Energy efficient hydraulic lift engineering essay

ASSIGN BUSTER

An attempt will be made to develop an energy efficient lift which does not consume any external energy source. The potential energy that is going waste through gravity downward movement is applied through hydraulic means and it is reutilized for upward movement.

The energy efficient lift (prototype) is developed in such a way that it will consume an energy developed by itself during downward gravitational movement. The energy stored during this will be used for the upward movement of cage. This prototype consists of a cage, counterweights and hydraulic motor with pulley, accumulator, and a tank with oil.

The prototype is worked as follows: Initially the cage is at the bottom which is moved up without any load in it with the help of balancing counterweights. Now, this cage can bring the load to the bottom as the gravitational force of load is greater than the balancing weight. During this process the oil from tank will be pumped to the accumulator with the help of pump (hydraulic motor) coupled to the pulley of cage. This potential energy is stored in the form of pressure energy. Now, the loaded cage can be moved up by using this pressure energy supplied to hydraulic motor. In this way the prototype lift is going to work without consuming any external energy source. As it uses only energy developed by itself so energy is saved. In this way the lift is energy efficient.

Index Terms- Lifts and Lift components, Need of energy efficient of lift, Specification of lift components, Design of energy efficient of lift.

INTRODUCTION

Means of vertical transportation, for both people and other loads, have been employed by mankind since ancient times. In early agricultural societies, these devices relied on men, animal or water power to lift the load. Rudimentary rope and pulley arrangements were used to support and move the required weight.

The Industrial Revolution brought with it a number of technological advancements. Machine power allowed for fast developments and safety systems were introduced. In 1880, the first electric motor was used to power a lift. Led by ever growing needs in the industry, with the necessity of moving great amounts of raw materials and the introduction of steel beam construction and increasingly taller buildings, lift technology evolved rapidly.

Energy efficiency has not been a major market and technological driver in this sector. Other design options like space restrictions, reliability and safety, riding comfort, etc. have been the central concerns of the vast majority of manufacturers. The last few years have witnessed a change of course with companies introducing energy efficient technologies for competitive reasons and at the same time, to help their customers save energy and money.

Hydraulic lifts only consume energy to lift the car. During downwards travel the car descends due to gravity and controlled oil flow. One simple way to reduce the energy consumption of hydraulic lifts is to adjust the travel speed without compromising the roundâ€ trip time, to make use of this characteristic. This is done by reducing the up travel speed and raising the down travel speed. This way a smaller motor can be used and energy consumption can be reduced by around 20%. Another simple way to reduce the energy consumption is to reduce the weight of the car by using lighter materials.

Mechanical hydraulic valves, where the flow of oil is controlled by internal hydraulic feedback have problems in compensating for variations in oil viscosity and pressure. Electronic sensing of the flow of oil using proportional solenoids fully compensates for these variations while providing better efficiency.

The cage is suspended by ropes wrapped around a sheave that is driven by an electric motor. The weight of the car is usually balanced by a counter weight that equals the mass of the car plus 45% to 50% of the rated load. The purpose of the counterweight is to make sure a sufficient tension is maintained in the suspension system so as to ensure adequate traction is developed between ropes/belts and drive sheave. In addition, it maintains a near constant potential energy level in the system as a whole, heavily reducing energy consumption [1].

Taking into account demographic trends as well as a growing need for convenience, it is expected that the number of lifts and escalators will be rising worldwide as well as in Europe. Further urbanization in developing countries and a growing awareness of accessibility issues due to an aging population in Europe will foster the need for more of this equipment. There is already about 4, 8 million lifts, as well as about 75 thousand escalators and moving walks installed in the EUâ€ 27. Their energy consumption adds up to 3 to 5 % of the overall consumption of a building. About one third of the final energy consumption in the European Community occurs in the tertiary and residential sector, mostly in buildings. Due to the increasing comfort requirements, energy consumption in buildings recently experienced a significant raise, being one of the leading reasons for a growing amount of CO2 emissions. High untapped saving potentials exist with respect to energyâ€ efficient equipment, investment decisions and behavioural approaches, in these sectors. The E4â€ project is targeted at the improvement of the energy performance of lifts and escalators in tertiary sector buildings and in multiâ€ family residential buildings.

Lifts and components of lift:

Types of lift-

Traction lift- Electric traction lifts can nowadays be used in almost all applications without any considerable limitations regarding travel height, speed or load. There are two main types of traction lifts: geared and gearless.

Geared lift- It uses a reduction gear to reduce the speed of the car (cage).

Gearless lift- In these lifts the sheave is directly coupled to the motor.

Hydraulic lift- Hydraulic lifts are by far the most common type of lift installed in low rise applications (up to 6or 7 floors). One of the main reasons for its wide acceptance is its relatively low initial cost. This type of lift uses a hydraulic cylinder to move the car.

Components of Lift- Cage(car), Counterweights, Rope, Motor, Gearing mechanism, accessories and control devices.

Need of Energy Efficient Lift:

Figure 1 shows the distribution of the installed lifts according to building type.

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The energy efficient lift (prototype) is developed in such a way that it will consume an energy developed by itself during downward gravitational movement. The energy stored during this will be used for the upward movement of cage. This prototype consists of a cage, counterweights, and hydraulic motor with pulley, accumulator, and a tank with oil. The prototype is worked as follows.

Initially the cage is at the bottom which is moved up without any load in it with the help of balancing counterweights. Now, this cage can bring the load to the bottom as the gravitational force of load is greater than the balancing weight. During this process the oil from tank will be pumped to the accumulator with the help of pump (hydraulic motor) coupled to the pulley of cage. This potential energy is stored in the form of pressure energy. Now, the loaded cage can be moved up by using this pressure energy supplied to hydraulic motor. In this way the prototype lift is going to work without consuming any external energy source. As it used only energy developed by itself so energy is saved. In this way the lift is energy efficient.

Potential energy is constantly being transferred while the cage is moving. If, for example, a lift is travelling down full (or up empty) the motor is actually being driven by the load. When the lift is going down, and the load weight (people inside) is larger than the counterweight, then the motor torque is in opposite direction to the speed, i. e., the motor is acts as a pump and the accumulator is charged by pumping the fluid from tank to accumulator. In the same way, when the lift is going up unloaded, energy savings can be reached if the motor is controlled with accumulator.

Components of Energy Efficient Lift:

Hydraulic Motor- Hydraulic motors convert hydraulic energy into mechanical energy. In industrial hydraulic circuits, pumps and motors are normally combined with a proper valving and piping to form a hydraulic-powered transmission. A pump, which is mechanically linked to a prime mover, draws fluid from a reservoir and forces it to a motor. A motor, which is mechanically linked to the workload, is actuated by this flow so that motion or torque, or both, are conveyed to the work.

Types- gear type motor, vane type motor, piston type motor.

Hydraulic Accumulator- Accumulators store hydraulic energy and then provide this energy back to the system when required. Accumulators store energy when hydraulic system pressure is greater the accumulator and provide hydraulic energy when the accumulator pressure is greater than the system pressure. By storing and providing hydraulic energy, accumulators can perform 5 basic functions for hydraulic systems:

- Supply oil for high transient flow demands when pump can't keep up

- Help reduce pump ripple and pressure transients

- Absorb hydraulic shock waves (due to valve closures or actuators hitting stops)

- Used as a primary power source for small (low demand) systems

- Help system accommodate thermal expansion of the fluid

There are 4 types of accumulators: bladder, diaphragm bladder, piston (either spring or gas controlled) and metal bellows. The choice of accumulator to use in a given application depends on required speed of accumulator response, weight, reliability and cost. Pressurized gas accumulators will have the faster dynamic response and are reliable.

Roping system- A variety of roping systems can be employed dependant on the particular conditions of each installation.

Other components- hydraulic oil, shaft, pulley, frame, bearing, hose.

Component Specification:

Hydraulic motor

Type

Vane Motor

Direction Of Rotation

Unidirectional

Port Connection

½' Bsp

Operating Pressure

Max 100 Bar

Maximum Pressure

140 Bar

Motor Efficiency

85% Min

Hydraulic accumulator

Type

Bladder Type

Make

Bosch Or EPE/Hytech

Port Connection

¼' Bsp

Gas To Be Charged

Nitrogen

Capacity

0. 7 Lit/50 Bar

Pulley

Sr no

Material

Diameter

Quantity

1

Cast Iron

40 mm

2

2

Aluminum

230 mm

1

3

Casting

35 mm

1

Hydraulic oil

Oil Used

Hydrol 68

Shaft

Sr no

Material

Diameter

1

M. S. bar

18 mm

2

M. S. pipe

Do= 25mm, Di= 21mm

Bearing

Type

Deep groove ball bearing

Bearing No.

SKF 6005

Frame

Length

2. 5ft

Height

3 ft

Width

1. 5ft

PROBLEM DEFINITION

Figure 2 : Experimental Setup

As there is fast development and enhancement of life style, the present generation becomes more reliable on technologies. Looking up the present situation almost every residential society, apartments, commercial market, educational society and small scale industry use lifts for the transportation of people or material. The energy consumed by such large no of lifts used presently is considerable. There is loss of energy during the downward motion as it uses some amount of energy. Looking about consideration the use of lifts in various fields and there energy consumption, there should be some provisions made to store the energy developed while downward movement. This will help in minimizing the energy losses and can reuse the stored energy. This process will help in energy conservation which finally leads to saving of economy.

Abbreviation

μ = Coefficient of friction

D1 = Diameter of aluminum pulley

D2 = Diameter of cast iron pulley

RA = Reaction at bearing A

RB = Reaction at bearing B

B. M. = Bending moment

N = Newton

N-m = Newton-meter

Te = Equivalent twisting moment

k = Diameter ratio

A = Area

H = Height

Î˜ = Angle of contact

N = Speed in rpm

V = Volume in mm3

Q = Volume flow rate

Design of energy efficient lift

Shaft design

Given:

D1= 0. 040m

R1= 0. 020m

D2= 0. 230m

R2= 0. 115m

AB= L= 600mm

AC= 300mm

BD= 180mm

Coefficient of friction= μ= 0. 3

Angle of contact= Î¸= (0. 611Ï€) rad

Allowable shear stress= Ï„= 42MPa

T1= 10kg= 98. 1N

Solution:

The space diagram is shown in fig 3(a)

We know that ;

2. 3*log(T1/T2)= 0. 3*0. 611Ï€ = 0. 5758

log(T1/T2)= 0. 2504 or (T1/T2)= 1. 78

and T2= T1/1. 78= 55. 112N

Vertical load acting on the shaft at C,

WC = T1+weight of pulley C

= 98. 1+4. 905 = 103. 005N

And vertical load on shaft at d,

Weight of pulley D = 4. 905N

The vertical load diagram is shown in fig 3(b)

We know that torque acting on the pulley 1,

T= (T1-T2)*R1

= (98. 1-55. 112)*0. 02= 0. 8597N-m

Since the Torque on both pulleys is same, therefore

(T3-T4)*R2= T= 0. 8597 or T3-T4= 7. 476N …… (1)

We know that

(T1/T2)=(T3/T4)= 1. 78 or T3= 1. 78*T4 …… (2)

From eq.(1) & (2) we find that,

T3= 17. 06N & T4= 9. 58N

Therefore, Horizontal load acting on shaft at C,

= 55. 112N

At D, = T3+T4= 26. 645

(a)Space diagram

(b)Vertical load diagram

(c)Vertical B. M. diagram

(d)Horizontal load diagram

(e)Horizontal B. M. diagram

(f)Resultant B. M. diagram

Figure 3. Vertical Loading Diagram

From fig 3(b) we know that,

RAV + RBV = 107. 91N ..... (3)

Taking moment about A,

RBV*0. 6= 103. 005*0. 3+4. 905*0. 42 ..... (4)

From equation (3) & (4), we get,

RBV= 54. 936N & RAV= 52. 927N

We know that, B. M. at A & B, MAV= MBV= 0

B. M. at C, MCV= RAV*0. 3

= 15. 892N-m

B. M. at D, MDV= RBV*0. 18

= 9. 88N-m

Horizontal Loading Diagram

From fig (d) we know that,

RAH + RBH= 81. 757N ..... (5)

Taking moment about A,

RBH*0. 6= 55. 112*0. 3+26. 645*0. 42 ..... (6)

From eq (5) & (6), we get,

RBH= 46. 2075N & RAH= 35. 5495N

We know that, B. M. at A & B, MAH= MBH= 0

B. M. at C, MCH= RAH*0. 3

= 10. 665N-m

B. M. at D, MDH= RBH*0. 18

= 8. 3174N-m

Resultant B. M.

At C, MC= MCH2+ (MCV2)

= 19. 139N-m

At D, MD= MDH2+ (MDV2)

= 12. 915N-m

We see that B. M. is maximum at C.

Therefore, maximum B. M., M= MC= 19. 139N-m

We know that equivalent twisting moment,

Te= M2+(T2) = 19. 1583N-m

Also, Te= (Ï€/16)*Ï„*d3

= (Ï€/16)*42*d3

d3= (19. 1583*103)/8. 2467

d = 13. 24mm

for hollow shaft,

d3= do3*(1-k4)

13. 243= do3*(1-0. 844)

do= 16. 65mm â‰¤ 25mm

k= di/do

hence, di= 13. 99mm â‰¤ 21mm

Hence design is safe.

RESULT AND DISCUSSION

The above experiment has following observations and result, for one cycle i. e. movement of cage from top position to bottom position, under 3kg weight following observation are noted

Observations

Height of cage = 1030 mm

Oil discharge during discharging (h) = 2 mm

Rotation of motor shaft = 22

Diameter of oil tank(d) = 120 mm

Speed of motor shaft(n) = 306 rpm

Time required for 1 cycle(t) = 6 sec

Calculation for oil flow rate of one cycle

Volume flow rate of oil= (A*H)/t

Here, Area of tank= A=(Ï€/4)*d*d,

Therefore, Volume flow rate of oil = ((pi/4)*120*120*2)/6)

= 3769. 911mm3/sec

For 1 cycle of cage, 3769. 911mm3/sec of oil pumped during charging process of accumulator.

For 1 cycle of cage, Q= 3769. 911mm3/sec

Hence, volume V= Q*t

= 3769. 911*6

= 22619. 467mm3

= 22619. 467*10^(-9)*10^3

= 0. 02262 lit

Number of cycle for total charging

For volume V1= 0. 02262 lit cycles required n1= 1 For volume V2= 1 lit cycles required n2=?

Hence, V1/V2= n1/n2,

n2 = (V2/V1)*n1

n2= (1/0. 02262)*1

n2= 45 cycles required

By taking consideration of above calculation and observation, we come to conclusion that for complete charging of accumulator nearly 45 cycle are required.

Advantages of energy efficient lift

Installation is simple and fast.

Space occupied by equipment, such as controls, motor, and pump is little and, therefore, the overhead machine room becomes unnecessary. These parts are normally located in lowâ€ cost areas of the building such as basements or below stairs.

Substantially low initial cost of equipments and maintenance.

No electricity supply is necessary.

Limitations of energy efficient lift

Leakage problem of oil in ground surrounding.

Properties of oil may changed with change in temperature.

Installation cost is high.

Application of energy efficient lift

In small scale industry, for material handling purpose.

In domestic use, commercial market, educational society.

It can be used as regular lift for heavy application in combination with other energy source.

CONCLUSION

From the above experiment, the conclusion is made that energy efficient lift is advanced as compared to traction lift and hydraulic lift. The energy efficient lift is more efficient than any other type of lift as it does not require any external source of energy. Energy efficient lift develops pressure energy by weight of passengers and reuse it.

This type of lift can be use for various type of applications by designing the required size of accumulator for the desired capacity. Though the installation cost is high, its maintenance and operating cost is low. As there is no other type of energy consume so it is economical.

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