Brick Lifting Machine

Hasan Iqbal, Divendu Mishra, Anchal Ojha, Arun Yadav, Ravi Kumar Srivastava, Satish Kumar Dwivedi

Abstract— As we can see that during any type of construction work there is a need to carry the bricks from one floor to the other which is done manually by the workers because of which they often get injured and it also consumes a lot of precious time and in turn increases the labour cost, So in order to tackle with this problem with the help of mechanical engineering we had proposed to design a brick lifting machine which can lift up to 50 bricks at a time we had also focused on minimum power consumption and the efficiency so that in minimum power consumption maximum no. of bricks can be lifted. The key points in the designing of the lift is are factor of safety and the counterweight, there are many else technical parameters on which designing of lift depends such as Rate load, rated speed, Height of travel, the number and location of stops, type of drive etc. The motor which will be used for lifting the load will be D.C series motor and the type of drive is gearless traction drive. The gearless traction drive is preferred over geared traction drive because it provides higher efficiency.

Keywords- D.C.

I.INTRODUCTION

Brick lifting machine is a machine which is used to lift bricks from one floor to another. The designing of the brick lifting machine is on the basis of design of the elevators but the advancement and the work is done on reducing the power consumption and increasing the efficiency of the lifting machine. The lift is designed on the basis of gearless traction elevators and type of motor is D.C series motor. This project is an interesting one. This machine is designed for lifting 50 bricks at a time and according to the calculations done the power of the motor which will be required will be 3.6 HP. This brick lifting machine will be much advantageous as it will reduce the time required to lift the bricks from one floor to another as it takes much time to carry it manually so in turn it will also reduce the risk involved in carrying the bricks manually and it will save the workers from any type of injury and will also reduce the labour cost.

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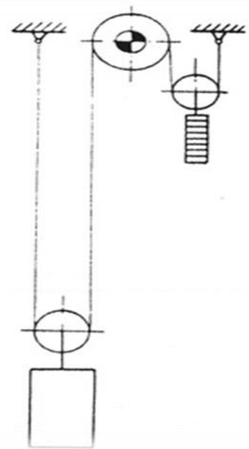
II.COMPONENTS OF BRICK LIFTING MACHINE

The main parts of the brick lifting machine are suspension which means for car and counterweight which are represented by either steel wire rope or chain, Driving machine which is power unit consisting of electric motor, mechanical gearing, brake and car in which the bricks will be kept for lifting up. The type of drive or the roping system is single wrap drive with a roping factor of 2.

The machine is equipped with a special low speed D.C motor the speed of which is in the range of 100 to 240 rpm, there is no gearing between the rotor and the sheave. All principle components of the machine i.e. the rotor, traction sheave and brake drum are mounted on the same shaft supported by two bearings. Since no gearing is employed the mechanical efficiency of the system is higher than with the geared elevators. the below shown drive system will be used for lifting the car.



The initial cost of a gearless machine is higher but the life of the low speed D.C motor is higher and the maintenance cost is low.

III.DESIGN SPECIFICATIONS MINIMUM BRAKING LOAD

We are designing the lifting machine for lifting 50 bricks and as we know the weight of one brick is between 1.5-2.5 kg so we have taken an average weight of 2 kg.

So the rated load Q = 100 Kg

K = 125 Kg

Z = $125+\varphi \times 100 + 10 \times (0.365/4)$

Nominal Diameter= 10 mm

Weight = 0.365

Rated = 100 Kg = Q

Car load = 125 Kg = K

Z = $K+ \varphi \times Q + H \times (q_e/4)$

Z = $125+0.5\times 100 + 10 \times (0.442/4)$

Z = 176.105 Kg

H = 10 m

I = 2

n = 1

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$n \times N = [(Q + K) / I] + m_L \times g_n \times f$
d = 11 mm
N = Minimum braking load = 53.2 KN
F = 1500 N/mm^2
n = 1
$1\times 53.2 \times 10^3 = [(100+125)/2] \times 9.81 \times f$
$f = (53.2 \times 10^3) / [(225/2) \times 9.81]$
$= (53.2\times 10^3) / 1103.625$
$N\times n = 13243.5$
N = 13243.5 N
Minimum braking load = 13243.5 N

FORCE ON THE SHEAVE

$T_1 = [(Q+K)/I] + m_L\times g_n$
$= [\{100+125)/2] \times 9.81$
$T_1 = 1103.62$ N
$T_2 = (Z/I) \times g_n$
$= (176.105/2) \times 9.81$
$T_2 = 863.795$ N
$T_1/T_2 = e\mu\theta$
$\text{Log } (T_1 / T_2) = \mu \times 3.14$

$$\mu = 0.03$$

MAXIMUM PERMISSIBLE SPECIFIC PRESSURE

$P = (12.5 + 4V_c) / (1+V_c)$
$P = (12.5 + 4 \times 1.6) / (1+1.6)$
P = 7.269 N/mm^2.

MAXIMUM TENSILE FORCE

$T = [(K+Q)\times g_n] / n$
$= [(100+125)]\times 9.81$
T = 2207.25 N

MAXIMUM SPECIFIC PRESSURE

$P = (\delta \times T \times \cos\beta/2) / [D\times d \times(\pi - \beta - \sin\beta)]$
$P = (8\times 2207.25 \times \cos 52.5^0) / [200\times 11-(\pi - \left(\frac{105}{180}\right) \times \pi - \sin 105^0)$
P = 4.88 N/mm^2

COEFFICIENT OF FRICTION

$F = 4 \times 0.003 \times (1 - \sin 52.5^0) / (\pi - 1.83 - \sin 105^0)$
f = 0.344
$T_1 = 1103.62$ N
$T_r = T_1 \times R$
$= 1103.62 \times 0.100$
Torque $T_r = 110.36$

POWER OF MOTOR

$P = 2\frac{\pi NT}{60}$
P = 2749.14 W
P = 3.6 HP
$V = R\omega$
$2.5 = 0.10\times \omega$

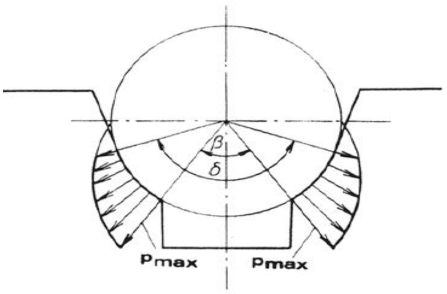
$$\omega = 25$$

$2\frac{\pi N}{60} = 25$
N = 238 rpm

IV.WORKING

The ropes are attached to the elevator car, and looped around a **sheave**. A sheave is just a pulley with grooves around the circumference. The sheave grips the hoist ropes, so when you rotate the sheave, the ropes move too.

The sheave is connected to an electric motor. When the motor turns one way, the sheave raises the elevator; when the motor turns the other way, the sheave lowers the elevator. In **gearless elevators**, the motor rotates the sheaves directly.
In **geared** elevators, the motor turns a gear train that rotates the sheave. Typically, the sheave, the motor and the **control system** are all housed in a **machine room** above the elevator shaft.
The ropes that lift the car are also connected to a **counterweight**, which hangs on the other side of the sheave. The counterweight weighs about the same as the car filled to 40-percent capacity. In other words, when the car is 40 percent full (an average amount), the counterweight and the car are perfectly balanced.
The purpose of this balance is to conserve energy. With equal loads on each side of the sheave, it only takes a little bit of force to tip the balance one way or the other. Basically, the motor only has to overcome friction -- the weight on the other side does most of the work. To put it another way, the balance maintains a near constant **potential energy** level in the system as a whole. Using up the potential energy in the elevator car (letting it descend to the ground) builds up the potential energy in the weight (the weight raises to the top of the shaft). The same thing happens in reverse when the elevator goes up. The system is just like a **see-saw** that has an equally heavy kid on each end.



Both the elevator car and the counterweight ride on guide rails along the sides of the elevator shaft. The rails keep the car and counterweight from swaying back and forth, and they also work with the safety system to stop the car in an emergency.

V.ANALYSIS OF ROPE

Material

The raw material for steel wire is unalloyed carbon steel with carbon content of 0.4 or better 0.6 to 0.8 % by weight. Other materials such as silicon and manganese are only present in minimal quantities as regulated by EN 10016.
Steel wires for elevator have nominal tensile strength of 1370, 1570 and 1770 N/mm2.
Higher strength levels of up to 2500 Ntmm^2 are possible with special approval.

Stress factor

When running over the traction sheave and the deflection sheaves, the wire in the rope are exposed to a high complex of stress factor comprising tension, flexural stress, torsion and compression-which all contribute to material fatigue.

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Flexural stress

During flexural stress, the wires bend in relation to each other. The friction created between the wires results in additional abrasive wear. Added to this is the influence of corrosive media.

Hardness of wire

Wire hardness rises on a linear basis with nominal wire strength which is lower in elevator rope compared to crane ropes. The limited nominal wire strength and consequently limited wire hardness should protect the traction sheave than the unhardened sheave.

Strand

Suspension rope for traction elevators are regularly produced using seale, Warrington and filler strand constructions.
Today the eight strand rope with a natural fiber core great in roads in the international arena and can be considered the most frequently used elevator rope today.
When using ropes with a steel-wire core it should be made clear that it will enhance longer service life and reduce rope elongation.
The rope and strand construction must be selected depending upon predominant source of stress. If exposed to high levels of flexural stress, preference should be given to a Warrington rather than a seale rope.

Seale strand

The world's most frequently used strand construction for elevator ropes is the 19- wire seale strand (1-9-9). Because of the thick outer wires, the seale strand offers a higher degree of resistances against external wear in use when running over the traction sheave and the deflection points.

Rope Terminology

Wire Rope Diameter
1/2" 8x19S BRT TRC RR FS FC
It is important to recognize that wire rope is always manufactured larger, never smaller, than the nominal diameter. In standard practice, the nominal diameter, or 1/2" in our example, is the minimum diameter to which the wire rope will be manufactured.

Wire Rope Construction
1/2" 8x19S BRT TRC RR FS FC
Wire rope is identified by its construction, or the number of strands per rope and number of wires in each strand. For example, the construction8x19 Seale denotes an 8-strand rope, with each strand having 19 wires. Seale (S) denotes the design. Other designs include Warrington and Filler Wire. Constructions having similar weights and breaking strengths are grouped into wire rope classifications such as the 8x19 and 6x19 Classes. Factors that influence the type of construction specified include the type of groove contour, diameter of the sheave, and rope flexibility requirements.

Wire Rope Finish
1/2" 8x19S BRT TRC RR FS FC
(BRT = bright)
The term bright refers to a wire rope manufactured with no protective coating or finish other than lubricant WW manufactures and stocks all elevator rope as bright unless otherwise specified. Some applications require more corrosion protection than lubricant can provide, such as with elevator ropes used in underground mines. In these instances, a galvanized finish is specified. Galvanized elevator rope is not stocked, and is manufactured and sold by special order in master lengths only.

Wire Grade
1/2" 8x19S BRT TRC RR FS FC
(TRC = traction)
In the early days, most elevator hoist ropes were made to an iron specification that has a very soft grade of steel. After the traction elevator was developed, iron became obsolete in hoist applications due to its inadequate strength and minimal ability to withstand abrasion. Instead, a special grade of steel, suitably named traction steel, was developed to meet the service conditions of traction machines The tensile strength of traction steel (TRC) is between 170,000 and230,000 lbs. per square inch. It is characterized by an excellent combination of strength, toughness, ductility and fatigue resistance. Traction steel rope sare designed primarily for use as hoist ropes on modern passenger and freight elevators of the traction drive type. Traction steel elevator ropes provide the qualities needed for satisfactory elevator service. In hoist rope, as well as many compensating and governor rope applications, traction steel is more durable and reliable than iron.

Wire Rope Lay
1/2" 8x19S BRT TRC RR FS FC
(RR = right regular lay)
The helix or spiral of the wires and strands in a rope is called the lay. Regular lay denotes rope in which the wires are laid in one direction, and the strands in the opposite direction to form the rope. The wires appear to run roughly parallel to the center line of the rope Lang lay is the opposite; the wires and strands spiral in the same direction and appear to run at a diagonal to the center line of the rope. Due to the longer length of exposed outer wires Lang lay ropes have greater flexibility and abrasion resistance than do regular lay ropes.
Right or left lay refers to the direction in which the strands rotate around the wire rope.

Right Regular Lay

Right Lang Lay

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VI.SIZING OF MOTOR FOR ELEVATORS AND COUNTERWEIGHT

A drive decides the performance of a propulsion system. For propulsion application two powers i.e. peak and continuous power has to deliver by same motor.
Energy required for propulsion = mgh joule
Power required for propulsion = (mgh/time) Watt
m = total mass of lift passengers
g = acceleration due to gravity
h= distance of propulsion
Force required for acceleration F = ma N
Drive sheave is coupled with shaft of motor through sheave axle for handling rope of the elevator.
Sheave axle torque = force × radius of sheave
Motor torque = sheave axle torque / gear ratio

POWER OF MOTOR

$P = 2\frac{\pi NT}{60}$
P = 2749.14 W
P = 3.6 HP
$V = R\omega$
$2.5 = 0.10\times \omega$

$$\omega = 25$$

$2\frac{\pi N}{60} = 25$
N = 238 rpm

Counterweight

The counterweight is used with traction and chain drive elevators for balancing the mass of the car and a portion of the rated load, this portion usually being 45 to 50 %. With high rise installations the mass of the counterweight for ideal balancing is also affected by the mass of travelling cable. The ideal balancing of both sides of the traction sheave, the equation of equilibrium can be formulated as
$(K + \varphi \times Q) \times g_n + (H - z) \times q_l \times g_n + z \times q_k \times g_n + y \times q_e \times g_n = Z\times g_n \times z \times q_l \times g_n + (H - z) \times q_k \times g_n$.
Where Z is the mass of the counterweight in Kg, φ is coefficient taking account of percentage of rated load balanced by the counterweight, H is car travel in meters, q_l is unit weight of suspension ropes (Kg/m), q_k is unit weight of compensating cables (Kg/m), q_e is unit weight of travelling cable (Kg/m), y is variable length of travelling cable under the car in meters, z is variable distance from the car to its lowest level in meters, g_n is the standard acceleration of free fall (m/s^2).
The relation between y and z may be easily expressed, if we neglect the fact that the length of the travelling cable is greater than H/2 by a few meters
Y = z/2

VII.ANALYSIS OF BRAKE

The elevator braking system, which must be set in operation automatically in the event of loss of power supply and for loss of supply to the control circuits must be provided with an electromechanical friction brake. This brake must be capable of stopping the machine when the car with 125% of rated load is travelling at its retardation must not be in excess of that resulting from the operation of the safety gear or by stopping the car on its buffers.
The brake is usually mounted on the high speed shaft because of the braking torque being relatively small here, provided that the shaft is operated coupled to the sheave (drum, sprockets) by direct mechanical means.
The brake must be applied by compression spring or by gravity. It can be released either electromagnetically or electro hydraulically. Braking should occur as the electric circuit operating the brake is interrupted. When the machine is fitted with a manual emergency operating device, to keep the brake open in that case.
The most common form of elevator brake is an electromagnetic brake, consisting of a spring assembly, brake shoes with linings and a magnet assembly, the release of the brake is effected by energizing the solenoid; when de-energized the brake shoes grip the brake drum under the influence of of the compression spring and induce the braking torque.
The actuating force is induced by air pressure the compressed air is provided by a small compressor with an air tank, the volume of which is either 20 or 40 liters. The air pressure in the tank is in the range of 6-8 bars.
A pressure switch determines whether there is sufficient pressure in the system or whether the brake has been set to operate. If the air drops below 5 bars, or if the brake is activated the elevator's control circuit is interrupted the brake is released by four compression springs.

CALCULATION OF BRAKING TORQUE AND BRAKE SELECTION

The braking torque must be sufficient to stop a car with a load equivalent to 125 % of the rated load and hold it at rest afterwards. The torque is composed of two parts: the static component necessary to hold the system at rest and the dynamic component for absorbing the kinetic energy of all moving parts of the system.
The braking torque will be calculated in the event of the car stopping at the lowest landing as this component or this condition is decisive for braking.

CALCULATION OF THE STATIC TORQUE MSt –

M_{St} is given by the formula:
$M_{St} = [(1.25\, Q + K - Z) / l + m_L] \times g_n \times (D / 2i_G) \times \eta_2$ (N-m)
Where Q is rated load (Kg), K is the mass of the car (Kg), Z is the mass of the counterweight (Kg), i is the roping factor, m_L is the mass of one fall of suspension ropes (Kg), g_n is the acceleration of free fall (m/s^2), D is the sheave diameter (m), i_G is the gear ratio, and η_2 is the mechanical efficiency of the system related to the conditions of braking .
It is possible to calculate η_2 as a product:
$\eta_2 = \eta_{RS} \times \eta_S \times \eta_{G'}$
Where η_{RS} is the efficiency of the roping system, η_S is the efficiency of the sheave and $\eta_{G'}$ is the efficiency of mechanical gearing between the motor and the sheave for reversed power the transmission. It is necessary to consider the direction of power transmission. It is necessary to consider the direction of power transmission especially with worm gearing application, as its efficiency is affected by this factor to a large extent.

CALCULATION OF THE DYNAMIC TORQUE M –

$M_i = I \times \in$ (N-m)
Where I is the moment of inertia of all moving parts of the system related to the high speed shaft (brake drum shaft) (Kg-m^2)

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And $\in$ is the angular retardation of the high-speed shaft (I/S^2).

The total moment of inertia I may be calculated as –

$I = I_1 + I_2 + I_3$

Where I_1 is the moment of inertia of the rotor, brake drum and worm (Kg-m^2) I_2 is the moment of inertia of the worm wheel and the sheave (Kg-m^2) and I_3 is the moment of inertia of all parts of the system which are in linear motion (Kg-m^2).

If the moment of inertia of the worm wheel and sheave (I_2) related to their axis of rotation, is known, the transmission to the high-speed shaft can be easily carried out on the basis of the conservation of kinetic energy:

$I_2 = I_{2'} \times (\eta_{G'} / i_G^2)$

The same principle in calculating I_3 can be applied. The moment of inertia I_3 related to the low speed shaft (traction sheave shaft) will be calculated by utilizing the following equation, expressing the quality of the translational and rotational energies.

$1/2\ I_{3'} \times \ \omega^2 = ½[(1.25\ Q + K + Z)] \times v^2 + m_L \times (i \times v^2)] \times \eta_{RS} \times \eta_S$

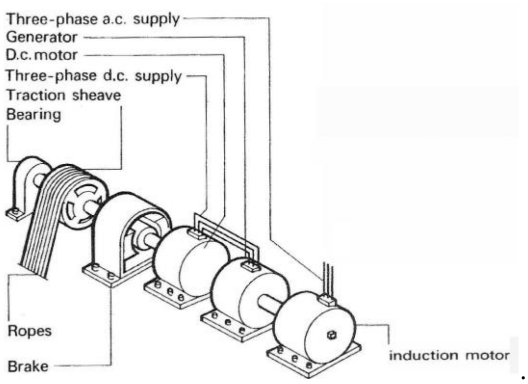
Where ω is the angular velocity of the low speed shaft (1/ S)

$\omega = (2\ i \times V) / D$

And v is the leveling speed of the car and counterweight

VIII.MOTOR USED

Gearless machines are generally used for high-speed lifts, i.e. speeds from 2.5m/s to
10 m/s. The gearless machine is equipped with a special low-speed DC motor with
Speeds in the range of 100 to 250 rpm. DC motors have provided the best ride quality
in the past because the speed of the motor can be easily controlled using a DC Generator with a variable output. Consequently, DC motors had in the past been used for the majority of applications requiring a smooth ride and accurate leveling



There is no gearing between the rotor and the traction sheave. All principal components of the machine, i.e. the rotor, traction sheave and brake drum are mounted on the same shaft, supported by 2 bearings. The shaft and the bearings must sustain the load imposed on the sheave as well as the weight of all these components and transmit the complete load to the building structure. The traction sheave and
Brake drums are usually made as one piece.

With no gearing employed, the mechanical efficiency is higher compared to geared elevator machines. The initial cost of a gearless machine is higher, but the life of the
Low-speed DC motor is long and the maintenance cost is relatively lower for speed regulation, several systems may be used. With older DC drive systems, a variable voltage control through a motor-generator set (Ward-Leonard system) was employed. Its application resulted in good ride comfort and accurate leveling at each stop, regardless of car load and direction of travel. However, the installation cost was relatively high, space was needed for the motor-generator set, extra maintenance had to be provided for the Commutator and the brushes of the high-speed generator, and the total losses (at least 3 rotating components were employed) reduced the overall efficiency of the machine. Compared with motor-generators, static convertors are more efficient, provide improved control, more reliable and incur lower maintenance cost.

Advanced voltage and frequency control techniques have also led to the introduction
of A.C gearless motors drives. These provide ride quality matching DC gearless machines for speeds of 2.5m/s and above.

IX.CONCLUSION

After a lot of literature survey on previously designed elevators and then putting the concept of elevators we have designed our brick lifting machine and this paper will prove efficient for understanding the concept of the lifting machine as it consists of all the required analysis of each and every components such as the analysis of rope, analysis of brake, the torque and power calculations. We had focused on minimum power consumption and efficiency, we had tried our level best to make this paper a major source of for designing of construction lifts such as our brick lifting machine and we hope that it will be much advantageous during the construction work to lift the bricks easily in minimum power consumption and higher efficiency and there are further many possibilities of improvement in it.

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