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# Composite Fluid Hydraulic Lift

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**_Abstract_**

*In the industrial application hydraulic lifts have a variety of applications on a massive scale. As the energy resources required for the operation are relatively high as compared to the output provided by lifts, there is an alarming rate to optimize the process. So, to bridge the gap we have come up with an innovative and exclusive fabrication of the hydraulic lift systems based on the use of Composite Fluids for the operation. This will eventually lead to the energy conservation at the input level with high performance rate and output. To maintain the same displacement at output by reducing the input effort of the hydraulic system compared to existing hydraulic system by using a 'Non-Uniform Composite Fluid' by employing the thermal effects on it as well.*

**Keywords:** Hydraulic lift, composite fluid application, energy conservation, thermal application, numerical analysis

## INTRODUCTION

Hydraulic lifts are advantageous in many aspects over mechanical lifts, but inevitably all comes down to the cost, where the hydraulic elevators outweigh by far. Nevertheless, over the last years an awareness concerning the energy saving and the carbon footprint of all installations has risen and as a natural effect the lift installation of any construction is now evaluated from that aspect as well.

At first glance, the hydraulic elevators are more than enough impaired against mechanical ones at their energy levels, mainly because of their installed capacity and power consumption. This is mainly due to their operating principals and one might invoke that it is "a psychological disadvantage" that does not fully reflect with the reality. This is easily understood if we consider that although a hydraulic lift usually requires three times the power levels of a mechanic one, on the other hand, this power is consumed only during ascent and not during the descent of the elevator [1]. Thus, building on this work, on the input side the power consumption must be optimized maintain the same output as involved in the lifting mechanism for industrial use.

To reduce the energy consumption and power installation requirements, the energy-regenerative hydraulic elevators have been developed since 1997. In this paper, different generations of the design are discussed for energy-regenerative system; in particular, a new generation is focused on in detail. Experimental studies of this new design are carried out to compare the energy consumption of different system designs of hydraulic elevator. Finally, a conclusion is drawn that the new generation of hydraulic elevator can achieve a significant energy-saving performance compared to the traditional elevators [2].

The concept of energy regeneration can be taken forward to change the composition of fluid involved, perhaps unlike some composite

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materials, composite fluids can also show some relevant properties towards energy saving through some specific means.

Barewar et al. [3] have fabricated a screw jack to automatic. The screw jack is a device which is used to lift the heavy loads with the application of small force. The effort which is required to operate the screw jack is made easy and reliable by using 12V DC motor, the motor works with the battery used in vehicle. The rotary motion is transferred from motor to lead screw through worm gear drive. The gear which is mounted on motor shaft is pinion and the driver gear is mounted on lead screw caused to transfer rotary motion. By fabrication of screw Jack, it is easy to operate and lift the heavy loads by pressing the switch. This indeed gives an insight idea of lifting heavy loads by applying small magnitude force, which can also be achieved in case of hydraulic lifts.

Hydraulic lift is a type of machine that uses a hydraulic cylinder to lift and lower objects by applying relatively small force compared to the weight of the objects to be lifted. Its working is based on Pascal's Law [4].

i.e. $[F_1/A_1 = F_2/A_2]$ (Eqn.1)

$P_1 = P_2\ [A_1 \neq A_2]$

So, the lifts which operate on the conventional basis are effective with heavy loads as the power provided at input results in great lifting efficiency.

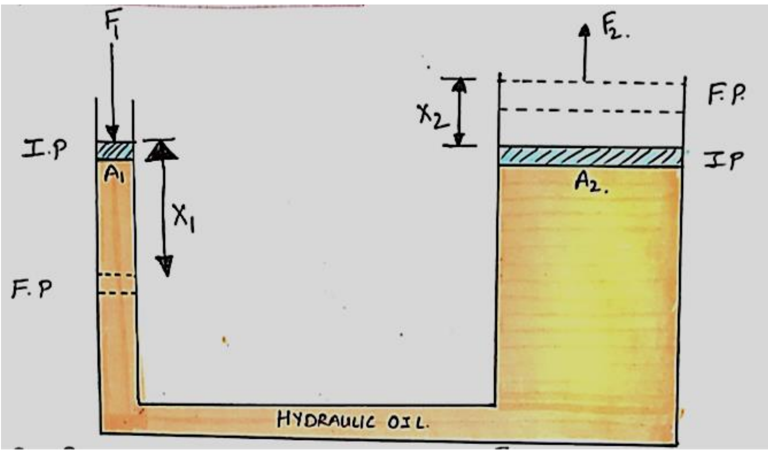


**Figure 1.** Conventional Setup.

From the Figure 1, we can state

$F_1X_1 = F_2X_2$

$X_1 = (F_2/F_1)^*\ X_2$

$= (A_2/A_1)^*\ X_2$ (from Eqn.1)

$X_1 = [A_2/A_1]\ X_2$
$X_2 = [A_1/A_2]\ X_1$

Generally,

$F_1 = (A_1/A_2)^*\ F_2$

 

$F_1$= $(F)_{external}$ (completely)

In the above expressions, $F_1$ stands for the external input force required to actually push the piston down at the inlet to cause a certain displacement. So the main focus is to reduce this magnitude of external fore requirement by inducing some internally induced forces to compensate the energy conservation and maintain the same output (the displacement caused at the output) by employing a composite fluid application, which in this case is Mercury (Hg) with the conventional Hydraulic oil. This modified mechanism involves the usage of the fluid properties of mercury and the thermal aspects of the same [5].

## HYPOTHESIS (PROPOSED APPROACH)

The main objective of this hypothesis formulation is to reduce the external force requirement to cause the same lift in a quantitative way. However, magnitude wise the total input force remains the same. This can be achieved if there are some internal forces are generated by some means which drives the mechanism as it was driven before. In this case Mercury is used to compliment that role as it has some exceptional fluid properties such as very high density, very less Compressibility and ability to show volumetric expansion on heating. So, to state the fact down to the line, to reduce the external applied input force we bring in the concept of composite fluid.

i.e. Hg + Conventional oil

By stating the above combination, it actually implies that Hg is only used in some percentage complimenting the conventional oil to cause some desirable results.

Now further the Hg Column is subjected to some temperature changes by using the heat exchangers and further the results are numerically analysed (Figure 2).

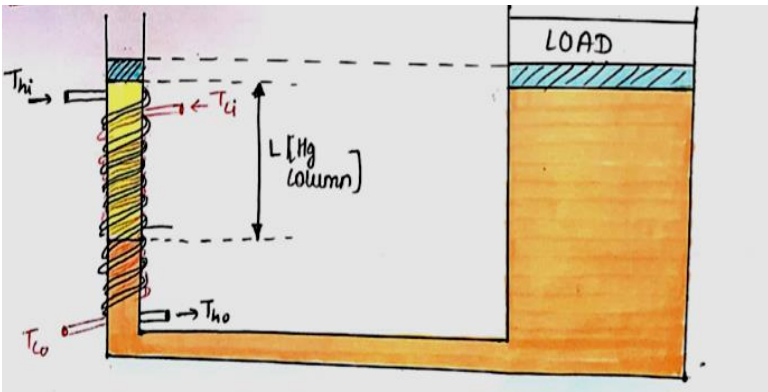


**Figure 2.** Modified Setup.

This is the initial setup for the composite fluid hydraulic lift without force being applied at input. The limb containing mercury as a composite fluid is surrounded by Heat exchangers to cause a certain rise in the temperature of the mercury column [6].

### Mechanical and Thermal Analysis Behind using Mercury (Hg) as A Part of the Hydraulic Fluid [7]

High Density as that of convectional hydraulic fluid; Primary auxiliary force (F') analysis
$\boldsymbol{\rho}$=13600 kg/m$^3$ $\boldsymbol{\rho}$=m/v
m= $\boldsymbol{\rho}$.v so, $m_{Hg}\ \alpha\ \boldsymbol{\rho}$
Weight = $m_{Hg}$ g

So, the force exerted by the mercury column is given by the formula

 

Due to weight (mg) of Hg Column, F' is induced in the downwards direction which is given by

$F' = mg$

$F' = \rho V g$
$F' = \rho A_1 L g$ (Eqn.2)

Thus, the weight itself act downwards helping the initial input force to a certain level.

Ability of Hg to show Volumetric Expansion on Heating

The Hg column as shown in Figure 2 is surrounded by the heat exchanger which is responsible to maintain a proper temperature of the respective column as per the modified operation (Figure 3).

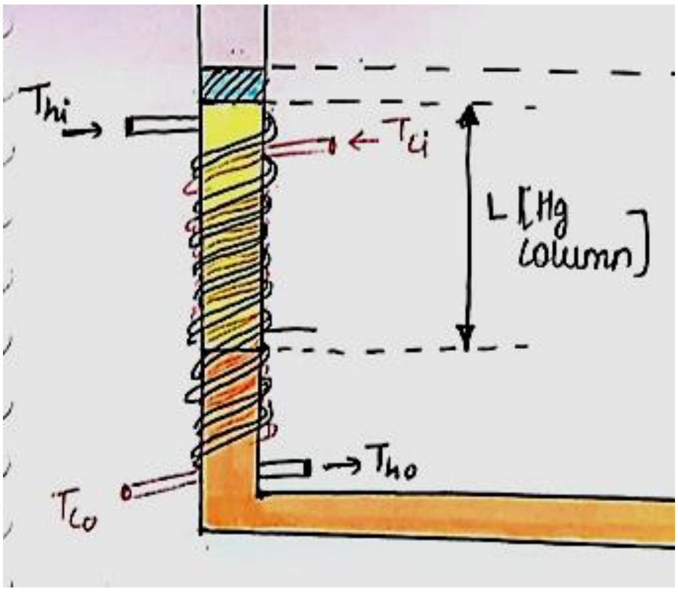

**Figure 3.** Heat Exchanger setup.

Let the fluid entering the inlet of the H.E. coils have following specification

For Hot fluid
a. Input temperature $T_{H(i)}$ ($T_{H(i)} > T_{Hg(i)}$)
Exit temperature $T_{H(o)}$
b. Mass flow rate $\dot{m}_h$ (kg/s)
c. Specific heat of fluid in H.E. $C_{Ph}$ (kJ /kg-k)
d. Input temperature $T_{C(i)}$
For Cold Fluid

Exit temperature $T_{C(o)}$ ($T_{C(i)} < T_{Hg}$)
e. Mass flow rate $\dot{m}_c$ (kg/s)
f. Specific heat of fluid $C_{Pc}$ (kj/kg-k)

***Heating of Hg Mechanism***
$Q_{given} = Q_{taken}$ ($T_{H(i)} > T_{Hg}$)
$\dot{m}_h C_{Ph} [T_{H(i)} - T_f] = (\dot{m}_c)_{Hg} C_{Pc} [T_f - T_{Hg}]$

The temperature of the mercury inside the column rises.

 

***Cooling of Hg Mechanism***

$[Q_{given}]_{Hg} = Q_{taken}$

$[\dot{m}_h]_{Hg} [T_{Hg} - T_f] = \dot{m}_c C_{Pc} [T_f - T_{C(i)}]$

The temperature of the mercury inside the column decreases.

Therefore, in this way the H.E. acts as a catalyst in the uplifting mechanism of hydraulic systems which impart the required temperature difference to cause the desired effects within the Hg column

Now we know that

$e_V = \alpha\Delta T$ ($\alpha = 181 * 10^{-6}/°k$) $V_1 = (\pi/4).d^2.L$ ………....(without Heating)

Now when the temperature is increased by $\Delta T$ by the use of heat exchangers the initial volume $V_1$ increases i.e. $V_2$

$\Delta V/V_1 = e_V$…………… (volumetric strain)

$\Delta V/V_1 = \alpha.\Delta T$ ………… (thermal strain)

$(V_2 - V_1)/V_1 = \alpha.\Delta T$

$V_2 = V_1\alpha\Delta T + V_1$

$V_2 = V_1 [1+\alpha\Delta T]$

$V_2 = V_1 [1+181 * 10^{-6}\Delta T]$ (Eqn.3)

This increase in volume after heating cause a certain change in pressure exerted by the Hg column which is dependent on the final temperature attained.

As the internal pressure of Hg column varies with temperature rise or fall, a resultant force can be calculated exerted on the oil to assist the mechanism (Figure 4).

Pressure variation and its effect of the Hg Column with the temperature variations; Secondary auxiliary Force (F'') analysis.

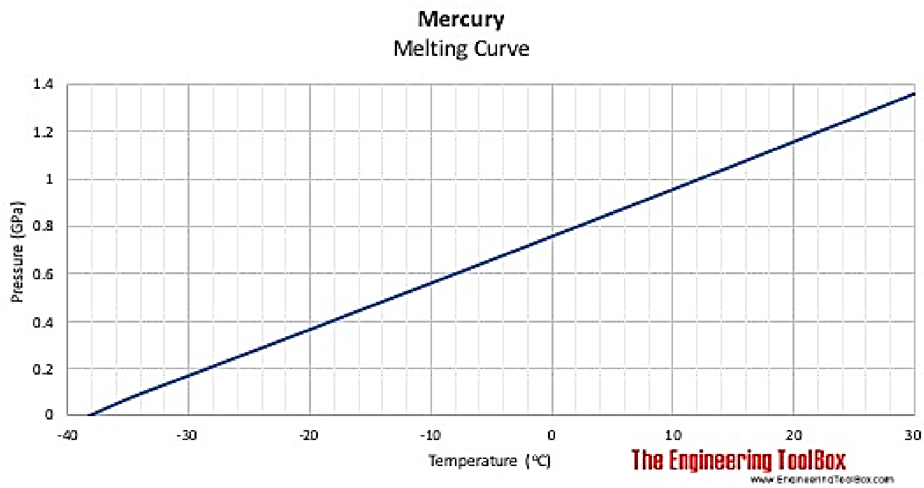


**Figure 4.** Pressure vs. temperature graph of mercury fluid [8].

Consider any two points on the graph.

Let them be,

| | |
|---|---|
| $(X_1, Y_1)$ | (0,0.8) |
| $(X_1, Y_1)$ | (30,1.4) |

By two-point form, the equation of the line is given by-

 

$(X – X_1)/(X_2 – X_1) = (Y – Y_1)/(Y_2 – Y_1)$
$(X – 0)/(30 – 0) = (Y – 0.8)/(1.4 – 0.8)$
$X/30 = (Y - 0.8)/0.6$ ………(i)

Now we know that from the graph X coordinate stand for “Temperature” and the Y coordinate stands for “Pressure”.

So, by substitution i.e. X = T and Y = P in (i) we get,
$P = (T/50) + 0.8$……. (ii)

Now we know that at inlet we have,
$F = P.A_1$……………….. (iii)

The force exerted by the Hg column on the conventional oil at the room temperature ($T_R$) is given by, From (ii) and ()
$F_0 = [T_R/50] +80$……. (iv)

After some time when the temperature is increased from $T_R$ to $T_{required}$ the magnitude of the force changes which is
$F_0' = [T_{required}/50] +80$……. (v)
Since $A_1$ is constant and $T_{required} > T_R$

Thus $F_0' > F_0$

The force applied by the mercury column is, from (iv) and (v), we get
$F'' = F_0' – F_0$ (Eqn.4)

**WORKING**

Now we apply certain load at inlet, to lift the load at the outlet by causing a certain displacement at inlet, at the expense of thermal expansion of ‘Hg’ and applying force at the inlet ,with change in temperature i.e. rise in temperature, the pressure inside the Hg column also varies resulting in the generation of internal force in the direction of motion of the external force being applied so this will also assist in the lifting mechanism to some extent. The below Figure 4 shows the full assembly in action ,the initial input force is applied at the input ,the temperature of the Hg column is risen up due to the heat exchangers and the auxiliary forces are induced within and the rest mechanism as that of conventional system (Figure 5) [5].

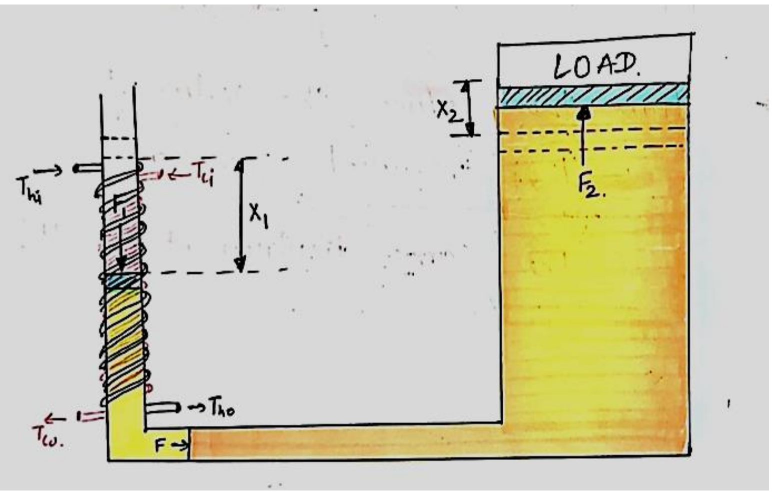


**Figure 5.** Working.

$F_1$ => Initial applied force at inlet
$F_2$ => Obtained force at outlet

Due to the external assembly made the auxiliary forces are induced and their magnitude is given by

$F' = \rho_{Hg} A_1 L g$……. (from Eqn.2) and
$F'' = F_0' - F_0$………… (from Eqn.4)

These forces, which are induced internally will assist the external input force to maintain the same lift at outlet and accordingly reducing the external force requirement for the general operation.

## CONCLUSION

The following promising conclusion can be drawn out by the above analysis and numerical formulations that,

In the existing setup $F_1 = (F)_{external}$ [completely]
And by using modified setup
$F_1 = (F')_{external} + F' + F''$
Therefore $\mathbf{(F')_{external} < (F)_{external}}$

Magnitude wise there is no reduction in the input force but the externally required force can be reduced to a suitable extent by employing the modified setup for a better performance.

Thus, this reduces the value of $F_{external}$ required for causing the same displacement at the outlet

## REFERENCES

1. Theocharis Ch. Dimitrios. (November 2013). Energy efficiency of the hydraulic lifts: reality and perspectives. [online]. Available at: http://biofial.gr/biofial/wp-content/uploads/2014/01/article-ENG-low.pdf
2. Yang Huayong, Sun W, Xu B. New investigation in energy regeneration of hydraulic elevators. IEEE ASME Trans Mechatron. 2007;12(5):519–26. doi: 10.1109/TMECH.2007.905691.
3. Barewar Abhishek Madhukar, Padole Abhishek Ashok, Yugal Dhanpal Nagpure, et al. Fabrication of automatic screw jack. Int J Adv Res Dev. 2018;3(4):64–7.
4. TechTarget Contributor (2017). hydraulics. [online] WhatIs.com. Available at: https://whatis.techtarget.com/definition/hydraulics
5. Basic hydraulic principles. Vol. 07. p. 25 [online]; 2009. Available from: http://www.brighthubengineering.com/hydraulicscivilengineering/43171-what-are-the-basic-principles-ofhydraulics/.
6. iKONIC mercury hydraulic lift, UK bespoke lift specialist. Providing design, engineering, installation and service solutions for Passenger, Goods and Platform lifts [online]. Available from: https://www.ikoniclifts.co.uk/products/mercury-hydraulic-passenger-lift/.
7. Saeid NH, Seetharamu KN. Finite element analysis for co-current and counter-current parallel flow three-fluid heat exchanger. Int J Numer Methods Heat Fluid Flow. 2006;16(3):324–37. doi: 10.1108/09615530610649744.
8. Engineeringtoolbox.com. (2021). Mercury—Melting Curve—Temperature vs. Pressure. Mercury: Thermodynamic Properties. [online] Available at: https://www.engineeringtoolbox.com/mercury-d_1002.html

 