Design, Modification, Analysis of a Tractor Driven Container Lifting Device Used for Solid Waste Management

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Abstract— For transport of solid waste the concerned authority need to decide the type of vehicles to be procured and the system of transportation to be adopted. In all mega cities and municipal corporations' HCV chassis are used for loading and unloading the containers having size more than 5.5 cubic meters. But for all towns and Nagarpalikas these may not be preferred due to space limitations and narrow size roads. So here tractor driven lifting device may be used which will lift up to 4.5 cubic meter containers. They can use containers of up to 4 to 4.5 cubic meters capacity, which will make optimum use of the tractors. The objective of this dissertation is to design, modify and analyses the existing design parameter, to identify the parameter which affecting the performance of the device and by conducting survey from end users, manufacturer to know the problems associated with the existing device. Based on the survey and study new improved optimum utilization and convenient design will be suggested for easy operation and less maintenance.

Key words: Hydraulic cylinder, performance, hook, FEA.

I. INTRODUCTION

For transport of solid waste the concerned authority need to decide the type of vehicles to be procured and the system of transportation to be adopted. In all mega cities and municipal corporations' HCV chassis are used for loading and unloading the containers having size more than 5.5 cubic meters. But for all towns and Nagarpalikas these may not be preferred due to space limitations and narrow size roads. So here tractor driven lifting device may be used which will lift up to 4.5 cubic meter containers. They can use containers of up to 4 to 4.5 cubic meters capacity, which will make optimum use of the tractors. There are 159 Nagarpalika in Gujarat where container lifting device on tractor trailer chassis are used for transportation of garbage from secondary collection Centre to final disposal dumping site.

The container of capacity 4.5 m3 is used for secondary collection of garbage. The container is fully covered during transportation.

A. PROBLEMS ASSOCIATED WITH OVERHEATING BRAKES:

If the temperatures reached in braking become too high, deterioration in braking may result, and in extreme conditions complete failure of the braking system can occur. It can be difficult to attribute thermal brake failure to motor vehicle accidents as normal braking operation may return to the vehicle when the temperatures return to below their critical level One of the most common problems caused by high temperatures is brake fade; other problems that may occur are excessive component wear, rotor deterioration, and thermally excited vibration (brake judder). Heat conduction to surrounding components can also lead to damaged seals, brake fluid vaporization, as well as wheel bearing damage, while heat radiated to the tyre can cause damage at tyre temperatures as low as 200°F (93°C).

II. LITERATURE REVIEW

R. D. Dixon and E. H. Perez (2009) [3] presents a paper in new design formulas for thickness requirements and determination of peak stresses and stress distributions for fatigue and fracture mechanics analyses in thick blind ends. The use of these proposed design formulas provide a more accurate determination of the required thickness and fatigue life of blind ends. The proposed design formulas are given in terms of the yield strength of the material and address the fatigue strength at the location of the maximum stress concentration factor.

$$\frac{P_d}{S_y} = 1.203\left[\frac{H}{D_i}\right] - 0.0319 \quad \text{.........(1)}$$

The formula given in Eq. (1) is appropriate for thick plates and it is based on a factor of safety of 2 against plastic Collapse it cannot be readily applied to blind end closures for high pressure vessels because it does not take into account the corner radius and the thickness effect of the attached cylindrical shell.

The formulas provided in this paper allow for accurate design and fatigue life determination of blind end closures subjected to internal pressure. The proposed formulas were derived from finite element stress results from a parametric study performed by the authors. The procedure can be performed by hand or with a spreadsheet for a quick determination of the required blind end closure thickness and fatigue life.

Rashmi Ranjan Nath (2008) [2] presented work on stress analysis of thick walled cylinders with variable internal pressure states is conducted Elastic analysis of uniform cylinder & cylinder with holes is predicted both from theory (lame's formulae) under & Finite element method. Also elastic plastic analysis with bilinear kinematic hardening material is performed to know the effect of hole sizes. It is observed that there are several factors which influence stress intensity factors. The Finite element analysis is conducted using commercial solvers ANSYS & CATIA.

Nidhi Dwivedi (2012) [4] propose various types of Finite Element Methods used for the calculation of burst strength of pressure vessel. The pressure at which the pressure vessel should burst if all of the specified design tolerances are at their minimum values is called burst pressure. Prediction of burst strength is the very important aspect in the pressure vessel design. The present study mainly focuses on various types of factors which tremendously affect the burst strength of pressure vessel. FEA is a very powerful tool used to determine burst strength of pressure vessel. Axi-symmetric FEA is carried out to accurately predict the burst strength of a thin cylindrical pressure vessel.

Leone Corradi and Lelio Luzzi (2005) [1] proposes a procedure for the evaluation of the collapse load of cylindrical shells subject to pressure and axial force, accounting for possibly significant wall thickness. The result is obtained by using the kinematic theorem of limit analysis, which produces the exact result instead of a mere upper bound_ provided that the collapse mechanism is identified without ambiguity. A crucial role to this end is played by the assumption of generalized plane strain, imposing that axial strains are uniform without preventing possible elongation of the tube. The assumption is reasonable for long cylinders under axially symmetric loading, since any attempt at possibly non uniform longitudinal strains is contrasted by the adjacent portions and received indirect corroboration by numerical analyses performed on tubes of moderate length, with no a priori enforcement of the constant axial strain condition.

III. PROBLEM STATEMENT

To modify the existing design available for container lifting device to improve the performance of solid waste management. Also identify the problem faced with the existing design of the container lifting device. Fig. 1 shows the existing working model in present.

Fig. 1: Container lifting device attached with tractor

IV. EXISTING MODEL REVIEW

In the existing model its operation is smooth in loading and unloading. But some problem are there with its hook design connected at the end of chain link which connects with anchor pin of container, it is found bend in some device so it is to be Re design again to safe lifting . The whole mechanism is to be analyzed in FEA software like Ansys to insure that there is no any stress concentration in any part of the container lifting device.

V. DESIGN METHODOLOGY

In designing container lifting device we have to Design (1). Double acting hydraulic cylinder of 5 ton capacity because a fully filled container of 4.5 cubic meter can hold maximum of 1.5 ton garbage. So to hold for factor of safety as 2 we design it for 5 ton. Empty weight of container is approx. 700 kg.

Design for double acting hydraulic cylinder of 5 ton capacity

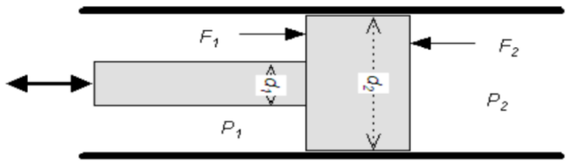

Fig. 2: forces acting on double acting cylinder

Force acting on the piston rod side can be calculated as follows:

$F_1 = \pi/4(d_i^2-d^2)$…………………….…...…….. (2)

F1 = rod pull force or retract force (N)

d = rod diameter (mm)

d_i = piston diameter or bore diameter (mm)

P1 = pressure in the cylinder (rod side) (MPa)

F2 = piston push force or extend force (N)

P2 = pressure in the cylinder (opposite rod) (MPa)

Force acting on the piston side can be calculated as follows:

$F_2 = \pi/4(d_i^2)$ P2……………………………… (3)

Data available are:

Weight of empty container of 4.5 m^3 capacity = 700 kg (approx)

Weight of filled container of 4.5 m^3 capacity = 1500 kg (average)

Pressure range = 100 to 200 bar

Hydraulic Cylinder Tube material ST52 and ST52.3 with excellent machinability and weldability.

So total weight to be lifted is = 700+1500 = 2200 kg

After solving these equation we get,

– Piston diameter d_i=99.96 mm =100 mm (standard)
– Piston rod diameter d = 61.27 = 63 mm (standard)
– Thickness of cylinder tube will be (t) = 8 mm
– Outside diameter of cylinder = 116 =115 (standard)

When we design a cylinder we design for 20 percent more load capacity to account for losses. In the present model we use outer diameter as 110 and inside diameter as 63 with maximum operating pressure as 200 bar.

Also we design chain link with capacity of lifting 5 ton load vertical.

VI. CONCLUSION

This paper shows that after studying and surveying existing model of container lifting device it is found that there is some minor issue are there associate with load bearing part like hook bend but small problem sometimes create a big problem in device. So it is to be redesign and should be tested in FEA software for safe operation and further study in modelling container lifting device in modelling software and check for any failure under extreme condition can be carried out with proper arrangement.

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