A PROJECT REPORT

ON

"PROPOSED DESIGN OF ENERGY SAVING IN LIFT"

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Date: ___________

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ABSTRACT

In this modern world, we all are enjoying the gift given to us that is electricity. so, we must use it wisely and efficiently. It is a boon to us in this fast moving lives of ours. We cannot even imagine our life without power. Power is really the greatest power for us these days. Most of the household appliances, office machinery is running with the help of electricity. It not only helps us in saving our money by reducing electricity bills but also play a major role in saving the environment. So, it’s the time to do something for our environment by saving electricity. The objective of this Study is to understand the type of approaches and methods used for saving electricity in conventional elevator and to proposed a design of energy saving lift which minimize the use of electricity.

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ABBREVIATIONS

ATS	Automatic Transfer Switches
BAT	Best available technology
BNAT	Best not-yet available technology
EGCS	Elevator Group Control System
ELA	European Lift Association
ERU	Energy Regenerative Unit
EU-27	European Union
FCM	Fuzzy Cognitive Map
NEC	National Electric Code
PERS	Potential Energy Recovery System
PMSM	Permanent Magnet Synchronous Motor
TWh	Terawatt-hour
VVVF	Variable Voltage Variable Frequency

REPORT OUTLINE

In chapter 1, a brief introduction on elevator along with the background, motivation, aim and objective of the project are mentioned. In chapter 2 literature survey, problem definition and the scope of the project are highlighted. In chapter 3 basic principle on which elevators are working its design parameters of different components and construction of conventional elevators are discussed. In chapter 4 working of energy saving regenerative system and its usage in different sectors are presented. In chapter 5 use of energy efficient elevators in Europe with its effect, analysis, technological factor, campaign and estimation of savings are defined. In chapter 6 a popular elevator company Otis manufacturer of regenerative drive with its working and installation in different areas and energy saving with their drives along with the results are mentioned. In chapter 7 proposed design of energy savings lift which will not entirely work on electricity nor on the counter weight is presented.

Chapter 1

Introduction

1.1 Background

1.2 Types of Elevators

1.3 Motivation

1.4 Aim and objectives

CHAPTER 1
INTRODUCTION

1.1 Background

Lift and escalator in a multi-store building serve to bring people up and down the building floors. As most of the buildings are getting taller, new lifts are running faster and are essential mechanical installation for vertical transportation now a day. The energy consumption of lift and escalator installations are almost as much as that of lighting installation in commercial buildings. This is mainly due to their invariably large electrical motors and virtually continuous operation throughout the day in many cases. The contribution of this study is to provide an analysis of the variable literature on power saving mechanisms in lifts.

These are used in many areas like agriculture, manufacturing, etc. Elevators are classified into different types based on our requirement. Elevators are frequently used in the latest multistory constructions, in particular wherever ramps of wheelchair would be not practical. The working principle of an elevator or lift is similar to the pulley system. A pulley system is used to draw the water from the well. This pulley system can be designed with a bucket, a rope with a wheel. A bucket is connected to a rope that passes throughout a wheel. This can make it very easy to draw the water from the well. Similarly, present elevators use the same concept. But the main difference between these two are; pulley systems are operated manually whereas an elevator uses sophisticated mechanisms for handling the elevator's load.

Basically, an elevator is a metal box in different shapes which is connected to a very tough metal rope. The tough metal rope passes through a sheave on the elevator in the engine room. Here a sheave is like a wheel in pulley system for clutching the metal rope strongly. This system can be operated by a motor. When the switch is turned ON, the motor can be activated when the elevator goes up and down or stops.

The elevator can be constructed with various elevator Components or elevator parts that mainly include speed controlling system, electric motor, rails, cabin, shaft, doors (manual and automatic), drive unit, buffers, and safety device.

1.2 Types of Elevator

The different types of lifts or elevators [1] include building lift, capsule lift, hydraulic elevator, pneumatic elevator, passenger lift, freight elevator, traction elevator/cable driven, residential elevators, machine room-less elevator, etc.

1) Hydraulic Elevator

A hydraulic elevator is power-driven by a piston that moves within a cylinder. The piston movement can be done by pumping hydraulic oil to the cylinder. The piston lifts the lift cab easily, and the oil can be controlled by an electrical valve. The applications of hydraulic elevators involve in five to six-floor buildings. The operating of these elevators can be done at speeds up to 200 feet or 61 meters [1] for each minute. Older hydraulic elevators now started up suddenly, transmitting mains power at full-blast right into the electric motor. This sets a lot of damage on the motor, which will make it burn out quicker than motors on Solid-State or Y-Delta Contactor starters.

2) Pneumatic Elevator

The pneumatic elevator can be designed with an external cylinder, and the cylinder is a crystal clear self-supporting cylinder. This cylinder includes modular sections to fit effortlessly into one by one. The top of this tube is designed with steel material that ensures tight air shutting by suction valves as well as inlets. A lift car runs within the cylinder, & the head unit on the top cylinder surface consists of valves, controllers, and turbines for controlling the elevator movements. Pneumatic elevators are very easy to fit, operate as well as maintain when compared with the traditional elevators. These are used in existing homes because of their solid design. The main benefits of using these elevators include solid design & smooth, speed and flexibility, energy efficient and very safe.

3) Cable Driven or Traction Elevator

The traction elevator or cable driven elevators are the most popular elevators. It consists of steel cables as well as hoisting ropes that run above a pulley which is connected to the motor. In this kind of elevator, several wire and hoisting cables are connected to the surface of an elevator car with covering around it on sheaves at one end & the other side is connected to a counterweight that travels up & down on its guide rails. The counterweight is equivalent to the car’s weight and half of the weight of the passenger in the car. This means, throughout the lifting process it needs extra power for the additional passengers in the car; the rest of the load is managed with the weight of the counter. When the control system is connected to the lift, then it drives the motors in a frontward way, and sheave turns around to move the car lift upwards and stops in the preferred floor where the car is controlled by the weight of the counter. For the car downstairs movement, overturn occurs during a rotating motor through a control method. For conserving the energy, some types of lift use electric motors with four quadrant operation in the regenerative method. Because of the high rise as well as high-speed capacities, these are applicable in several escalators, lifts, etc.

4) Capsule Lift

Capsule lift or Elevators are used in prestigious buildings, which can be called as decoration of a building because they improve the building's beauty as well as carries life into it. The main features of this elevators mainly include design, and travel comfort is best. The interior design of these lifts is attractive with a large glass panel for viewing. The ultramodern design of these lifts offers a cosmic zone travel experience for the passengers. These lifts are consistent and inexpensive with the least maintenance.

5) Building Lift

A building lift is a vertical transportation among the floors of the building. These are frequently used in public buildings, complexes, offices, and multistory building. These lifts are important in providing vertical movement, mostly in high buildings, for a wheelchair as well as other non-ambulant building customers. Some type of lifts also is applicable for emigration & firefighting purposes.

6) Passenger Lift

This type of lift has entirely included a lift car that moves vertically in a specially equipped lift shaft. Passengers are traveled between the floors in the building at quick speed. The control systems in the lift frequently designed to offer the most economical sharing of passengers all over the building. These lifts are very space efficient which are used in existing buildings where space is at a best. The main advantages of using passenger lift give a very comfort traveling among different floors, particularly space efficient, fully fixed shaft, small construction works, and no level loadings on the building.

7) Freight Elevator

In the world of elevators, these lifts are workhorses. These are very useful for transporting materials, goods in warehouses, manufacturing industries, shopping malls, seaports, etc. This type of elevator is separated into classes, to describe their load capacity as well as application. These lifts are strong in nature, and they are specially manufactured by engineers. The features of this elevator include: the range of loading capacity is from 2500 lbs to 10000 lbs, height of the travel up to 50fts. The benefits of these elevators include; these elevators are designed for commercial as well as industrial applications. The flexible design to hold the application, door designs can be changed, eco-friendly, etc.

8) Residential Elevators

Residential elevators provide stylish options to the platform as well as stair lifts. These lifts can be effortlessly incorporated in any available home, otherwise incorporated in edifice plans for latest homes. These types of elevators are available in different styles, and these can be installed in your home walls, otherwise included effortlessly to improve your home’s decoration. The main benefits of residential elevators are; they can move you securely among floors even during a power failure. Quick installation and offers you an effortless life. Thus, this is all about an overview of elevators or types of lifts. These have been around for 100’s of years; however, they work on a very fundamental principle. Even though the fundamentals of the elevator have not altered over the decades, but small twists have been made for the smooth ride as well as by using computer-controlled systems, efficiency has been improved for quicker transport.

1.3 Motivation

The use of lifts have increased in real world which makes life easier along with comfortable and relaxation in society, having more improvement with ongoing research and development making progress in energy saving however increase in power consumption with technologies has increased developing a such mechanism for lift technology which reduces the energy consumption also environmental friendly, less maintenance and effective in cost which leads to scope of development in energy saving for society as future outcomes and motivation to do work in this energy saving technology.

1.4 Aim and Objective

The aim and objective of these study is to investigate the available lift mechanism and different methods used for saving energy in elevator system. The different methods that have been studied in the proposed papers are stepping stone in the betterment of the energy saving system. Our aim is to represent a such mechanism for lift which is more efficient in power saving and comparing the consumption of power with ongoing energy saving lift technologies and effective in cost as compared to other methods and technologies.

Chapter 2

Literature review

CHAPTER 2

LITERATURE REVIEW

Boonyang Plangklang, Sittichai Kantawong [2] concluded that ERU is a concept that can be connected to the existing elevator system using permanent magnet motors. This investigated ERU can be applied for future use of existing elevator system. They are able to generated electric output energy from the elevator when the elevator motors work force of gravity therefore ERU will receive DC voltage from the elevator's inverter system then converts to AC voltage therefore this power can be fed into the grid system. Thus power output can be fed back to the system for replacement of the energy that has been used.

Malan D. Sale, V. Chandra Prakash [3] Studied computing techniques employed to optimize the efficiency of EGCS. Different algorithms used for scheduling of the EGCS are discussed and compared in this study. The fuzzy algorithm, zoning algorithm, and the artificial intelligence algorithm are the main categories of the scheduling algorithm. Zoning methods are too sophisticated to implement if the number of floors and elevators increases. The Fuzzy algorithms result in memory related problems.DSP boards used are complex and challenging to implement. Expert systems require human expert knowledge to provide a better result, which is not possible because human knowledge is limited. All the algorithms give better results at their level.

Tatiana A. Minav, Lasse I.E. Laurila, Juha J. Pyrhönen [4] examined PERS in an electro-hydraulic industrial forklift. The drive train contains an efficient permanent magnet synchronous motor drive directly connected to the reversible hydraulic machine of the forklift system. Such a system allows full lifting position control without any servo valves. Differences between the two different lift zones of the telescopic system were analyzed. The energy-saving ratios were calculated for different test arrangements as functions of speed and payload. The maximum achieved energy-saving value in PERS was 50%. It can be concluded that the test results favored the second lift zone because of its higher tare, thereby compensating the hydraulic system losses. The test shows that the direct electric pump drive system has numerous advantages. Therefore, it makes the recovery approach practical in cases where the lifting and lowering ranges and the masses vary.

Anibal De Almeidaa, Simon Hirzel b, Carlos Patraoa, Joao Fonga, Elisabeth Dütschk [5] in their paper provided a full analysis of the elevator and escalator market with regard to energy efficiency. As a basis for a sound analysis, first of all, the stock of installations throughout the EU-27 was analyzed. After developing a measurement methodology, 81 different installations in five different countries using all relevant technologies were monitored. Combining this data provided an estimation of the annual energy demand of elevator and escalators installations in Europe. It turns out that elevators and escalators consume about 19.3 TWh per year. This is equivalent to a share of 0.7% in the electricity consumption in the EU-27 in 2008 (2.856 TWh). The impact of elevators is much higher than the impact of escalators, due to the much lower number of escalators installed. From a sectoral point of view, elevators in the residential sector, although they form the majority of elevators installed (64% of all units), are responsible for only 36% (6.7 TWh) of the overall electricity demand by elevators. This is due to their less intensive usage. On the other hand, elevators installed in the tertiary sector usually have a more intensive use and consume about 59%(10.9 TWh) of the total elevator electricity consumption, which corresponds to almost 1.4% of the electricity consumed in that sector in 2008 (753 TWh). In terms of stand-by consumption, the elevators in the sample showed a large range of values, ranging from below 50W to 700W. In terms of running consumption, hydraulic elevators that are usually not equipped with counterweights showed a significantly higher running consumption than traction elevators. The overall effect on the energy consumption of an installation, however, depends on the actual balance of stand-by and running consumption. While it is informative to know how much energy is consumed by elevators and escalators, it is more important to analyze whether this consumption could be reduced without decreasing comfort and accessibility. This was analyzed, drawing on data about BAT and BNAT which, however, are expected to be on the market soon. The use of BAT in all existing elevator installations could result in technical savings during stand-by consumption of more than 70%. In particular, energy-efficient lighting and the use of electronic components with low stand-by power (e.g. controllers and inverter) were found to play a major role in this reduction. Turning off nonessential equipment or putting it into a very low power or sleep mode, whenever possible, would produce even higher electricity savings (BNAT scenario). The potential overall savings (running and stand-by) are estimated to account for savings of 11.5 TWh (BAT) or 13.6 TWh (BNAT). Compared to elevators, the estimated electricity consumption of escalators in Europe is relatively modest (0.9 TWh), and a potential reduction of around 0.25 TWh (30%) would be feasible if all the escalators installed were to be equipped with automatic speed controls and with low power stand-by modes.

However, these energy savings scenarios are far from becoming reality. Elevators and escalators have long life cycles, which imply a slow market penetration for new technologies. Additionally, various barriers to energy-efficient technology are present in the market as shown by the study of this topic presented above. The main barriers identified are lack of information and awareness, split-incentive problems and an unclear state of knowledge about 158 A.

Ta-Cheng Chen, An-Chen Lee , Shih-Lun Huang [6] In this study, a fuzzy cognitive map based estimation approach by using particle swarm optimization has been developed for deciding the minimum required elevators in EGCS so as to minimize the electricity consumption with predefined service quality. In literature, most of the studies were focused on the scheduling strategy with all elevators in the EGCS. However, the minimum numbers of elevators activated to sustain the required service quality has not been studied in literature. The experimental results show that the performance of the proposed FCM based approach is feasible to accurately estimate the required electricity consumption and average waiting time so as to decide the optimal numbers of elevators in EGCS. Furthermore, the computational cost is quite high by using the proposed hybrid evolutionary computation approach, it is suggested that the grid computing techniques may be applied to improve the computational efficiency. The other possible improvement could be with more accurate estimation of passenger flows by using face detection technologies. These may possibly bring more improvements for the performance of EGCS in the future.

Kun-Yung Chen , Ming-Shyan Huang , Rong-Fong Fung [7] concluded that the elevator system driven by a PMSM is dynamically modeled, and input-energy comparisons are made in this paper. The mechatronic model includes both the mechanical and electrical equations, and their dimensionless forms are developed for the upward and downward movement. The electrical energy of the elevator system is defined, and the total input energy equals the sum of dissipation energy, potential energy and output energy. The four trajectories including trapezoidal, cycloidal, 7-D polynomial and industry trajectories are compared in dynamic responses and energy consumption. It is found that under the same car’s displacement and travelling time, the trapezoidal trajectory has the minimum total input energy, while the 7-D polynomial trajectory has the maximum one. Finally, the proposed SMC is realized to demonstrate that the controller has the robustness and well tracking control performance numerically.

Toni Tukia, Semen Uimonen, Marja-Liisa Siikonen, Harri Hakala, Claudio Donghi, MattiLehtonen [8] in their paper presented two methods to predict elevator annual electricity consumption based on short-term electrical energy measurements of a few days to a week. The simpler method relies on linearly extrapolating the annual consumption based on the attained daily consumption measurements. The other method additionally incorporates the effect of seasonal differences in the elevator usage, which are caused by, e.g., holiday seasons, and is expected to provide a more accurate prediction than the simpler method but requires more detailed data on the intra-year traffic patterns. This paper analyzed the performance of the proposed methods with one elevator in an office building. Clearly, measurements, surveys, and other possibly employed methods for estimating and projecting the annual electricity consumptions of office elevators should be conducted outside the holiday season to gain reliable results, as the consumption heavily depends on the traffic. This claim is also supported by our findings of the elevator group having significantly lower average daily consumption on workdays during the holiday season. However, without accounting the effect of seasonal holidays, the annual usage estimate may result in a higher figure than actual. Nevertheless, both of the proposed methods provided adequate consumption projections of the entire year with the studied elevator. Furthermore, additional measurements in other office elevators support the idea of utilizing short term measurements of energy over the most significant day types to predict the long-term energy consumption. Competing methods, such as the VDI 4707-1 guideline and the ISO 25745-2 standard, seem to yield similar results as the proposed methods when applying high-quality traffic data. However, attaining reliable traffic data is a challenge in most elevator installations. Moreover, with the elevator analyzed in this paper, the VDI and ISO schemes estimated the annual consumption much higher than actual and performed worse than the proposed methods.

Chapter 3

Conventional elevator

3.1 Introduction

3.2 Conventional Elevators

3.3 Elevator Safety

3.4 Components Parts of the Elevator

3.5 Design Parameters

3.6 Construction Data

3.7 Calculation

CHAPTER 3
CONVENTIONAL ELEVATOR

3.1 Introduction

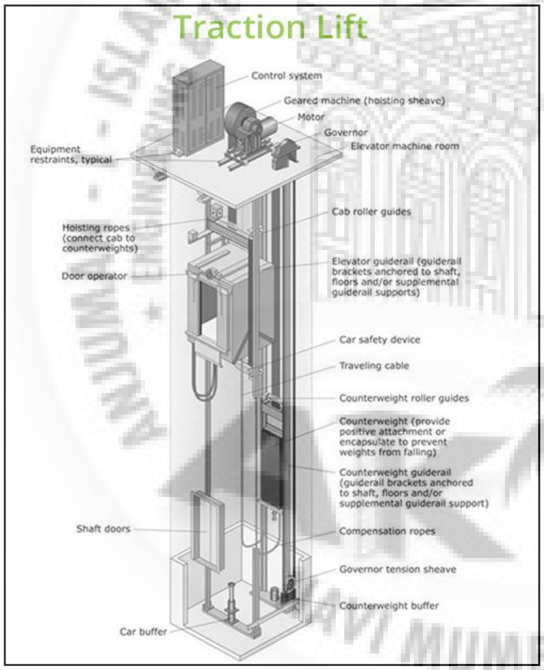
Elevators of nowadays are constructed using hydraulic and other complex systems. What we try to establish in this part is to develop an elevator that does not use the hydraulic system but more to the conventional system. The reason for this includes the following: The systems of other elevator are complex and difficult to maintain; cost of maintaining an elevator is high and takes time to maintain; the construction and installation of other system of elevators are quite expensive compared to the conventional system [9] (Moore and Niall, 2000). Skyscrapers are symbols of technological development, employed the services of elevators the movement of people from one floor to another without which the construction of skyscrapers could have been rendered useless. The materials used in the fabrication are steel bar, hollow bar, pulley, rope, wheel, and bearing. The first reference to an elevator is in the works of the Roman architect Vitruvius. In some literary sources of later historical periods, elevators were mentioned as cabs on a hemp rope and powered by hand or by animals. In the middle 1800's, there were many types of crude elevators that carried freight, most of them ran hydraulically. The first hydraulic elevators used a plunger below the car to raise or lower the elevator. A pump applied water pressure to a plunger, or steel column, inside a vertical cylinder. Increasing the pressure allowed the elevator to descend. The elevator also used a system of counter-balancing so that the plunger did not have to lift the entire weight of the elevator and its load.

In 1852, Elisha Otis introduced the safety elevator, which prevented the fall of the cab if the cable broke. The design of the Otis safety elevator is somewhat similar to one type still used today. On March 23, 1857 the first Otis passenger elevator was installed at 488 Broadway in New York City. An elevator shaft was included in the design for Cooper Union, because Cooper was confident that a safe passenger elevator would soon be invented. The shaft was cylindrical because Cooper felt it was the most efficient design. The first electric elevator was built by Werner von Siemens in 1880. The development of elevators was led by the need for movement of raw materials including coal and lumber from hillsides. The technology developed by these industries and the introduction of steel beam construction worked together to provide the passenger and freight elevators in use today.

3.2 Conventional Elevators

Traction Elevators: These can be either geared or gearless: Geared traction machines are driven by AC or DC electric motors. Geared machines use worm gears to control mechanical movement of elevator cars by "rolling" steel hoist ropes over a drive sheave which is attached to a gearbox driven by a high-speed motor. Gearless traction machines are low-speed, high-torque electric motors powered either by AC or DC. In this case, the drive sheave is directly attached to the end of the motor. A brake is mounted between the motor and drive sheave to hold the elevator stationary at a floor as shown in Fig.3.1.

Hydraulic Elevators: They use an underground cylinder, are quite common for low level buildings with 2 to 8 floors and have speeds of up to 1 m/s. The low mechanical complexity of hydraulic elevators in comparison to traction elevators makes them ideal for low rise, low traffic installations. This is shown in Fig.3.2.



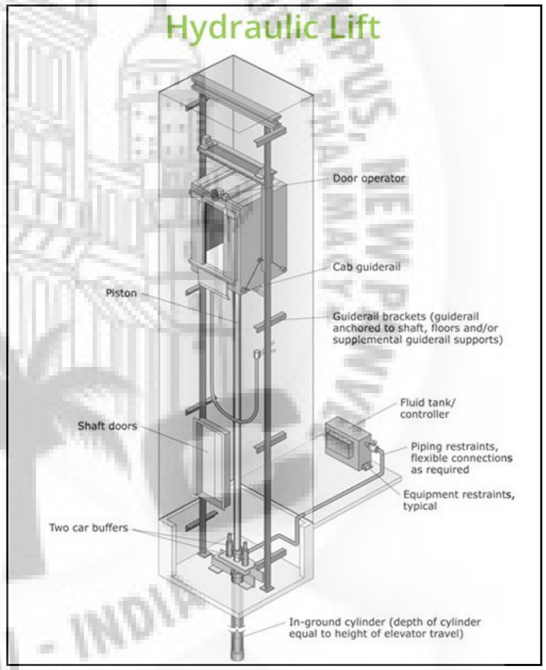


Fig 3.1: Traction Elevator [9]

Fig 3.2: Hydraulic Elevator [9]

Pneumatic Elevators: Pneumatic elevators are raised and lowered by controlling air pressure in a chamber in which the elevator sits. By simple principles of physics; the difference in air pressure above and beneath the vacuum elevator cab literally transports cab by air. It is the vacuum pumps or turbines that pull cab up to the next floor and the slow release of air pressure that floats cab down.

Pulley System: A rope and pulley system is characterized by the use of a single continuous rope to transmit a tension force around one or more pulleys to lift or move a load as shown in Fig.4. The simplest theory of operation for a pulley system assumes that the pulleys and lines are weightless, and that there is no energy loss due to friction. In equilibrium, the forces on the moving block must sum to zero. In addition, the tension in the rope must be the same for each of its parts.

3.3 Elevator Safety

An elevator cab is typically borne by six or eight hoist cables, each of which is capable on its own of supporting the full load of the elevator plus twenty-five percent more weight. In addition, there is a device which detects whether the elevator is descending faster than its maximum designed speed; if this happens; the device causes copper brake shoes to clamp down along the vertical rails in the shaft, stopping the elevator quickly, this device is called the governor (Kopetz, 2011). In addition, a hydraulic buffer is installed at the bottom of the shaft to somewhat cushion any impact.

3.4 Components Parts of the Elevator

The elevator consists of the following key parts: One or more cars (metal boxes) that rise up and down; Counterweights that balance the cars; An electric motor that hoists the cars up and down, including a braking system; A system of strong metal cables and pulleys running between the cars and the motors.

1) Counterweight: In practice, elevators work in a slightly different way from simple hoists. The elevator car is balanced by a heavy counterweight that weighs roughly the same amount as the car when it's loaded half-full. When the elevator goes up, the counterweight goes down—and vice-versa, which helps in four ways: The counterweight makes it easier for the motor to raise and lower the car; the counterweight reduces the amount of energy the motor needs to use; the counterweight reduces the amount of braking the elevator needs to use. The counterweight makes it much easier to control the elevator car.

2) Electric Motors: The electric current from the battery connects to the motor's electric terminals as shown in Fig.5. These feed electric power into the commutator through a pair of loose connectors called brushes, made either from pieces of graphite or thin lengths of springy metal, which "brush" against the commutator. With the commutator in place, when electricity flows through the circuit, the coil will rotate continually in the same direction. A simple, experimental motor such as this isn't capable of making much power. We can increase the turning force (or torque) that the motor can create in three ways: either we can have a more powerful permanent magnet, or we can increase the electric current flowing through the wire, or we can make the coil so it has many "turns" (loops) of very thin wire instead of one "turn" of thick wire. In practice, a motor also has the permanent magnet curved in a circular shape so it almost touches the coil of wire that rotates inside it.

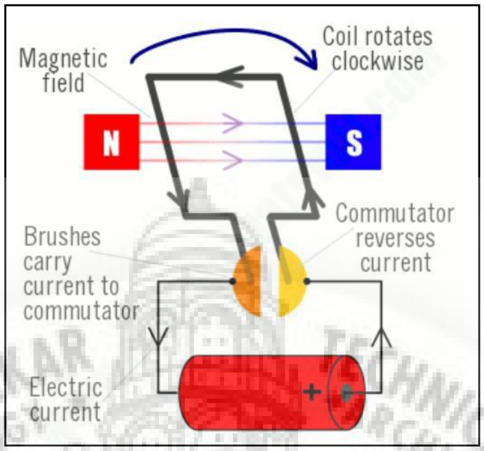


Fig.3.3 simplified diagram of an electric motor. [9]

3) Brakes: The most common elevator brake is made up of a compressive spring assembly, brake shoes with linings, and a solenoid assembly. When the solenoid is not energized, the spring forces the brake shoes to grip the brake drum and induce a braking torque. In order to improve the stopping ability, a material with a high coefficient of friction is used within the breaks, such as zinc bonded asbestos. Typically, the efficiency of the geared machine is 60 percent for the motor and gear box assembly. The force exerted by the spring is much closer to the pin joint and, therefore, is easily overridden by the force of the magnetic pull because of its longer moment arm (great distance from the point of rotation).

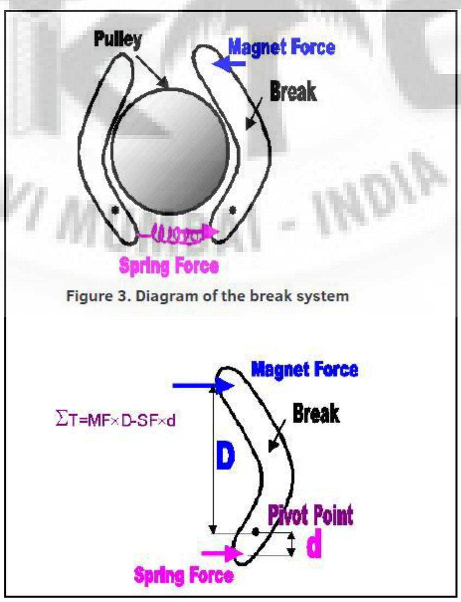


Fig.3.4 Free body diagram of the break system [9]

4) Electronic Components: The electronic components in an elevator are; Resistors, Diodes, Capacitors, Transistors and Optical electronic components. The key to an electronic device is not just the components it contains, but the way they are arranged in circuits. The simplest possible circuit is a continuous loop connecting two components, like two beads fastened on the same necklace.

3.5 Design Parameters

1) Elevator Car
The number of passengers shall be obtained from the formula:

Number of passengers = rated load /75

2) The Counter Weight

Elevator Counterweight = Half of Elevator Maximum Capacity + Cab Weight for four (4) passenger

3) The motor power

The motor power required is given by:

$$F\,dt = mv \tag{3.1}$$

$$P = F * X/t \tag{3.2}$$

Where F is Weight, m is mass of counterweight, V is velocity, t is time, X is distance and P is power.

4) Rope Breaking Strength

Natural breaking strength of manila line is the standard against which other lines are compared. The basic breaking strength factor for manila line is found by multiplying the square of the circumference of the line by 900lbs.

3.6 Construction Data

Construction Data [9]

Height of elevator 1829mm

Length of elevator 457mm

Breadth of elevator 305mm

Height of elevator shaft 1524mm

Elevator car height 375mm

Elevator car length 300mm

Elevator car breadth 300mm

Elevator car weight 3.75kg

Rope diameter 4mm (0.16")

Diameter of pulley 100mm

3.7 Calculations

THE CAR:

From standard, the number of passengers shall be obtained from the formula:

Number of passengers = rated load /75 = 320kg/75 (3.3)

Therefore, the number of passengers = rated load/x = 3.75kg/x (3.4)

Equating equation (3.3) and (3.4)

x = (3.75 x 75) / 320 = 0.9kg

Therefore: No. of item carried by the elevator = 3.75/0.9 = 4.16

Approximately 4 item can be carried can be carried by the elevator car.

Therefore, maximum load carried by the elevator car = (0.9 x 4) kg = 3.6kg

THE COUNTER WEIGHT

Elevator Counterweight = Half of Elevator Maximum Capacity + Car Weight

Therefore, Counter Weight is (3.6/2 + 3.75) kg = 1.8Kg + 3.75kg = 5.6kg

This is just to create an imbalance between Elevator cab and counterweight in order to save power in the drive.

THE MOTOR

Known Data:

- Mass of counter weight (MCo) = 5.6kg
- Mass of Car Max load (MCa) = 7.35kg
- Velocity (V) = 1m/s
- Time (t) = 1sec

F = (MCa + MCo) x V/t

F = (7.35 + 5.6) kg x 1/1

= 12.95kg

The distance required to accelerate to cruising speed is,

Distance (X) = ½ at2 (3.5)

Since we have stated that 1 m/s reached in 1 sec, then a = 1 m/s2. Thus,

X = ½ x 1 x 12

X = 0.5

The power calculation:

P = F x X/t (3.6)

= 12.95 x 0.5/1

=6.475w

P = 0.006475kw

THE ROPE

Breaking strength for synthetic line = comparison factor x 900ibs x circumfernce2

Rope diameter = 4mm (0.16inch)

Circumference of rope = πd = 3.14 x 0.16 = 0.5024inch

Therefore, breaking strength = 1.4 x 0.50242 x 900lbs = 318.0 pounds of breaking strength

The testing of the elevator to determine the maximum loads it can carry was carried out using load of average weight of 0.9kg. The load was selected based on the design calculation made

Table 3.1 shows the parameters for constant load when the elevator car is moving up. It was observed that with a constant load, the speed of the elevator car remains the same from the down floor to the first, second and third floor. From table 3.2, the weights of the loads determine the time of travel of the elevator, that is, increase in load causes increase in time it takes to travel and therefore determine the speed at which the car travels from one distance to another.

Therefore, the working load is 3.6kg and the maximum load is 4.5kg. The elevator car will not move at a load above 4.5kg as can be seen in table 3.2. As can be seen from the Table 3.3, increase in load causes decrease in time of travel of the elevator car.

Table 3.1 Parameters for a constant load when the car is moving up. [9]

No	Time (T) Sec	Distance (H) mm	Load +Car weight (P) kg	Floor	Speed (S) mm/s
1	6	375	0.9	0 –1	62.5
2	12	750	0.9	0 –2	62.5
3	18	1125	0.9	0 –3	62.5

Table 3.2 Parameters for a variable load when the car is moving up. [9]

No	Time (T) sec	Distance (H) mm	Load +Car weight (P) kg	Floor	Speed (S) mm/s
1	18	1125	0.9	0 - 3	62.5
2	18	1125	1.8	0 – 3	62.5
3	19	1125	2.7	0 – 3	59.2
4	21	1125	3.6	0 – 3	53.6
5	27	1125	4.5	0 – 3	41.7
6	-	-	5.4	0 – 3	-

Table 3.3 Parameters for a constant load when the car is moving down [9]

No	Time (T) sec	Distance (H) mm	Load +Car weight (P) Kg	Floor	Speed (S) mm/s
1	18	1125	0.9	3 – 0	62.5
2	18	1125	1.8	3 – 0	62.5
3	17	1125	2.7	3 – 0	59.2
4	15	1125	3.6	3 – 0	53.6
5	10	1125	4.5	3 – 0	41.7
6	-	-	5.4	3 – 0	-

This Study work aims at designing and constructing a simple but effective elevator using cable and pulley system, and which will be powered by a D.C source. From the result obtained, the maximum load to be lifted by the elevator should not be exceeded as this will prevent the elevator car from moving and might also leads to gradual breakdown of the elevator. The importance of elevator in this century cannot be overemphasized; therefore, it is necessary to always come up with better and improved designs to other elevators available in order to save cost in construction, installation and maintenance.

Chapter 4

Regenerative System

4.1 Introduction

4.2 Regenerative lifts at the Tamar Central Government Offices

4.3 Effects of Regenerative Elevators on Generators

4.4 Savings

CHAPTER 4
REGENERATIVE SYSTEM

4.1 Introduction

Lift and escalator in a multi-storey building serve to bring people up and down the building floors. As most of the buildings in Hong Kong are getting taller, new lifts are running faster and are essential mechanical installation for vertical transportation nowadays. In Hong Kong, the energy consumption of lift and escalator installations are almost as much as that of lighting installation in commercial buildings. This is mainly due to their invariably large electrical motors and virtually continuous operation throughout the day in many cases. To meet the challenge of energy conservation, one of the latest technologies adopted in lifts is regenerative function which recovers braking energy from lift operation. To assess the energy saving performance of regenerative lifts, passenger lifts in the Tamar Central Government Offices were studied [10] in 2013.

For conventional lifts, the power generated by the traction machine is dissipated as heat in the building. Whereas, lift with regenerative function obtains power from electrical supply network, when it travels downwards with heavy load or upwards with light load, the traction machine will be act as power generator and the lift is running at "regenerative mode". In 2009, EMSTF replaced the lifts at the Sheung Shui Police Married Quarters with regenerative lifts, which convert the energy generated from the lift motor driven by gravity into electricity for other uses. This energy efficient installation provides a green lift option for client departments to consider applying in their venues. Compared to conventional lifts, regenerative lifts are 20% to 30% more energy efficient. [10]

Lift is recognized as the second-most electricity consuming system in communal areas of public rental housing blocks. While the Housing Authority (HA) has been adopting energy-efficient variable voltage variable frequency (VVVF) type lift power systems for many years, since 2013, the HA has taken a further step to adopt lift regenerative power for large lift motors of 18 kW or above to save more energy. Lifts equipped with regenerative power feature can capture and condition the regenerated electricity for feeding directly into the power grid for immediate consumption by communal facilities. The amount of energy saving arising from lift regenerative power varies with the lift traffic pattern. The Housing Department have assessed the lift system in Kai Ching Estate1 and found that the amount of energy regenerated is generally up to 20% to 30% of the energy consumed by the lifts. Traction machines are commonly adopted in lifts of

Hong Kong and could be retrofitted with regenerative braking module either by geared or gearless traction drives. However, the add-on regenerative braking module can only be added on the Variable Frequency (VF) drives to serve as regenerative braking function. The regenerative braking module is connected in parallel with the rectifier of the motor drive (between the DC bus and AC supply). After installing the regenerative braking module to the Variable Voltage Variable Frequency (VVVF) drive, it can save electricity consumption of lift up to one fourth as compared with that of lifts without regenerative function.

4.2 Regenerative lifts at the Tamar Central Government Offices

Lifts at the Tamar Central Government Offices were equipped with power regeneration drive whereby energy was regenerated as electricity whenever the lift machine was operating in a "generator mode". By adopting the lift power regeneration technology, using reclaiming energy for a useful purpose rather than wasting it as heat is an effective form of overall energy conservation. Lifts at the Tamar Central Government Offices were designed to achieve flexibility services for low zones (i.e. serving 1/F to 14/F) as well as high zones (i.e. serving 1/F, 14/F to 23/F) of East Wing and West Wing. In 2013, we studied energy performance on passenger lifts with rated capacity of 1,600 kg and rated speed of 6 m/s, 5 m/s, 3.5 m/s, 3 m/s, and 2.5 m/s. Results indicated that the amount of energy saving from regeneration depended on various operating factors and parameters such as the design capacity, travelling speed, loading profile and travel distance. The table 4.1 below shows the energy consumption and energy regenerated from several categories of lifts in the Tamar Central Government Offices.

Table 4.1 Energy consumption and energy regenerated [10]

Lift No. (Speed)	Item	Energy from 16 Aug to 16 Dec 2013 (kWh)	% of Electricity Saving
East Wing High Zone (6 m/s)	Energy Consumed	45,913	25.7%
	Energy Regenerated	15,847	
East Wing Low Zone (5 m/s)	Energy Consumed	29,311	22.4%
	Energy Regenerated	8,459	
West Wing High Zone (5 m/s)	Energy Consumed	43,518	27.0%
	Energy Regenerated	16,072	
West Wing Low Zone (2.5 m/s)	Energy Consumed	24,640	18.9%
	Energy Regenerated	5,760	
East Wing Passenger (High + Low Zone) (3 m/s)	Energy Consumed	9,405	23.3%
	Energy Regenerated	2,852	
West Wing Passenger (High + Low Zone) (3.5 m/s)	Energy Consumed	16,181	26.4%
	Energy Regenerated	5,796	
East Wing Services (High + Low Zone) (2.5 m/s)	Energy Consumed	7,361	22.4%
	Energy Regenerated	2,120	
West Wing Services (1 to 3/F) (1.75 m/s)	Energy Consumed	2,505	17.1%
	Energy Regenerated	565	

From the above results, the lift regenerative function could achieve an energy saving [10] of 17% to 27%. The high zone lifts could achieve more saving as compared with the low zone lifts under the same configurations. It indicates that the amount of regenerative power obtained depends on lift operating speed and travel distances.

Regenerative lifts can save electrical energy under certain lift operating speed and travel distance. For lifts operating at speed greater than 2.5 m/s under light load in upward direction and heavy load in downward direction with the designed lift, the energy saving performance is obvious. Besides, regenerative function of lifts can greatly reduce the heat dissipation arising from braking of lift, thus saving overall power consumption of lifts. On electrical power quality aspect, the harmonic distortion could also be minimized so as to prevent possible abnormal disturbance of the power network and to reduce the energy losses due to harmonic currents.

However, the payback period may be longer as the cost of energy retrofit is likely higher than the expected saving from lift regenerative function. Besides, extra cost will be incurred if the existing lift drive has to be upgraded or replaced together with the installation of add-on regenerative braking module.

Nevertheless, energy saving of 17% to 27% could be achieved through lift regenerative function according to the study on passenger lifts at the Central Government Office. Regenerative function will become best practices for new lift installations as well as retrofits on existing lift installations. As energy saving is one of the concern factors of most lift manufacturers, in a long run, it is believed that the lift regenerative function will become a standard feature of lifts, especially for high speed lifts. Finally, please select a lift system with regenerative power which can be reused by other electrical installations in the building

4.3 EFFECTS OF REGENERATIVE ELEVATORS ON GENERATORS

Although recent advancements in technology have made elevators more energy efficient than ever, regenerative type of drives in elevators can prevent a building's generator from performing its essential job to provide power to equipment, devices and lighting for particular scenarios which will be outlined in this paper. A defective generator can result in interruption or damage to products/processes, hamper rescue operations or, worst of all, create serious life safety hazards. It is important to understand the effects of regenerative type elevators for the case of a brand-new building or an existing building in which the elevators are being replaced. Shaft or rope type elevators exert energy back into the system when the carriage is descending. During this process the mechanical load causes the motor to turn faster than synchronous speed so that in effect the motor acts like a generator, producing current. Traditional elevator systems utilize braking resistors to dissipate the extra energy which is then turned into heat that is distributed into the elevator machine room. Regenerative type elevators differ from traditional type in that they use drives which recycle energy by capturing heat generated by the elevators and converting it into reusable energy. The problem with connecting regenerative type elevators to a generator is there most often will not be other loads to absorb the extra power generated back into the system. The generator will then act as a motor and possibly cause the engine to over speed which can then lead to engine failure. Most generator manufacturers indicate that their generators can handle up to 10% of regenerative loads [11] without an issue. For example, a 100kW generator can accept up to 10kW of regeneration power.

The effect of regenerative loads on a generator is an important issue that should be well thought out at the beginning of a design for new buildings and also factored in to decisions that are made when refurbishing elevators in an existing building. The impact of ignoring this can lead to serious implications for both building systems and the occupants inside of the building. If there are excessive regenerative loads on a generator steps can be taken to establish a safe and orderly system by introducing a load bank.

Loads connected to generators are activated at different times as programmed; these loads are separated onto different automatic transfer switches (ATS). It represents a simple partial emergency power riser diagram. The loads served by the generator distribution panel, “GDP-1”, are branched off per National Electric Code (NEC) requirements. 3 separate transfer switches are shown in the diagram; they feed the following load types as defined by the NEC: emergency, legally required standby and optional standby.

ERU is a concept that can be connected to the existing elevator system using permanent magnet motors. This investigated ERU can be applied for future use of existing elevator system. They are able to generated electric output energy from the elevator when the elevator motors work force of gravity therefore ERU will receive DC voltage from the elevator’s inverter system then converts to AC voltage therefore this power can be fed into the grid system. Thus power output can be fed back to the system for replacement of the energy that has been used.

4.4 Savings

A Commonplace Scenario,

• Elevator Motor is Geared DC-20 HP

• Motor Gen Set 20 HP

• Elevator Run Time 4 hours/day

• Motor Gen Set Idles 20 hours/day 20 HP = 15 KW

• Idles at 1/3 Capacity: 20 hours @ 5 KW = 100 KWH/day

• Full Capacity: 4 hours @ 15 KW = 60 KWH/day

• Total Usage: 160 KWH/day @ $0.20 = $32/day

After regenerative system [10]

• Permanent magnet AC (PMAC) motor eliminates motor gen set saving 100KWH

• PMAC sized at 25% lower capacity: 15 HP or 11.75KW

• Operation for 4 hours @ 11.75KW = 45KWH

• Regenerative drive captures 35%, or 15.75 KWH

• Net usage is 45KWH – 15.75KWH = 24.25KWH/day

• Cost of 24.25KWH @ $0.20 = $5.85

• Savings over worst case: 32KWH - $5.85 = $26.16, or 81.7% savings!

Chapter 5

Energy-efficient elevators

5.1 Introduction

5.2 Technological analysis

5.3 Monitoring campaign

5.4 Estimation of savings potentials

CHAPTER 5
ENERGY-EFFICIENT ELEVATORS

5.1 Introduction

Elevators and escalators are the crucial elements that make it practical and comfortable to live, work and shop several floors above and below ground. Elevators typically account for about 3 to 8% of the overall electricity consumption of a building. Further urbanization in developing countries, growing awareness of accessibility issues, an ageing population in many western countries as well as a rising demand for convenience will lead to the installation of additional equipment. By improving the energy efficiency in existing and new equipment, elevators and escalators can contribute to current energy and climate targets in Europe. For this purpose, a thorough analysis of the efficiency potentials and suitable policy measures are required.

Until now little research has been carried out on the electricity demand of elevators and escalators, especially with a focus on the European market. Most prior studies have a limited focus, e.g. the analyses remain at an aggregate level or are limited to a national context: Sachs, for example, provides estimates and reflections on the energy consumption of elevators by discussing opportunities for efficiency improvements of elevators, however, his study focuses on the United States. Nipkow conducted a more detailed study, including a monitoring campaign of 33 elevators, and provided an estimation of energy efficiency potentials of elevators for Switzerland, but he does not provide an in-depth analysis of barriers and policy recommendations. Other studies subsume elevators and escalators as one energy service among others and focus on specific building types, not providing the coverage of this study: Clausnitzer and Hoffmann discuss, for example, the electricity demand of elevators in the context of general electricity demand, focusing on multi-family residential buildings.

Beier, who analyses the electricity demand of elevators as part of an analysis of energy consumption in hospital buildings. Other approaches focus on modelling aspects concerned with the energy consumption of escalators, as for example found in Ma et al. and Al-Sharif.

For these reasons, knowledge about the impact of elevators and escalators on energy consumption in Europe is limited, little is known about specific saving potentials, and no policy recommendations can be provided. This paper aims to fill this gap and is structured as follows, the current stock of installations in Europe is estimated, based on an expert survey, also including a short overview of the relevant drive technologies in the elevator market. This data is then combined with the results of a monitoring campaign which includes 81 installations in different countries. The current energy consumption of elevators and escalators is estimated on this basis. Based on this data on the current situation, an analysis of technical efficiency potentials is carried out, by looking at currently best available technology (BAT) and best not-yet available technology (BNAT) that will be available in the near future. While this analysis indicates considerable efficiency potentials, experience from other technologies has shown that, even if efficient technology is available at a reasonable price, it is still often not implemented. Section 3 therefore provides an analysis of possible barriers to energy efficiency in the elevator and escalator market and proposes policy measures to overcome those barriers. The concluding Section 4 summarizes the results and provides directions to further improve and extend the analysis. Methodological details for each step will be described in the corresponding sections.

5.2 Technological analysis

In order to derive valid estimations of energy consumption and energy efficiency potentials, knowledge about the currently installed stock of installations is required. For this purpose, data was collected in cooperation with the European Lift Association (ELA) who approached their technical experts in the national member associations to provide nationwide estimates of the number of existing installations, classified by building type and including a characterization of basic technological aspects such as motor size, number of trips, average car size, etc. In order to standardize data collection, an identical questionnaire was sent out to experts in national ELA member associations. Detailed answers were received from 16 out of 19 surveyed member's associations, including feedback from the most relevant countries such as Spain, Italy, Germany, France, Greece and the United Kingdom. These questionnaires were further analysed in expert discussions, also to provide estimates for the stock in the remaining countries in the EU-27. The summarized distribution of elevators in these countries by economic sector and drive technology. The results indicate that there are currently over 4.8 million elevators [12] installed and operated in the European Union. Every year about 115,000 new elevators are put into service.1 Elevators can be differentiated in two types, according to the motor system. Traction elevators are used in many different applications without many limitations regarding travel distance, speed or load. In these systems the elevator car is suspended by ropes that are moved via an electrically driven sheave. The opposite end of the ropes is connected to a counterweight. Depending on whether the sheave is driven directly by the electric motor or whether a gearbox is used, these elevators are further differentiated into geared and gearless traction systems. According to the survey results, geared traction elevators are the most commonly used elevator type in Europe, constituting more than two thirds of the European elevator stock. Gearless traction elevators are a comparatively young technology and only constitute about 8% of the total elevator stock, but they have a comparatively high share in tertiary sector buildings. The remaining elevators operate on hydraulics. This type of elevator is often used in low-rise applications and is widely used in some European countries due to low initial costs. It relies on a hydraulic piston to move the car. Energy is usually provided to the hydraulic fluid by an electrically driven hydraulic pump. These elevators typically do not use a counterweight to compensate for the weight of the car. With regard to the location of these installations, elevators in residential buildings represent by far the largest group with 3.1 million elevators in use. In the tertiary sector, there are about 1.5 million installed units. The industry sector only plays a minor role, only about 175,000 units can be found there, according to the results. The number of installed escalators is considerably smaller than the stock of elevators. According to the survey results, ELA statistics and ELA expert input, there are approximately 75,000 escalators and moving walkway units installed in the EU-27, of which 60,000 units (80%) are located in commercial buildings and the remaining units in public transportation facilities (train stations, airports, etc.). Every year, about 3500 new escalators are put into service.

5.3 Monitoring campaign

In order to obtain an empirical basis for the energy consumption data of elevators and escalators, a monitoring campaign was carried out. Its aim was to provide the basis for an estimate of the electric energy used by installations throughout Europe. In total, 74 elevators and 7 escalators, i.e. a total of 81 installations, were analysed [12] in Germany, Italy, Poland and Portugal. In general, elevators are often individually engineered systems instead of off-the-shelf products. Therefore, elevators with different characteristics and from different buildings types were selected to obtain information about the energy demand of a wide range of different elevator configurations.

The segmentation of the monitored sample by building type and drive technology. To ensure the comparability of the measurements, a common methodology was developed and used in all countries. The methodology considers power measurements relating to the normal operation of the elevator or escalator. Particularly, a distinction was made between running and stand-by consumption of the equipment analysed. To assess running consumption, the energy consumption of a reference cycle was measured, using power meters. This cycle includes a complete round-trip from the bottom landing of the elevator to the top landing and back to the original position again, including three complete door cycles, two at the bottom landing (beginning, end) and one at the top landing. The overall energy consumption in the running mode for this reference cycle is influenced by numerous factors, such as the consumption of the control system, frequency converter, ancillary equipment and parameters such as acceleration and deceleration or speed. Especially the length of the hoist way renders a direct comparison of absolute running consumption values for a reference cycle difficult, and thus this information provides few insights for technological comparisons. Thus, the specific energy consumption values according to the specifications of VDI 4707-1 [10] for the running mode were calculated, relating absolute energy consumption to rated load and travel distance [mWh/(kgm)]. The results show that the specific running consumption of hydraulic elevators is significantly higher than that of traction elevators, mainly due to the fact that they do not possess a counterweight and thus the entire cab plus the load has to be lifted. Comparison of the geared and gearless traction elevators of the sample shows that gearless elevators tend to have lower consumption values than geared elevators. The measured stand-by power varied widely as well. Stand-by consumption is caused by various components, such as the control systems, lighting, floor displays, frequency converters and operating consoles in each floor and inside the elevator cabin. In the analysed elevators, the stand-by power consumption ranges from below 50 W to more than 700 W. In order to gain on the share of stand-by in the total energy demand, running and stand-by consumption have to be complemented by information on actual usage, i.e. the number of trips per year. For the analysis, either the number of trips was collected from trip counters or documentation or otherwise typical trip numbers by building type were assumed, based on expert input. Using these numbers, the share of elevator stand-by consumption shows a large variance, ranging from 5% to 95% across the different installations. These large differences originate especially from different usage patterns (the higher the number of trips, the higher the running consumption tends to be), on the one hand, and from the different consumption values during running and stand-by, on the other hand. Annual energy demand thus also reveals a large diversity, ranging roughly between values of 500 and 20,000 kWh per year and unit. For escalators, the power consumption was determined in different states of operation. The running consumption is determined by conducting measurements over a period of 5 min when the escalator is running at nominal speed. Concerning stand-by, two different modes were distinguished: a stop mode (when the escalator is actually not running, however, prepared to start if passengers enter it) and a low-speed mode. Low-speed modes are available on escalators with variable speed drives: in this mode of operation, the speed and thus the energy consumption of the escalator is reduced while waiting for the next passengers to board. Therefore, it is also considered to be a stand-by mode. According to the developed methodology, the stand-by consumption is considered to be the sum of the low-speed mode consumption, if available, and the stop mode consumption. Measurements were carried out for empty escalators only. To take passenger load into account as found in real systems, annual consumption values were calculated by multiplying running consumption with a typical load factor.

The results of the monitoring action on 7 escalators show that, in this low-speed mode, the energy consumption is more or less half of the consumption of the normal operation mode. Estimations of the annual electricity consumption of the analysed escalators indicate energy demand values of roughly 4000–10,000 kWh per year and installation, depending on the respective configuration and usage.

Combining stock estimates with the data from the monitoring campaign, the annual electrical energy demand of elevator and escalator installations in the EU-27 is estimated. For elevators, average consumption values both for stand-by and running mode were calculated for each drive technology and sub-sector, using the results of the monitoring campaign. These values were then combined with information from the survey on elevator stocks. Concerning escalators, the average value for the electricity consumed during running and stand-by modes were combined with the average operating and stand-by hours per year, as detailed in The results indicate that elevators in the EU-27 consume about 18.4 TWh of electrical energy per year, of which 6.7 TWh originate from installations in the residential sector, 10.9 TWh from the tertiary sector and only 0.8 TWh from the industrial sector. Although the number of installed elevators in the tertiary sector is smaller than in the residential sector, their consumption is considerably larger, due to their more intensive use. Stand-by electricity consumption represents a very significant share of the overall electricity consumption. Accounting for 68% (4.5 TWh) of overall consumption in this sector, elevators installed in the residential sector have a very high share in stand-by consumption. For the tertiary sector, stand-by accounts for another 4.6 TWh. Escalators (including moving walkways) are estimated to consume around 0.9 TWh of electricity each year and thus represent only a fraction of the yearly energy consumption of elevators.

5.4 Estimation of savings potentials

For the calculation of savings potentials, it is assumed that currently used equipment (CT) is replaced by best-available technological solutions. The estimation of the potential savings for elevators is made by assuming two technological scenarios

- Best available technologies (BAT) are used,
- Best not-yet available technologies (BNAT) are used.

BAT are state-of-the-art components currently being commercialized while BNAT are new and existing technologies that are not commercially available yet. The assumptions used for both scenarios are the result of a careful evaluation of the available technological solutions [12], the results of the monitoring campaign and the specialist advice of several manufacturers and experts.

The results for elevators show that considerable savings are possible. A reduction by 11.5 TWh (62%) is achieved using BAT and 13.6 TWh (74%) can be saved when BNAT are used. Savings in the stand-by mode are particularly noticeable also, in both the BAT and the BNAT scenarios. For the BAT it is assumed that low power equipment is used, which, however, constantly consumes energy all the time. In particular, the use of LED lighting plays a major role in this reduction, as it drastically reduces the energy consumption of 24/7 operated lighting in the car. If equipment is turned off and put into a sleep-mode when not in use, corresponding to the BNAT scenario, a reduction in stand-by power of more than 80% is considered Feasible. For the estimation of possible energy savings in escalators, it is assumed that currently 30% of all escalators are equipped with a variable speed drive. To calculate the efficiency potentials, it is assumed that all escalators could be equipped with a VSD and would therefore be capable of operating in a "reduced speed" mode. Furthermore, it is assumed that when stopped, the controller and inverter only consume 1 W each. These assumptions lead to an overall reduction in the energy consumption of escalators of approximately 0.25 TWh (28%). It summarizes the consumption values and efficiency potentials for the currently installed elevators and escalators in Europe. With respect to the estimated savings, it is important to note that some technologies may increase stand-by consumption, while reducing consumption during the running phase. Therefore, their application in a given installation should be carefully evaluated on a case-specific basis, especially taking the usage into account.

To sum up, this paper provides a full analysis of the elevator and escalator market with regard to energy efficiency. As a basis for a sound analysis, first of all, the stock of installations throughout the EU-27 was analysed. After developing a measurement methodology, 81 different installations in five different countries using all relevant technologies were monitored. Combining this data provided an estimation of the annual energy demand of elevator and escalators installations in Europe. It turns out that elevators and escalators consume about 19.3 TWh per year. This is equivalent to a share of 0.7% in the electricity consumption in the EU-27 in 2008 (2.856 TWh). The impact of elevators is much higher than the impact of escalators, due to the much lower number of escalators installed.

From a sectoral point of view, elevators in the residential sector, although they form the majority of elevators installed (64% of all units), are responsible for only 36% (6.7 TWh) of the overall electricity demand by elevators. This is due to their less intensive usage. On the other hand, elevators installed in the tertiary sector usually have a more intensive use and consume about 59% (10.9 TWh) of the total elevator electricity consumption, which corresponds to almost 1.4% of the electricity consumed in that sector in 2008 (753 TWh). In terms of stand-by consumption, the elevators in the sample showed a large range of values, ranging from below 50 W to 700 W. In terms of running consumption, hydraulic elevators that are usually not equipped with counterweights showed a significantly higher running consumption than traction elevators. The overall effect on the energy consumption of an installation, however, depends on the actual balance of stand-by and running consumption. While it is informative to know how much energy is consumed by elevators and escalators, it is more important to analyse whether this consumption could be reduced without decreasing comfort and accessibility. This was analysed, drawing on data about BAT and BNAT which, however, are expected to be on the market soon. The use of BAT in all existing elevator installations could result in technical savings during stand-by consumption of more than 70%. In particular, energy-efficient lighting and the use of electronic components with low stand-by power (e.g. controllers and inverter) were found to play a major role in this reduction. Turning off nonessential equipment or putting it into a very low power or sleep mode, whenever possible, would produce even higher electricity savings (BNAT scenario).

The potential overall savings (running and stand-by) are estimated [12] to account for savings of 11.5 TWh (BAT) or 13.6 TWh (BNAT). Compared to elevators, the estimated electricity consumption of escalators in Europe is relatively modest (0.9 TWh), and a potential reduction of around 0.25 TWh (30%) would be feasible if all the escalators installed were to be equipped with automatic speed controls and with low power stand-by modes. However, these energy savings scenarios are far from becoming reality. Elevators and escalators have long life cycles, which imply a slow market penetration for new technologies. Additionally, various barriers to energy-efficient technology are present in the market as shown by the study of this topic presented above. The main barriers identified are lack of information and awareness, split-incentive problems and an unclear state of knowledge about 158 A. De Almeida et al. / Energy and Buildings 47 (2012) 151–158 the economic efficiency of the technological measures.

The first profound analyses on the topic of energy efficiency on a European scale. Therefore, it turned out to be necessary, as a first step, to collect data for estimating energy demand and efficiency potentials. Also barriers to energy efficiency have not been systematically analysed before. Against this background, several limitations are important to note. First of all, the analysis of efficiency potentials presented in this paper is restricted to a technological point of view. The initial as well as maintenance costs of the technologies used, while being an important issue regarding their application, have not been considered; therefore, no indications are provided about the cost-effectiveness of using those technologies. Within the barrier analysis it became apparent that cost issues might be a difficult topic, especially concerning elevators. Elevators are a more individually engineered product than off-the-shelf products. And, as pointed out above, their energy demand and their potential efficiency depends on a multitude of factors, most importantly the actual usage. On top of this, only for some of the technologies considered as part of the BAT and more importantly, the BNAT scenario, no valid data for expected costs exists. Complementing the analyses of energy efficiency with a cost perspective is therefore a topic that needs to be the subject of further research. Secondly, due to the fact that the specific literature for elevators and escalators with regard to energy efficiency is limited, our analysis is mainly a first step and could probably be improved in several ways, e.g. by measuring additional equipment or broadening the barrier analysis by studying valid market data, e.g. on using sales figures for certain technologies. Thirdly, the integration, especially of elevators into the building and the analysis of interfaces, e.g. elevator shaft, shaft ventilation, appropriate building design with regard to unnecessary elevator use, was out with the scope of our analysis. However, these topics might also significantly contribute to reducing overall energy consumption within the building. And, last but not least, an analysis including the full lifecycle from production to disposal would also enrich an analysis of sustainability for the means of vertical transportation; however, these topics were also clearly out with the scope of this paper with regard to the limited base of knowledge we started from. In sum, while our paper provides a first basis for estimations about demand and efficiency potentials, as well as providing recommendations for measures, more research is needed in this area.

Chapter 6

Otis Gen 2™ Flex+

6.1 Introduction

6.2 Closed-Loop Speed Control

6.3 Produces Energy for The Building

6.4 Energy Savings

CHAPTER 6

OTIS GEN 2 FLEX

6.1 Introduction

The Aim of OTIS company is "Six passenger's car in the same space as four". Otis philosophy is determined to lead the market towards a green present by developing a green, low consumption technologies. These philosophy is materialized in the OTUS GEN2 elevators [13] that do not produce hazardous waste and are up to 50% more efficient than conventional elevators, achieving subsential energy saving and significant reduction in CO2 emissions.

TODAY ELEVATOR TRAVEL IS A NECESSITY MORE THAN A COMMODITY

Buildings with very limited space can also have elevators. OTIS has launched a revolutionary elevator, the GeN2TM Flex⁺, which offers the possibility of installing an elevator where previously it was impossible or of changing the existing car for another one of greater capacity. The GeN2TM Flex⁺ elevator maximizes the space available and can be adapted to practically any type of hoist way. If there is already an elevator, it allows the passenger capacity of the car to be increased without requiring construction work to make the existing hoist way bigger. Thanks to its special configuration, GeN2TM Flex⁺ allows for two entrances at 90° and makes it possible to install a scenic elevator.

Fig 6.1 Four Passenger versus Six Passenger [13]

FLEXIBLE STEEL BELTS The flat, polyurethane-coated steel belts patented by OTIS are 20% lighter than conventional ropes and last three times longer.

OTIS GREENPOWER MACHINE The compact gearless machine is equipped with a synchronous, permanent-magnet motor of radial design. From an energy perspective, it is up to 50% more efficient than a conventional geared machine.

6.2 CLOSED-LOOP SPEED CONTROL

Speed: Consistently smooth acceleration and deceleration, a faster and more comfortable ride, and exceptional levelling accuracy are some of the many benefits of closed-loop speed control.

Time: THE GEN2™ SHEAVE The reduced sheave size of the GeN2™ system, only 80 mm in diameter, has allowed OTIS to design a machine that is 70% smaller than traditional machines.

PERMANENT MONITORING OF THE BELTS The PULSE™ system continuously monitors the status of the steel belts 24 hours a day, 7 days a week technicians

• Door restrictor Prevents passengers from opening the car doors if the elevator is stopped between floors, and from exiting the elevator without following the safety procedures.

• Hostway access detection to protect the maintenance technicians, a special safety system prevents the elevator from operating on normal service after a landing door has been opened, unless the car is on that floor.

• Entrance protection (optional) A screen of infra-red beams that acts as an invisible safety curtain. When an obstacle is detected, the entrance protection system immediately reopens the doors.

• Outstanding levelling accuracy The reduced stretch of the flat belts compared to conventional steel ropes, together with a closed-loop VF motion control, results in outstanding levelling accuracy (+/- 3mm).

• Machine brake system The VF system prevents the machine from operating before the brake is fully released.

6.3 PRODUCES ENERGY FOR THE BUILDING

An elevator consists of a car and a counterweight that are connected by a machine. When the counterweight travels down, the car travels up and when the counterweight travels up, the car travels down.

The GeN2TM Flex+ elevator is equipped with a regenerative system. The ReGen Drive complies with the most demanding energy efficiency requirements, significantly reducing the consumption and the energy costs of the building. In conventional elevator systems, the energy generated by the elevator is dissipated in the form of heat. The ReGen Drive is able to capture this energy and feed it back into the building grid, where it can be used to power other electrical components. A heavily or fully loaded car weighs more than the counterweight and utilises gravity to travel down, thus generating energy. The same occurs when an empty or lightly loaded car travels up. In this case, as the counterweight is heavier, it utilises gravity to travel down, thus generating energy.

OPTIONS: LIGHTING

LED lighting can provide energy savings of at least 50% compared with other systems such as fluorescent lights or halogen lamps. It does not generate heat which is an important issue in a small space such as an elevator car and lasts at least 10 times longer than other lighting systems.

AUTOMATIC CAR LIGHTING SWITCH-OFF Car lighting previously remained on 24 hours a day, 365 days a year, even when the elevator was not in use and was stopped for hours and hours. The solution in order to avoid this useless waste of energy is car lighting that switches off automatically. When the elevator is not in use, the car lighting is switched off after a certain time. It remains off until a passenger presses a call button and the elevator returns to service. In this way, the energy consumption of car lighting can be reduced more than 95%.

6.4 ENERGY SAVINGS

The table below shows a comparison of contract power required and energy consumption of the motor, according to the type of elevator and the car lighting consumption with LED automatic switch-off or constant fluorescent lighting. The savings achieved, in kWh and in euros, thanks to the GeN2^{TM} system and the automatic car lighting switch-off system, are as follows:

Contracted Power Consumption Contracted Power Consumption Contracted Power Consumption. Data according to VDI 4707 usage category 2 (average traveling time of 30 minutes per day). Nominal speed of the Gen2 Flex^{+} and the conventional traction elevator: 1 m/s. Nominal speed of the hydraulic elevator: 0,63 m/s.

Table 6.1 Comparison of contract power required and energy consumption of the motor [13]

Elevator	Hydraulic	2-Speed Traction	Hydraulic	2-Speed Traction
	Energy savings		Financial savings (including power supply contracted)	
4 passengers	930 kWh (68.8%)	237 kWh (36.0%)	€ 681	€ 244
6 passengers	1,324 kWh (73.8%)	301 kWh (39.1%)	€ 878	€ 352
8 passengers	1,868 kWh (77.8%)	392 kWh (42.4%)	€ 918	€ 261
Car lighting	833 kWh	833 kWh	€ 147	€ 147

Table 6.2 Savings Achieved [13]

Elevator	Hydraulic		2-Speed Traction		OTIS GeN2™ Flex⁺	
	Contracted Power	Consumption	Contracted Power	Consumption	Contracted Power	Consumption
4 passengers	13.5 kW	1,352 kWh / year	7.3 kW	659 kWh / year	3.3 kW	422 kWh / year
6 passengers	16 kW	1,793 kWh / year	9.2 kW	770 kWh / year	3.3 kW	469 kWh / year
8 passengers	17 kW	2,400 kWh / year	9.2 kW	924 kWh / year	5.4 kW	532 kWh / year
Car lighting	Consumption with constant fluorescent lighting		Consumption with constant fluorescent lighting		Consumption with LED automatic switch-off	
	840 kWh / year		840 kWh / year		7 kWh / year	

Annual savings [13] due to power supply contracted, system energy demand and car lighting. Assuming a cost of 0.14 kWh and a cost of € 40.20 per kW contracted per year, plus taxes. Savings in Euros may vary according to the tariff applied by the electric company.

We Increase the Space inside Your **Elevator Car from 4 To 6 Passengers.**

Chapter 7

Proposed Design of Energy Saving in Lift

7.1 Introduction

7.2 Components of Elevator

7.3 Working of Elevator

7.4 Dimensions

7.5 Calculation

7.6 Energy Savings

CHAPTER 7

PROPOSED DESIGN OF ENERGY SAVING IN LIFT

7.1 Introduction

With the development of architecture technology, the building structures are taller and elevators become important vertical transportation vehicles in high-rise buildings. For most people in urban cities, elevators have become an integral part of their life. Simply stated, an elevator is a hoisting or lowering mechanism, designed to carry passengers or freight, and is equipped with a car and platform that typically moves in a fixed guides and serves two or more landings. They are responsible to transport passengers, living/working or visiting in the building, comfortable and efficiently to their destinations.

Fig 7.1 Energy Efficient Elevator

In an elevator the energy, motor needed, is reduced by the counter weight by some extend. Energy-saving elevators are widely applied for replacement of morally and physically worn elevators equipment. The elevator we have designed works totally on counter weight just like a weight balance use at grocery stores. That is, the heavy side will move down due to gravity, lifting the counterpart which is light in weight for most of the working condition.

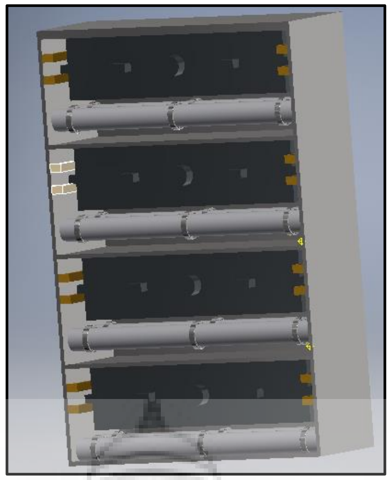


Fig 7.2 Counter Weight Frame

The counter weight is designed in such a way that the weight in it can be adjust according to the requirement. That is, whether the cabin is to be lifted or be put down. The elevator control system is essential in the smooth and safe operation of each elevator. This system work on algorithm for the cases of number of passengers in the cabin and the availability of the counter weight block on the floor where each floor will have estimated number of counter weight.

7.2 Components of Elevator

Cabin: The Elevator Cabin is used to transport person and goods. It is a small enclosure with transparent window where persons enter and are protected before the elevator moves on. The elevator cabin is designed by having in mind the number of passengers it is going to accommodate. Also it should have the capacity to bear the weight of the passengers travelling in the elevator. The proposed elevator is having the capacity to accommodate approximately 10 persons of 65 kg each.

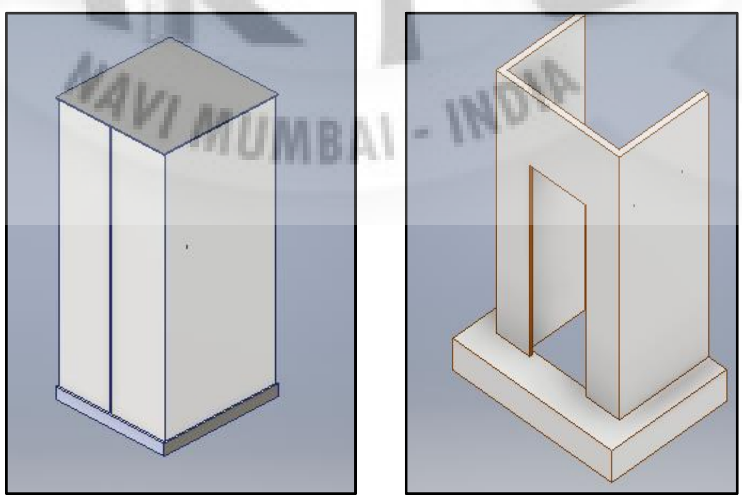


Fig 7.3 Cabin

Shaft: A Space in which the Lift cabin moves. The space is as a rule housed with pit bottom, walls and ceilings.

Machine room: A Room in which the Drive Unit and the Connected Equipment are Situated.

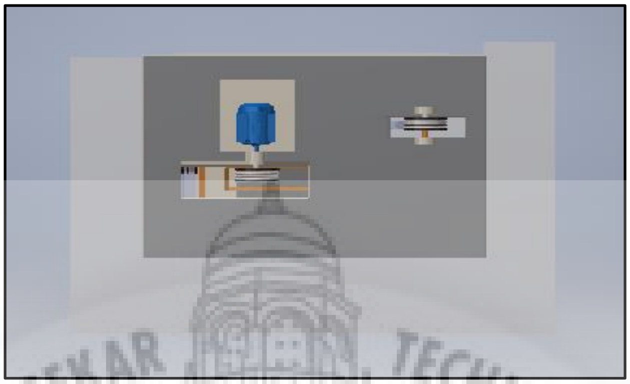


Fig 7.4 Machine Room

Drive Unit: A Unit that contains Motor that Drives a Lift.

T-guides: Rigid Elements that secure Guiding of a Car Frame and a Cabin.

Car Frame: A Rigid Construction that holds the Car and travel in the Guide.

Counter Weight: The Counterweights consist of individual Flat Plates of Steel. The number of plates in the stack depends on the amount of weight required. The Counterweights are secured within the counterweight frame by rods that run through the weights themselves. This design prevents the plates from becoming loose and falling out.

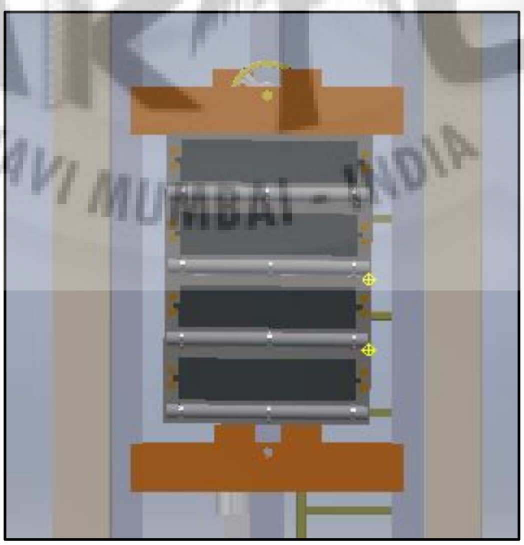


Fig 7.5 Counterweight

Solenoid Actuator: A pushing Mechanism use to push Counterweight Block from the resting section to the Counterweight or from Counterweight to the Resting Section.

Sensors: Sensors are used for Sensing the weight in the cabin and on the counter weight.

Controller: A Unit that Controls the Lift travel.

7.3 Working of Elevator

This elevator works on the simple principle of weight balance that acts under gravity. Just like a conventional elevator, one end of the cable is tied to the cabin and another with the counter weight and both of them will be drive by a motor in the motor room. There will be sections at each floor, inside the wall at the backside of the counter weight for resting and picking of the counter weight blocks according to the use.

As the passengers enters the cabin the sensors will detect the weight of the cabin with passengers and the counter weight, if the weight is to be added the weight will be added to the counter weight section from the resting section of the counter weight blocks and if the weight is to be remove it will shift the weight block from the counter weight to the resting section.

Fig 7.6 Woking of Elevator

Solenoid actuators do the movement of weight blocks from resting section to the counter weight or from counter weight to the resting section. The blocks are kept on the frictionless bearings because of this a slight push from the actuator will let the block move from one place to another. For the proper movement of weight block guideway is used.

The guideway helps to travel weight block from counter weight to resting position or from resting position to the counter weight because of this guideway slipping and misbalancing of weight block is provided during the adding or removal process.

To get stop at the proper position in the counter weight and resting position without any jerk or dis balance magnets are used. The entire system works on algorithm where the cases of availability of weight block and the resting section available for the weight block are considered. If the weight block is to be added to the counter weight and there is no weight block available at that floor then the system will let the motor to drive the cabin to his destination, like wise if the weight is to be remove from the counter weight and there is no resting section available for that block at that floor then the system will let the motor handle the situation. The stopping of the cabin over his desired destination is done by the motor.

7.4 Dimensions

Weight Block: L*B*H = 600*140*150 mm

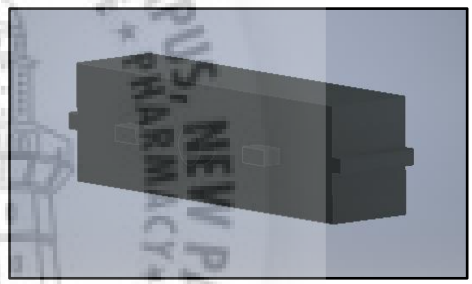


Fig 7.7 Counterweight Block

Counter Weight Frame: L*B*H = 680*240*1010 mm

No. of Magnets = Four in Each Block

i.e. Two at Front and Two at Back,

Size: L*B*H = 50*30*20 MM

Guide Plate stuck at both sideways of Block,

Size: L*B*H =140*20*30 MM

Shaft size: 680 mm length and 40 mm diameter

Bearings is 90 mm OD, 55 MM ID and 18 mm thickness

Bearing No.: N1011

Baseplate for sections,

Size: L*B*H = 680*240*10 mm

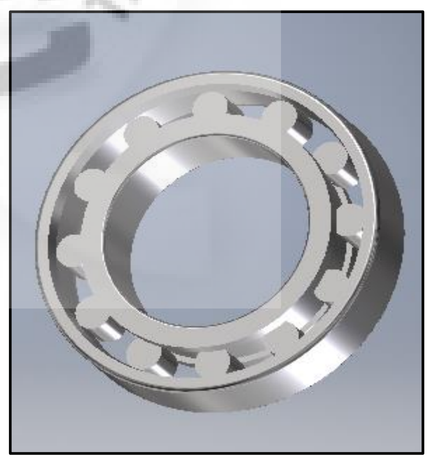


Fig 7.8 Bearing

7.5 Calculations

Actuator Selection Calculation,

Distance travelled by Actuator: 44 cm = 0.44 m

Time taken by Actuator = 2 seconds.

$S= ut + \frac{1}{2} at^2$

$0.44= (0)(2) + \frac{1}{2} a(2)^2$

a=0.22m/s

V= u+at

V= 0+ 0.22*2

V= 0.44 m/s

Considering mass of block as 150 kg

Force= mass* acceleration

Force= 150*0.22

Force= 33N

Selecting a suitable actuator as per the holding force as 40 N

Johnson Electric linear solenoid Actuator

Specifications:-

- Voltage : 44 V
- Resistance: 14.1 ohm
- Force: 40 N
- Power consumption: 130 watts

1. Ohm's Law

V=IR (V = 44V, R = 14.1 ohm)

I=V/R=3.12A

Now,

Elevator consumption depends upon number of trips by elevator in 24 hrs.

The continuous movement of elevator is 1hrs in 24 hrs. of time.

No of trips by elevator= 240 trips

i.e., 120 trips while going up

120 trips while going down.

Total trip time for all the 240 trip is 1 hr.

Elevator motor consumption for 1 hr. is 3.75KW

This is the consumption & details of normal residential elevator containing 4 floors.

Now,

In Our Elevator

- Total trips are 240 which is alternately calculated as :
- 70% operated on actuators
- Total no of trips are 168
- Power required by actuators in 1 hr is 130 Watts.
- Actual Power consumed by actuator is (130*70)/100=91 watts.

AND

- 30% operated on motors
- Total no of trips are 72
- Power required by motor is of 3.75 KW
- Actual Power consumed by motor is (3.75*30)/100=1.125 KW.

Now,

Working on actuator Cases (168)

1) 4 person using elevator=18

2) 3 person using elevator=40

3) 2 person using elevator=55

4) 1 person using elevator=55

Total=168 trips.

Now,

Power = Actuator power + Motor power

= 91+1120

= 1211 watts

= 1.21KW

Total power consumption of our elevator is 1.21 KW.

Now,

Efficiency = (1.21/3.75)*100

= 32.22 %.

7.6 Energy Savings

On Comparisons We get,

Normal elevator Power consumption = 3.75KW

Our Elevator consumption = 1.21KW

CHAPTER 8

CONCLUSION

The review of different research paper shows that power saving in an elevator can be saved by many methods one of which is regenerative system. Regenerative system generates energy from heat dissipation and work done by motor thus saves 17-27% of energy. Another method of saving electricity is proper optimization and utilization of elevators, which is done by improving the algorithm on which the elevator works. Energy to perform the same task that is eliminating energy waste. Energy efficiency brings a variety of benefits reducing greenhouse gas emission, reducing demand for energy imports and lowering our cost on a household and economy-wide level. Energy Efficient Elevator is the future model having regenerative drive and solar panel to make it more efficient elevator where power saving will be increased.

The elevator we have designed will not entirely work on electricity nor on the counter weight. The elevator will let the system and algorithm decide the mode of energy to use for the movement of the cabin. The algorithm is designed in such a way that it will work under most of the condition, minimizing the use of electricity.

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