2)}{(80^2-60^2)}$

= 12.35 N/mm^2

(σ) Radial = - pi

= - 3.46 N/mm^2

(σ) Longitudinal = $\frac{pi \times di^2}{(do^2-di^2)}$

= $\frac{3.46 \times 60^2}{(80^2-60^2)}$

= 4.44 N/mm^2

Principal stresses at outer surface of cylinder:-

(σ) Tensile = $\frac{2 \times pi \times di^2}{(do^2-di^2)}$

= $\frac{2 \times 3.46 \times 60^2}{(80^2-60^2)}$

= 8.89 N/mm^2

(σ)Radial = 0

(σ) Longitudinal = $\frac{pi \times di^2}{(do^2-di^2)}$

= $\frac{3.46 \times 60^2}{(80^2-60^2)}$

= 4.44 N/mm^2

Hence, we select the cylinder of outer diameter 80 mm and piston diameter of 60 mm.

6. Observation

6.1 back side dumping

Fig no 6.1 back side

6.2 Right side dumping

Fig no. 6.2 Right side

6.3 Left side dumping

Fig no. 6.3 left side

7. Conclusion:

In industrial and domestic considerations, trolley can pull a variety of products including gravel, grain, sand, fertilizer, heavy rocks, etc. The difficulties in unloading the materials were found in older dumping trolley. "THREE DIRECTION DUMPING TROLLEY" is nothing but one of the lifting system in automobile in three directions. In this Lifting system the additional hydraulic cylinder and turn table is provided in the automobile itself.

We have been able to unloading material easily. Problems occurred at the time of unloading the trolley in critical areas will be eliminated. And thereby reducing overall time and fuel required for unloading the trailer.

The design is safe for the maximum load of 1 ton which is rigid enough to transport loose material from one

site to another site. Design of cylinder and turn table is the most important part for side tilting of the trolley. In this paper, the turn table is used to rotate cylinder either in clockwise or anti-clockwise direction for lifting trolley in left, right and back side.

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