INVESTIGATION ON THREE-WAY DUMPING MECHANISM OF A TWO-WHEEL TRACTOR TROLLEY

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ABSTRACT

The conventional mechanism to dump material using one-side (back) of a tractor trolley was often prone to numerous drawbacks such as the inability to dump at less road space availability, improper roadside dumping that creates severe traffic problems. Therefore a novel dumping mechanism via tractor trolley with the advantageous and economic feasibility was needed. The research work presented in this paper was done on similar objectives by developing a prototype to save time and energy. Initially, the design of essential components like ring pin actuator holding mechanism, hinges and chassis was done by considering one-fourth of actual dimensions of a regular trolley. A model was developed based on the design considerations via CATIA software and verified for smooth three-directional (left, right and back dumping. Finally, the prototype was built based on the model with materials mild steel, low carbon steel and cast iron for trolley body, hinges and chassis respectively. The fabricated prototype includes essential devices like six hinges to support chassis, a hydraulic actuator and body. The prototype was tested for a maximum load of 1000N in all the 3 directions. It was found that the model effectively fulfilled the desired objectives.

Keywords - *Trolley, Hydraulic actuator, Hinges, Ring pin and Chassis.*

1. INTRODUCTION

A tractor as an engineered vehicle serves both on-road (transportation) and off-road (agricultural) and widely accepted as one of the essential machines for mechanized farming and rural community in all parts of the world. The report [1] published by the government of India mentioned that as per ICAR, the tractor density and demand was constantly on increasing trend for many years. Regarding tractor trolley, the on-road uses are numerous such as to transport agricultural goods, small-scale industrial parts, construction material and so on which signifies its multiple requirements. The dumping of material at workplace using conventional one side (back) trolley mechanism was not feasible due to various reasons like inability to dump at areas having less road space availability, improper roadside dumping which leads to traffic problems. The research [2, 3 and 4] successfully overcome the conventional dumping problems by using a combined mechanism of the conveyor and hydraulic jack for left/ right side and back side respectively. A 3-way tipper mechanism was developed [5] and tested to unload 20 KN found that it was successful besides saving time and money. A multi directional dumper to unload material in 180^0 was developed [6] and when tested found to be effectively fulfilled the objectives. The model developed [7] found to save time and energy.

From the literature study, it was found that there was a significant scope in this area to develop an effective model for three directional dumping mechanism of a tractor trolley and hence work was done as mentioned below.

1. Design of essential parts like chassis, hinge joint and actuator holding mechanism (ring pin).
2. Modeling of chassis (lower, upper and middle) and assembly.
3. Fabrication of hinge joint (six), chassis and frame.

2. THREE WAY DUMPING TROLLEY MECHANISM

The chief components of the fabricated three-way dumping trolley consist of a hydraulic cylinder, axle, hinges, circlip, oil seals, hydraulic fluid and universal ring type mechanism

2.1. Hydraulic Actuator

The hydraulic cylinder was a mechanical actuator that consists of a tight-fitting piston moving in a

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closed cylinder was used to provide a unidirectional force via a pressurized hydraulic fluid (oil). The mechanical motion produced may be linear, rotary or oscillatory.

2.2. Axle

The axle was a centrally placed shaft fixed to chassis that facilitates rotary motion of the vehicle wheels.

2.3. Hinges

The hinge was a typical type of joint that connects trolley chassis and body that allows a relative rotational movement about an angle of 50^0. In this work, the male part of the hinge was welded to upper chassis so that it lifts during the dumping and the female part of the hinge was welded to middle chassis which will be in a fixed position.

2.4. Oil Seals

Leather, synthetic rubber and silicones were the most commercially available materials used for making of sealing ring. In this work, rubber seal was used to prevent passage of fluid from one chamber to another of the hydraulic actuator.

2.5. Hydraulic Fluid

This was also known as tractor fluid basically petroleum-based oil that was available commercially. Some of the hydraulic machines require fire resistant-fluids depending upon the applications. In this work, SAE 10W86 oil was used as the hydraulic fluid in the hydraulic cylinder to extract force by pressurizing.

2.6. Universal ring type of mechanism

In the universal ring type actuator holding device shown in figure 1, there are two rings one inner and one outer, the inner ring will activate during the sideways dumping of the trolley and the outer ring during back way dumping.

This universal ring mechanism found to be simple to tilt the actuator in all the three ways (left, back and right). The actuator is placed at the center of two rings and the inner ring is connected to the outer ring via pins. The outer ring is connected to the middle chassis of the trolley. As the ring pin is used in above condition shear stress will act on the ring pin which was considered. During back dumping of the trolley, the cylinder jacket assembly rotates about the major axis of the ring while during side dumping the ring along with cylinder jacket assembly rotates about the minor axis of the ring.

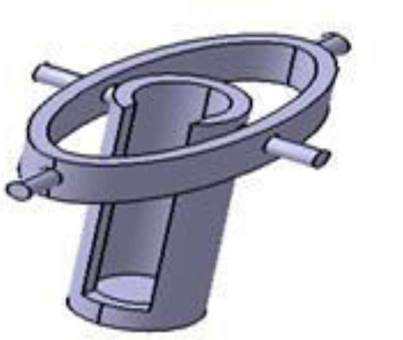

Fig.1. Three Dimension View of Universal ring mechanism

Universal ring mechanism consists of cylinder jacket assembly, ring, and four pins. Out of four pins, two pins are inserted and then welded to the jacket of the cylinder and remaining two pins are inserted in the ring then welded. The pins are inserted in such a way that they give more area of contact. So the strength of pin will automatically increase.

3. DESIGN CONSIDERATIONS

3.1. Design calculation for pin

The force diagram of ring pin was shown in figure 2.

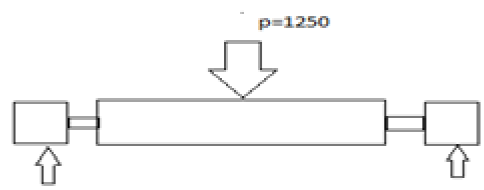

Fig.2. Force Diagram for ring pin

Total load coming on model as per dimensional analysis =62.5 kg But, we have design a model for 100 kg.

Total load coming on model = 100 kg

= 100 * Acceleration due to gravity

= 100 * 10 = 1000 N.

Load on single pin = 0.5 * Total load

=0.5* 1000 = 500 N.

Shear stress (τ) $= \frac{0.5 \times S_{yt}}{\text{Factor of safety}} = \frac{0.5 \times 380}{2.5} = 76\ N/mm^2$

Now, diameter of ring pin is calculated by shear stress formula

$\tau = \frac{P_1}{\frac{\Pi}{4} \times d^2}$, d = 3.89 mm

We were take d = 8 mm, for more safety.

3.2. Design calculations for ring

The force diagram of ring was shown in figure 3.
P = 500 N, A = cross sectional area = 35 mm^2
$\tau = \frac{P}{A} = \frac{500}{35} = 14.3 N/mm^2$
14.3 < 76 N/mm^2, hence the design is safe.

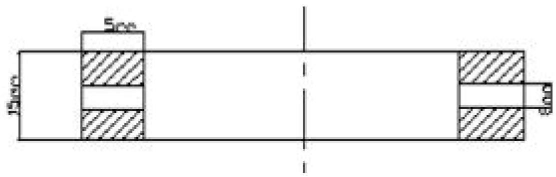

Fig.3. Force Diagram for ring

3.3. Design calculations for hinge

The block diagram of hinge was shown in figure 4.

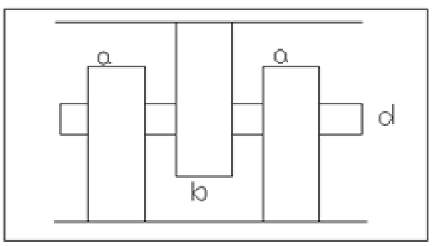

Fig.4. Trolley hinge

a- Hinge male part, b- Hinge female part, d- Hinge pin

Consider factor of safety 4 for hinges. Therefore Permissible Stresses will be
σ_t= 95 N/mm2, τ = 47.5 N/mm^2,
σ_b= 95 N/mm^2

Shear failure of pin
$= \frac{P}{2 \times \frac{\Pi}{4} \times d^2}$
d = 2.58 mm

Crushing failure of pin for Fork
Crushing stress (σ_{cf}) $= \frac{P}{2 \times a \times d} =$ 4.46 N/mm^2
4.45< 95 N/mm, σ_{cf} is less than the permissible crushing stress. Hence, Design is safe.

Bending failure of pin
$M_b = \frac{P}{2} \times \left(\frac{b}{4} + \frac{a}{3}\right) = 1020.833$ N.mm
$\sigma_b = \frac{M_b \times y}{I} =$ 10.15N /mm^2

10.15 < 95 N/ mm^2, σ_b is less than the permissible bending stress. Hence, the design is safe.

4. MODELLING OF PROTOTYPE

4.1. Lower chassis

Its position was exactly above the differential and nearer to the ground surface. It is used for to connect with the wheels also it distributes weight on wheels of a trolley. The lower chassis is the base of all chassis on which all chassis and component are placed as shown in figure 5.

4.2. Middle chassis

Its position was on above of lower chassis. It is the main chassis on which all mechanism of three-way dumping is placed as shown in figure 6.

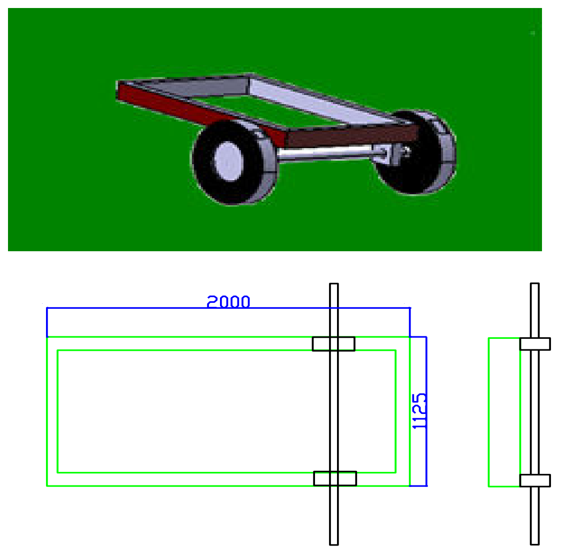

Fig.5. Modelling of lower chassis

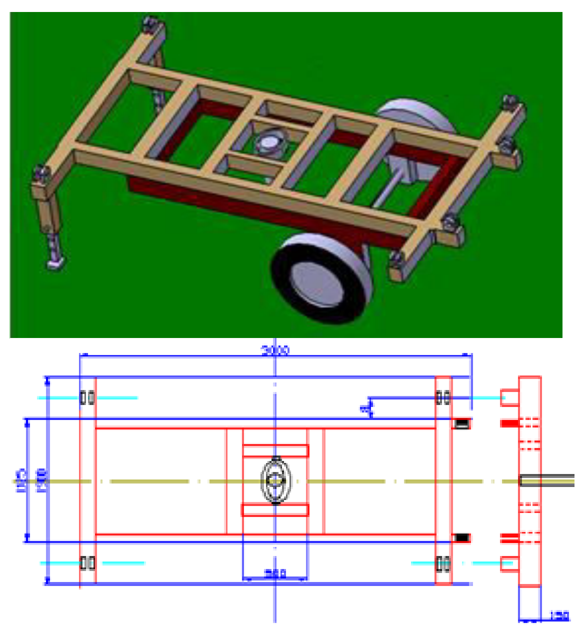

Fig.6. Modelling of lower chassis

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4.3. Upper chassis

The main purpose of inserting upper chassis above middle chassis was to avoid point loading and also the initial load was taken by this upper chassis as shown in figure 7.

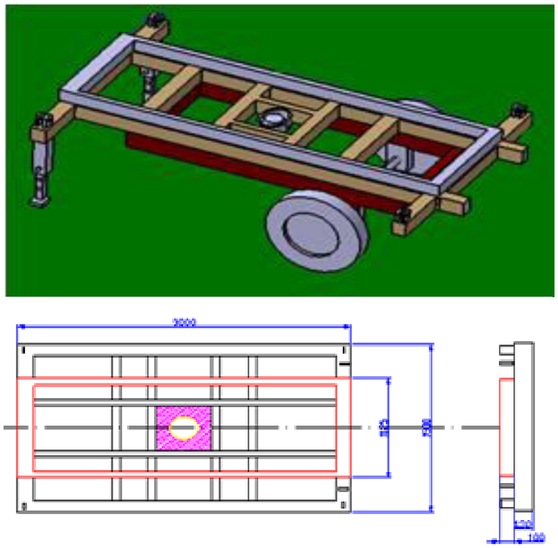

Fig.7. Modelling of upper chassis

4.3. Trolley assembly

The trolley was provided with doors to open manually on all the three sides as per dumping position and application. The trolley assembly was shown in figure 8.

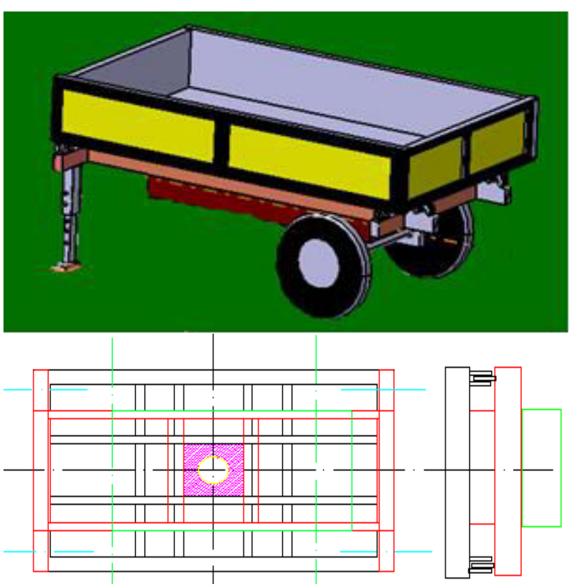

Fig.8. Modelling of trolley assembly

4.4. Modelling of lifting mechanism

The mechanism was modelled to lift the trolley on right, left and back sides. The front view rest position was shown in figure 9.

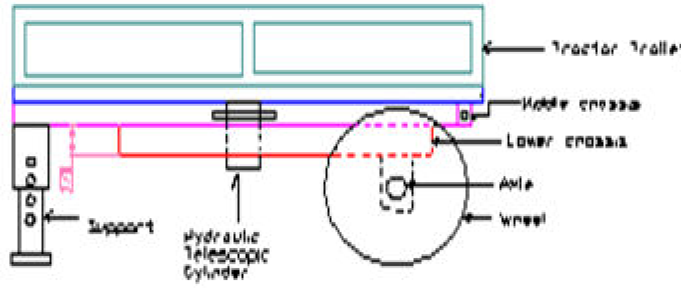

Fig.9. Front view rest position

The angle of inclination of the hydraulic actuator with horizontal is 70^o and the material is dump in right hand side properly as shown in figure 10.

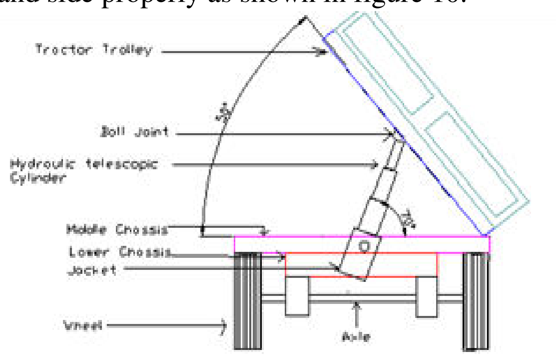

Fig.10. Right hand Side Dumping

The angle of inclination of the hydraulic actuator with horizontal is 70^o and the material is dump in left hand side properly as shown in figure 11.

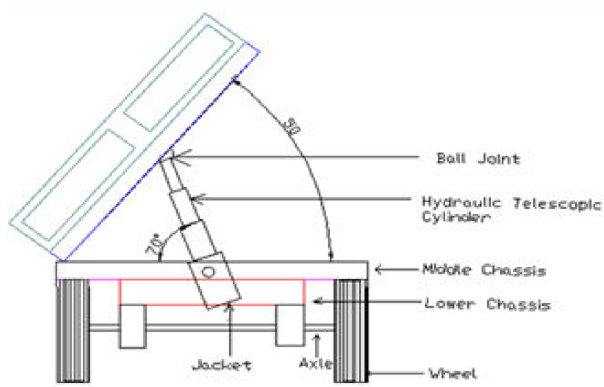

Fig.11. Left hand Side Dumping

The angle of inclination of the hydraulic actuator with horizontal is 68^o and the material is dump in back side properly as shown in figure 12.

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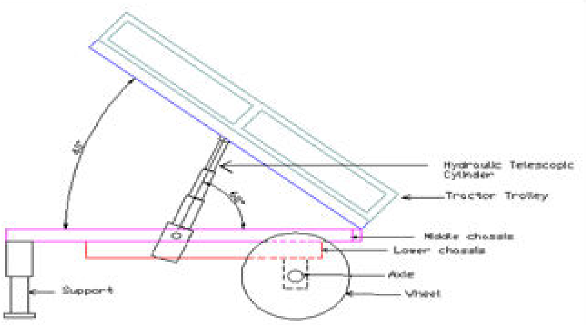

Fig.12. Side View back dumping

5. FABRICATION OF MODEL

5.1. Hydraulic actuator

Three stage telescopic actuator was designed on basis of load 100kg .it is hydraulically operating and placed on middle chassis in between universal ring to move freely during operation.it is as follows. The fabricated model of actuator was shown in figure 13.


Fig.13. Fabricated hydraulic Actuator

5.1. Trolley assembly and testing

The prototype was fabricated by precisely following the model that was developed keeping the accurate design considerations. Mild steel and low carbon steel material were used for trolley body and hinges. Cast iron material was used for all the chassis as shown in figures 14, 15 and 16. The prototype was tested for a maximum load of 1000 N in all the three directions. The materials mild steel, low carbon steel and cast iron were used to fabricate the trolley body, hinges and chassis respectively.


Fig.14. Fabricated trolley- Left side dumping


Fig.15. Fabricated trolley- Right side dumping


Fig.16. Fabricated trolley- Back dumping

6. CONCLUSION

A tractor trolley prototype capable of dumping material of 1000N in all the three directions (left, right and back) was effectively built based on the models developed via CATIA. The prototype upon tested for 1000N load in all the 3 directions showed smooth dumping of the material without any functional problems. Consequently, it was concluded that the desired objectives are successfully fulfilled.

REFERENCES

[1] http://eands.dacnet.nic.in/PDF/State_of_Indian_Agriculture,2015-16.pdf
[2] Jacob N. Gust, West Farso N.Dak invented “Trailer with continuous conveyor belt” Patent Number US5102285, April 7, 1992
[3] Simon Ariech, Geneva, Switzerland invented “Belt conveyor” Patent Number US4058204, Nov. 15, 1977.
[4] Thomas R. Brown, Randal L. Zerbe, Patrick C. O’Brien, James K. Bertsch invented “Conveyor Mechanism” Patent Number: US5934862, Aug. 10, 1999.
[5] Amboji Sudhakar R, Humane Yogesh A, Chavan Rohan R, Patil Jyotsna C, Kshirsagar Prashant R “Design and Fabrication of Three Way Tipper Mechanism” International Journal of Research in Advent Technology, Vol.2, No.4, April 2014.
[6] Shubham S. Ganar, Akshay D. Kakde, Rahul R.Pali, Shubham D. Kolhe, Mr. A.S Deshmukh “ Design and fabrication of multi-directional lifting dumper” Journal DOI: 10.21474/IJAR01
[7] Ganesh shinde, Prachi Tawele, Laukik Raut “Design and development of 3 way dropping dumper” IJETAE, ISSN 2250-2459, Volume 4, Issue 9, September 2014.
[8] R.K.Bansal, Pascal, Fluid Mechanic, Laxmi Publication LDT.
[9] Khurmi Gupta, 14th Edition.Stress Strain Analysis, Machine Design, S. Chand & Company Ltd.
[10] Khurmi Gupta, 2008, Degree of freedom, Theory of machine, S chand & Company Ltd; (2008).