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DESIGNING OF MODIFIED FORKLIFT WITH DOUBLE HYDRAULIC BUCKET SYSTEM FOR COAL TRANSPORTING IN THE COAL MINE

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Abstract

A forklift is a lifting machine used to lift and move loads. It can move loads with different weight, without taking a longer time than when it is been lifted by humans. The Applications of forklift can be seen mostly at sea port areas and industrial loading areas. It is designed for coal moving purpose and must be applied in finding the hydraulic system and strength of the shovel lifting the coal. The forklift design consists of the hydraulic system and the dredging system and the amount of coal that can be lifted in one work is up to 3tons.

Keywords: Forklift, coal

Introduction

There is a need to move objects from its original place to a desired destination. In the area of development, industry, ports and any similar area in the workplace for example, special equipment is needed to move materials with various types of shapes and sizes, which would be impossible to move by humans. To make the work less stressful and simple, a material transfer machine is needed to lift and move the materials (Jimmy, 2014)

Amongst the many types available, heavy equipment are often used in construction, port, industrial areas, and coal mine activities. This heavy equipment has different characteristics, methods of work, and dimensions according to the conditions of the field, the number, shape and size of items to be transported. Forklifts are examples of heavy equipment used in the lifting and moving of materials with different heights impossible to move by humans.

Figure 1 2C3000-2C6500 series CAT Forklift

An object given a heavy load continuously will experience fatigue which could lead to damage. If the forklift is not properly designed, it would not last long and would cause work accidents that can endanger the lives of workers. It is therefore necessary to do a research and create a design that is aimed at producing a strong and safer forklift.

The mainstream forklift is not suitable in the lifting of coal because of its design. The common forklift has just two arms used in lifting wooden pallets and most materials are basically been lifted by the wooden pallet. Coal can be lift by a dredging system that resembles a shovel so the design of the forklift has to be adapted.

In this study, the modified forklift design will be studied to provide more insight on its strength and the dredging system. This modified forklift design can be used to learn and understand its working principle.

The proposed system

In lifting heavy object such as coal, the forklift is required. With the modified forklift, transporting objects can be done vertically or angularly. Forklift is generally used to transport wooden pallet containing heavy items and it is necessary to have a thorough calculation in order to avoid problems goods transporting process. It would be made an experimental tool so as to know how it works from the original forklift.

This research is based on an applicative problem, which can be framed into 3 main problems; how to design the modified forklift, how to select a suitable motor used as a forklift drive, and how to analyse the strength of the forklift. For the purpose of this research, a literature study is needed to determine the required supporting theories, design and manufacture of tools, testing and analysis, as well as drawing conclusions

The methodology

The research methodology was carried out so that the research process would proceed systematically with several stages including: determining the objectives of the research, gathering the theoretical basis, determining the research procedure, and calculating the strength of the lifting system.

The lifting and tipping of a forklift is a mechanism that greatly determines the performance of the forklift. Components of this mechanism are the lift cylinders that function in raising and lowering the load and the tilt cylinder which functions in pulling the load

In this modified forklift design with various considerations on the condition and the availability.

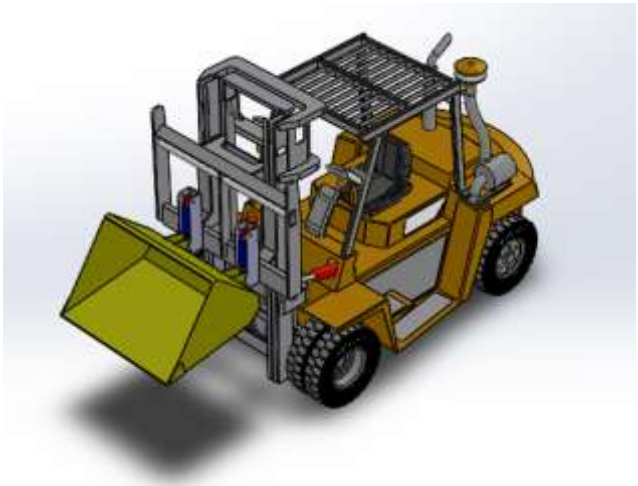

Figure 2. Modified forklift design

The lift cylinder is designed to lift a load of 7tons. The lift force must be calculated to ensure the cylinder can lift a load and based on the chain making type, the value of n can be determined. Calculation of cylinder lift force can be calculated using the equation:

$$Fsil = Wa + \frac{Wa}{n}$$

Description:
Fsil: hydraulic cylinder force (N)
Wa: large weight of lift load (N)
n: chain efficiency

Table 1. Forklift Specification

Forklift Specification	
Engine	Izuzu 6BG1
Power	114 HP @2000 rpm
Transmission	2 forward acceleration and 2 reverse acceleration
Fuel	Diesel
Dimension	Pxlxt (3600mm x 1995mm x 2250mm)
	Weight 16330 kg
Wheel	Front 8.25 x 15 – 14 PR.
	Rear 8.25 x 15 – 14 PR.
Brakes	Hydrolic
Lifting mechanism	2 strokes
	Max. heigh of 3000m
Weight capacity	7 ton
Lifting speed	550 mm/s (without load)
	460 mm/s (with load)
Forward speed	18.64 mph (without load)
	16.16 mph (with load)
Reverse Speed	18.64 mph (without load)
	16.16 mph (with load)

The following is the hydraulic lifting mechanism found on a forklift:

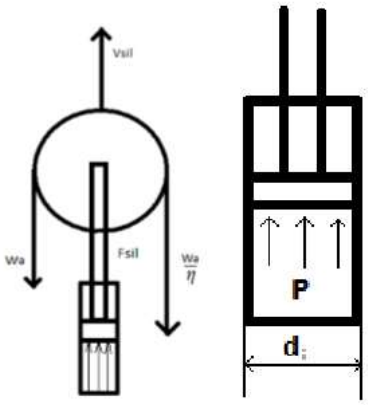

Figure 3. Hydraulic lifting mechanism

The hydraulic pressure checks on hydraulic lifts can be calculated using the equation below:

$$p = \frac{F}{A}$$

Description:
p: hydraulic pressure (N / mm)
F: hydraulic cylinder style (N)
A: hydraulic cylinder base area (mm2)

For the calculation of hydraulic pressure, the area of the cylinder base is needed. The area of the base can be calculated using the equation below:

$$A = \frac{\pi}{4} \times d^2$$

Description:
A: base area of the hydraulic cylinder (mm2)
π: constant to find the area of the circle
d: diameter of the circle of the cylinder base (mm)

There is a force that works from the frame to the mast, the F1/2 style. F1/2 style can be searched by pulling the hinge force line and making a long line from the point of the hinge past the point m so as to get the force diagram

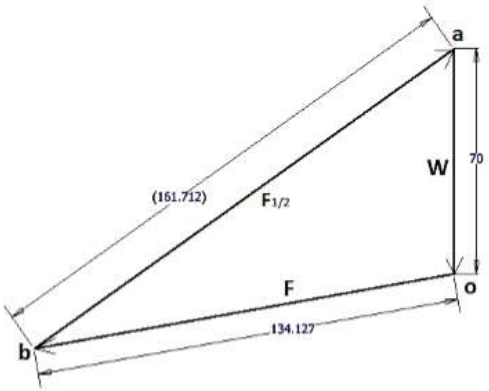

Figure 4. Polygon force diagram

From the drawing, the style equation can be taken to find a large cylinder style. The style that can be used is as seen below:

$$\Sigma F = 0$$
$$\Sigma F = \overline{W} + \overline{F} + \overline{F_{1/2}} = 0$$
$$F = \frac{ob}{oa}.W$$

Description:
W: force weight direction of charge (N)
F: cylinder force (N)
oa: long distance of the charge line (mm)
ob: long line style line (mm)

The transmission system used for these mechanisms is the chain transmission, with type BL-634. To calculate the stress that occurs in the chain, the equation below can be used:

$$\sigma = \frac{F}{A}$$

Description:
σ: Tensile stress (Nmm)
F: Tensile force that occurs in chain (N)
A: Area in chain (mm2)

Result and discussion

The amount of force needed to drive the cylinder can be calculated using Equation (1) with a value of η = 0.9 so as to get:

$$F = 68670\ \text{N} + \left[\frac{68670\ \text{N}}{0,9}\right]$$

$$F = 144970\ \text{N}$$

And the pump power can be calculated using Equation (2) and get:

$$p = 68670\ \text{N} \times 0,23\,\text{m/s}$$

$$p = 27\ \text{kW}$$

To calculate the weight of the tilt cylinder, Equation (5) can be used with a length of W = 71,451cm; length F = 163,308cm; length R = 166.5cm; and large W = 7tons = 7,000kg so as to obtain:

$$F = \frac{134,127\ \text{cm}}{70\ \text{cm}} \times 7000\ \text{kg}$$

$$F = 13412,7\ \text{kg}$$

To get a large tilt cylinder, it must be multiplied by gravity so that the below obtained

$$F = 13412,7\ \text{kg} \times 9,81\ \text{m/s}^2$$

$$F = 131578,578\ \text{N}$$

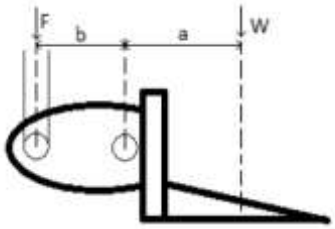

Figure 5. Tilt Hydraulic mechanism

The calculation of the weight of F can be done using Equation (6), with a length of b = 25cm; length a = 76cm; W = 7tons to obtain:

$$W \times a = F \times b$$

$$7\ \text{ton} \times 76\ \text{cm} = \text{F} \times 25$$

$$F = \frac{76\ \text{cm} \times 7\ \text{ton}}{25\ \text{cm}}$$

$$F = 21280\ \text{kg}$$

To get cylinder of 2 tilt force, it must be multiplied by the gravitational force with g = 9.81 m / s2 so that the below would be obtained:

$$F = 21280\ \text{kg} \times 9,81\ \text{m/s}^2$$

$$F = 208756,8\text{N}$$

While to calculate the power of the pump on the cylinder, 2 tilt can use equation (3, 4) with V = 0,05 m / s2 so as to obtain:

$$p_p = 208756,8\text{N} \times 0,1\text{m/s}$$

$$p_p = 21\ \text{kW}$$

Calculation of the occurrence of the tensile stress in the chain using Equation (7) and the below obtained:

$$\sigma = \frac{\frac{34335\ \text{N}}{3}}{57,9635\ \text{mm}^2}$$

$$\sigma = \frac{11445\ \text{N}}{57,9635\ \text{mm}^2}$$

$$\sigma = 198\ \text{N/mm}^2$$

Calculation of the stress allowed on the sprocket using Equation (9) and obtaining:

$$\sigma = \frac{1918688,85\ \text{Nmm}}{403,81\ \text{mm}^3}$$

$$\sigma = 4752\ \text{N/mm}^2$$

The bucket when given load of 7tons is as described below.

a. Shear Stress

The coal weight is represented as a force and the whole bucket area will be affected. There is a parameter scale on the left, the red area is the highest while the blue area is the lowest.

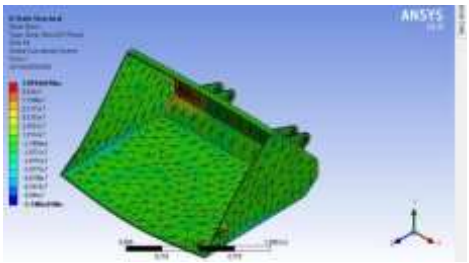

Figure 6.Shear stress analysis result (Ansys, 2015)

Based on the simulation results above, the bucket of the forklift will be safe because it is still in the green area.

b. Shape Change Analysis (Displacement)

Displacement is the change in the body shape due to its subjection to force. The part that suffers the greatest displacement is the most coloured red area, while that with the smallest displacement is the highly colored blue area (Fauzi, 2013). The displacement simulation results can be seen in the figure below.

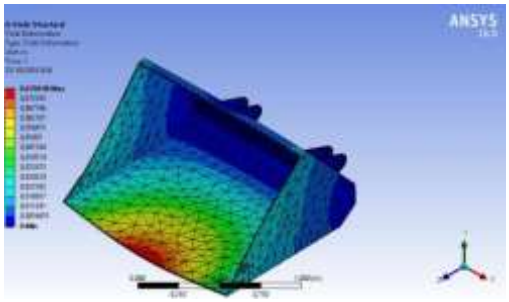

Figure 7.Deformation analysis (Ansys, 2015)

Based on the results above, the greatest displacement value occurred on the red part of 0.035797m

Conclusion

From observations, the conclusion on the calculations and analysis carried out, shows that the lift mechanism of the forklift lift system is efficiency = 0.9, the amount of the hydraulic is 2, while the diameter is 80 mm. The type of chain used is the ISO 606 / ANSI B29.100 with a tensile load = 17,000kg, and the results of the tensile stress occurrence in the chain is σt = 198 N / mm2. The load lifted by the forklift is 7,000kg, the pump power of the lifting system 27kW, pump power for the tipping system is 26.3kW, and the power for the tipping system 2 is 21kW. The hydraulic lift system circuit used is a series circuit, with a 3 4/3 directional control valves that works alternately. The material for the sprocket structure on the forklift lift system uses steel with a tensile load = 17,000kg and the tensile stress that occurs on the sprocket is σt 979 MPa.

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