Fabrication and Testing of an Improved Hydraulic Accumulator for a Truck Loading Lift

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Abstract- **The hydraulic accumulator stores the required amount of energy in the form of pressurised fluid from a pump, and then expends this energy when it is fully charged within a short time in order to do work effectively. The improved hydraulic accumulator for a truck loading lift operates at an efficiency of 52.6%. The machine operates with a manual pump and the lift system comprises of set of linkages made of mild steel which transfers power from the hydraulic accumulator to the load lifting operation. The machine stands at a total height of 1.62m and its frames are made of angular mild steel bars.**

Keywords- **Fabrication, Hydraulic Accumulator, Truck loading, Lift.**

I. INTRODUCTION

Hydraulic accumulator is a pressure storage vessel in which a non-compressible hydraulic fluid is held under a high pressure by an external source. The external source can be a spring, a raised weight, or a compressed gas. Hydraulic accumulators have been widely employed in many hydraulic systems such as the Suspension systems of numerous cars, the Tower Bridge in London, the hydraulic control systems of aeroplanes and in other numerous hydraulic machines and systems [1]. The function of the hydraulic accumulator is analogous to that of the flywheel of a reciprocating engine and an electric storage battery. It damps out pressure surges and shocks in the hydraulic system and thus functions as a pressure regulator [2]. The hydraulic accumulator truck loading lift operates by having the hydraulic accumulator receive a small power input over an extended period of time. The power is in the form of pressured fluid which is accumulated and used to power the ram of the integrated hydraulic lift. The lift stroke takes place in a shorter duration of time thereby improving the machine efficiency and maximizing energy and labour. The power input of the machine could be from a small electric pump or a manual pump. The engine pumps hydraulic fluid in low pressure pulses through a non-return valve to charge the accumulator over a longer period of time. When the hydraulic accumulator is charged to its capacity, it will power a full lift stroke of the heavy duty lift. This makes this machine highly functional in load at small cement deports and factories where the lift machine is required to lift bulky loads to certain heights quickly then lowered to be reloaded before lifting again. The lowering and reloading period is enough for the hydraulic accumulator to be recharged. This makes the machine a very effective machine in loading of cargo into trucks [3, 4].

Up till now, there is little or no work done on hydraulic accumulator for local factory utilization. Okegbile et al [5] designed an improved hydraulic accumulator for a truck loading lift. The design has a machine load capacity of 2500N with a lift platform of 40×50mm and is capable of lifting loads to a height of 1100mm from its minimum height of 40mm. The hydraulic accumulator ram is 72mm in diameter and 25kg in weight. This paper presents the fabrication and testing of an improved hydraulic accumulator for a truck loading lift using locally available materials. The lift machine is aimed at providing a more energy efficient lift machine for small loading applications in our cement deports and factories.

II. METHODOLOGY

A. Materials Selection

The material selection for the Hydraulic accumulator lift is based on availability, cost and functionality. The three material used are mild steel, high carbon steel and rubber. Their properties are discussed below [6].

1) Mild Steel

Mild steel has a carbon content of 0.16-0.29% and is grouped under Carbon Steels. Its low in price (compared to other carbon steels) and multipurpose application in many engineering construction makes it a very economic engineering material. It is relatively ductile and malleable. It has a density of 7850kg/m^3 and Young's modulus of 206.5GPa. Due to these properties and its availability, machinability and good strength quality, it was convenient to use in the construction of angle frame bars, hollowed link shaft, load platform and cylinder anchor plate. Mild steel has found applications in various other locally available fabricated machines such as refrigeration [7-9], water heater [10] and groundnut shelling, roasting and oil expelling machines [11-13].

2) High Carbon Steel

It contains 0.3-1.7% by weight of Carbon and characterized by its hardness. It is much less ductile than Mild steel and has a Young Modulus of 210GPa. It is used in applications where high strength is very much needed such as Hydraulic Ram Cylinder, Hydraulic Ram Shaft, Piston and compression springs [14].

3) *Rubber*

It has a very good elastic property and is very much available. Hence its use for the Seal rings and pipes. The flexibility of rubber makes it suitable for the connecting pipe of the hydraulic pump and accumulator. For the seal rings on the cylinder, the elastic property of rubber allows the seal rings to maintain a complete leak proof seal for the piston and ram shaft as it moves through the hydraulic cylinder [6].

B. *Procedure for Fabrication*

1) *Fabrication of Stand Frame*

A mild steel angular bars measuring $38 \times 38 \times 3mm$ was used for the fabrication of the stand frame holding the hydraulic accumulator lift. The fabrication operations were carried out on the angle bars while held in place by a vice as follows: The length of the various members of the frame were determined and marked on the angle bars. The bars were then cut to the dimensions specified above. The cut ends of the angle bars were surfaced to produce a smooth surface and the cut bars were then welded according to design to produce a rigid frame.

2) *Fabrication of Hydraulic Accumulator*

The Hydraulic accumulator cylinder is made up of high carbon steel. It measures 80mm in diameter and 8100mm in height. The hydraulic accumulator was fabricated from the hydraulic ram of a heavy duty construction vehicle. The following operations were carried out in construction of the hydraulic accumulator: The lower cover of the hydraulic ram was open and the shaft removed to allow for the compression springs to be placed inside. When the two compression springs were placed inside, the piston and shaft were re inserted and the lower cover replaced. The valve opening that will serve as the inlet and outlet valve was made in the lower portion of the lower compartment of cylinder using a blow torch. The anchor of the hydraulic accumulator was welded to the stand frame and the accumulator was mounted on it.

3) *Fabrication of Lift Linkage*

The links are hollow rods made up of mild steel and are 18mm in outer diameter and of thickness 2.5mm. The rods were cut according to the design, three frontal links and one rear link. The cut ends of the bars were surfaced to produce a smooth surface. Then the bars were welded together to form the link arm and then they were attached to hinges on the frame to allow for the desired motion. The slider rod was also attached to the ram shaft with the aid of a hinge support.

4) *Fabrication of Metal Plates*

The metal plates consist of the anchor plate and lift platform. The metal plates were used for the Load platform and the anchor plates that hold the hydraulic accumulator. The Anchor plate was cut to dimension $160 \times 200 \times 5mm$. Then the edge was chaffered and was curved in order to form a fit for the curve surface of the hydraulic accumulator. The lift platform was cut to dimension $380 \times 200 \times 3mm$. The plate was bent 10mm at the two edges of the 380mm length and then it was attached to the lift link with hinges.

C. *Assembly*

The fabricated components were coupled to form the lift machine using the following procedures:

After the lift linkages were attached to the lower end of the frame, the load platform was attached to the forward linkages with hinges that allowed it to maintain a permanent horizontal position at every position of the linkages in the lifting of loads. The hydraulic accumulator was mounted in a vertical position on the stand frame with aid of a lower supports and anchor plates. The positioning for the hydraulic accumulator was such that the ram shaft moved out downward from the cylinder. This is such that the hydraulic accumulator does work by forcing the ram shaft out downward thereby pushing down on the rear linkage which therefore lifts the forward linkages. The hydraulic accumulator was connected to a pump by a high pressure connecting pipe. The rubber flexible pipe linked the inlet/outlet opening on the hydraulic accumulator to the pump. The pump supplied the pressured fluid to fill the lower part of the hydraulic accumulator. The pump has a reservoir that stores up the hydraulic fluid when the machine does work in forcing out the fluid. The pipes were fastened to the pump and hydraulic accumulator using clips. Then the entire machine was painted blue for ergonomic and to protect it from corrosion as shown in Figure 1.

Figure 1. Assembled Hydraulic accumulator lift machine

D. Maintenance

The Hydraulic accumulator is a hydraulic system and hence all general maintenance of hydraulic should be observed with this machine. The machine should not be store or use under corrosive conditions to avoid developments of leakages. The machine's link fulcrum should always be kept oiled to avoid difficulties when using the lift machine.

III. TESTING AND EVALUATION

A. Operation and Testing Procedures

Below are the procedure for the test and operation of the hydraulic accumulator lift machine.

- First the hydraulic accumulator was emptied of all hydraulic fluid and air that was in the lower chamber of the hydraulic accumulator by opening the non-return valve tap of the hydraulic pump. This made the hydraulic fluid to return to the reservoir of the pump.
- The tap was closed and the reservoir was filled to the top.
- Now the piston and ram shaft were at their lowest positions respectively and thus the load platform at its maximum height.
- Then the pump operation began by moving the pump handle back and forth reciprocally through its full span of stroke.
- This caused the hydraulic fluid to flow through the non-return valve into the lower chamber of the hydraulic accumulator through the connecting pipe.
- As the pumping continued, the fluid kept filling the lower compartment therefore moving the piston and shaft upward and hence lowering the load platform and frontal links until they were at ground level.
- It was kept at this position for a few minutes to ensure that there were no leakages and that the hydraulic accumulator was capable of holding up or storing energy for long.
- After that, a load of 420N was placed on the load platform.
- The non-return valve tap was then released, allowing the compressed spring to push down on the piston and shaft and hence moving the load up and returning the hydraulic fluid back into the pump. After 627 strokes, the load moved through a distance of 94m.
- The experiment was repeated for three times and the average values recorded.

B. Performance Evaluation

The overall lift machine efficiency can be expressed as the ratio of work input (work from hydraulic pump) to work output (load lifting), expressed in percentage.

The Efficiency of the lift machine may therefore be expressed as:

$$\eta = \frac{W}{W_h} \times 100 \qquad (1)$$

Alternatively;

$$\eta = \frac{MA}{VR} \times 100 \qquad (2)$$

Where,

$$MA = \frac{F}{F_h} \qquad (3)$$

$$VR = \frac{L_h}{L} \qquad (4)$$

The distance moved by the effort is given as:

$$L_h = d_s \times N_s \qquad (5)$$

Where, η is efficiency of the lift machine (%); MA is mechanical advantage; W is work output; W_h is work input; VR is velocity ratio; F is load; F_h is effort; L is distance moved by load (m); L_h is distance moved by effort (m); d_s is the stroke distance (m); N_s is number of stroke.

IV. RESULTS AND DISCUSSION

The details of the machine and the results from the test carried out are tabulated in Table 1. The improved hydraulic accumulator for a truck loading lift was able to lift a load of 42kg through a distance of 1m using 627 strokes of the pump. The Mechanical Advantage and Velocity ratio of the machine were 49.4 and 94 respectively. The overall efficiency of the machine was 52.6%. The efficiency is acceptable to perform as an energy efficient lift machine for small loading applications in cement deports and factories.

Table 1: Machine details and test results

Parameters (Units)	Values
Load carried (kg)	42
Force of stroke of pump (kg)	0.8
Number of pump strokes	627
Strokes distance	0.15
Total volume of hydraulic fluid (l)	2
Load lift height (m)	1.0
Weight of machine without fluid (kg)	57
Weight of machine with fluid (kg)	58
Height of machine (m)	1.63
Maximum height of load platform (m)	0.85
Width of machine (m)	0.28
Mechanical Advantage	49.4
Velocity Ratio	94
Overall Machine efficiency (%)	52.6

V. CONCLUSIONS

The fabrication and testing of the hydraulic accumulator for application in a truck loading lift has been performed. The machine's capacity to store energy (in the form of pressure hydraulic fluid) with its hydraulic accumulator makes it a highly effective machine in loading trucks. From the test of the Hydraulic accumulator lift, it was determined that the machine operates at an average efficiency of 52.6% as it was able to lift a load of 420N to a height of 1m. The machine fines it usage in a small scale truck loading application.

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