Unit-5- Industrial Electrical Systems-II

Lecture- Elevators

An **elevator can be defined as an electric lift** which is used as vertical transportation of goods as well as people among the floors in buildings using bins otherwise silos. As usual, these are activated with the **electrical motors** that also to drive counterweight system cables for drive transaction such as a hoist, otherwise, pump hydraulic fluid for raising a cylindrical piston such as a jack.

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.

**Parts of Elevator and Its Function**

In this article, we will tell you about the various parts of elevators and its function.

**Elevators** have been around for many years. Let’s here take a closer look at parts of elevators and its function.

**Speed Governors**

The speed regulating system of elevators is known as the speed governor. If the elevator runs more than the speed limit, the speed governor controls the speed. It is usually attached to the bottom of the car and is also known as governor rope.

**Electric Motor**

In case the lift faces any serious condition, Electric Motors helps in preventing it and provides a smooth functioning of lifts.

**Elevator Rails**

Sliding up and down in the elevators is possible with the proper functioning of Elevator Rails.

**Cabin**

This is the main part of Elevator which is designed for the shipment of goods and services or the passage of persons.

**Elevator Shaft**

Lift cabin moves in this space. Depending upon the type of elevator, the location of the shaft can be varied.

**Doors**

As normal doors, elevator doors are also meant for entry and exit. Elevator door is of two types: Manual doors and Automatic doors.

- **Manual doors:** These types of doors are opened with the help of a person who wants to enter the lift.
• **Automatic doors**: Automatic doors are the type of doors which are automatically opened as it is powered by a door operator.

**Drive unit**
Everything that works under electricity must have a motor attached for the functioning. Drive unit is the part which contains a motor that drives the lift.

**Buffers**
The buffer is an apparatus located at the bottom of elevator designed to protect people. Buffers can stop a descending car by accumulating or dissipating the kinetic energy of the car.

**Safety device**
This is a mechanical device attached to the elevator for safety reasons. In case the lift travels downward with a maximum speed or over the speed limit, safety device can maintain a safety and secure traveling.

Well, these were some of the parts of elevators and its function. Traveling in an elevator is just amazing. But the skills and knowledge of technician and the effective maintenance of the elevators can bring up the travel an extraordinary one.

**Working principle**
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.
Comparison of Rheostatic braking and Regenerative braking:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Rheostatic braking</th>
<th>Regenerative braking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kinetic energy of moving masses is converted into electric energy as in this system, motor is made to work as generator.</td>
<td>Motor is not disconnected from supply and it works as a generator.</td>
</tr>
<tr>
<td>2.</td>
<td>Electric energy is dissipated in resistance and heat is produced.</td>
<td>Generated energy is fed back to the supply.</td>
</tr>
<tr>
<td>3.</td>
<td>Not economical due to loss of energy.</td>
<td>Most economical as energy is fed back.</td>
</tr>
<tr>
<td>4.</td>
<td>Braking torque: Due to generation, action energy is dissipated, produce braking torque.</td>
<td>Braking torque: Due to magnetic drag produced on account of generating action.</td>
</tr>
<tr>
<td>5.</td>
<td>Adjustment in braking torque: (i) by D.C. excitation control (ii) by varying rotor resistance</td>
<td>Adjustment by gradual increase in field excitation of separately excited motor.</td>
</tr>
</tbody>
</table>

**1.14 FUNCTION OF ELEVATORS.**

- Elevators are electrically operated devices used for lifting up and down, moving load in suitable direction, lifts in multistoried buildings/hotels for facilitating up and down movements of occupants. So function of elevators is transporting at a fixed place.

**1.14.1 Types of Electric Elevators**

Q. List any four types of electric elevators. Explain any one of them.  
Q. Write four types of elevator and explain about any one of them.

1. **With respect to Service, the Elevators are Grouped as:**
   (a) Passenger elevators.
   (b) Freight elevators: For hotels, apartments, stores etc.
   (c) Special elevators: Side walk, garages.
   (d) Combination of elevators: Mixed Passenger and Freight.
2. According to Capacity, the Elevators are Grouped as:
   (a) Light duty elevators.
   (b) Medium duty elevators.
   (c) Heavy duty elevators.
   (d) Extra heavy duty elevators.

3. According to Speed, the Elevators are Grouped as:
   (a) Low speed elevators.
   (b) Medium speed elevators.
   (c) High speed elevators.

4. According to power unit, the Elevators are Divided into two Groups:
   (a) Drum elevators.
   (b) Traction elevators.

5. According to Location of Power unit, the Elevators are:
   (a) Over mounted elevators.
   (b) Under mounted elevators.

6. According to Electric Current, these are Categorized as:
   (a) Direct Current (D.C.) elevators.
   (b) Alternating Current (A.C.) elevators.

7. According to Motor Drive used for Elevator, the Groups are:
   (a) Gearless elevators.
   (b) Geared elevators.

8. According to Rope Drive used, the Elevators are Known as:
   (a) Half wrap elevator
   (b) Full wrap elevator.

9. According to Control System Used in Elevators:
   (a) Semi-magnetic type.
   (b) Variable voltage type.

10. According to Method of Operating the Control:
    (a) Semi-magnetic type.
    (b) Full magnetic type.

11. According to Basic Principle of Control, these are Divided as:
    (a) Rheostatic.
    (b) Variable voltage.

12. According to Method of Operation of the Elevator:
    (a) Manual
    (b) Push button
    (c) Signal
    (d) Dual.
13. According to Velocity Ratio Between Motor and Car the Elevators are:
   (a) Direct drive
   (b) 2 : 1 reduction
   (c) Multi-reduction.

14. According to Method of Balancing the Load:
   (a) Counter balanced type
   (b) Compensated type.

Thus, there are many types of elevators used according to need, situation and purpose.

1.14.2 Applications of Elevators

(i) In apartments of multistoried buildings.
(ii) In hotels.
(iii) In stores etc. for passengers and goods.
(iv) For side walks and garages.
(v) In mines to lift and transport materials etc.
(v) In traction.

1.14.3 Ideal Requirements of Elevators

(i) Motor drive: Smooth working, easy control, reliable operation.
(ii) Size: Suitable (Explained in following sub-topics).
(iii) Speed: For different purposes of suitable speed.
(iv) Location: Suitable place.

These points are elaborated in the following topics.

1.15 SIZE AND SHAPE OF ELEVATOR CAR

Q. Describe size and shape of elevator car.

Q. State the factors to be considered for selection of shape and size of the car of elevator.

Q. Describe about: Size and shape.

Q. What are factors that decide the size and shape of elevator car?

- In planning an elevator installation, consideration should be first given to the size and shape of the elevator car. It is mainly dependent on the design of building and also it should be such as to obtain the highest operating efficiency in the movement of the traffic.
- By experience, the best shape for an elevator car is one having a wide front and shallow depth. The wide front provides ample door opening, facilitating quick transfer of passengers at floor level.
- The size of the car is determined either from the number of passengers to be carried or by limitations in the building design. The usual practice is to allow a space of 2 sq. ft. per person (i.e. 0.2 m² per person) and the maximum load capacity of elevator is figured on the basis of 75 lbs per sq. ft. (340 kg/m²) which assumes the average weight of a passenger to be 150 lbs (68 kgs).
1.16 SPEED OF ELEVATORS

Q. Describe about Speed.

Q. What is meant by speed of elevator? Give typical values of elevator speed for different installations.

The measure for the speed of a car is the number of feet the car will travel during the period of one minute.

Table 1.1: The usual practice for passenger elevators

<table>
<thead>
<tr>
<th>Type</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feet/minute</td>
</tr>
<tr>
<td><strong>1. Private residence:</strong></td>
<td>100 –150</td>
</tr>
<tr>
<td><strong>2. Hotels and apartment houses:</strong></td>
<td>100 –200</td>
</tr>
<tr>
<td>Upto 5 floors</td>
<td>200 – 350</td>
</tr>
<tr>
<td>6 to 10 floors</td>
<td></td>
</tr>
<tr>
<td><strong>3. Department stores:</strong></td>
<td>100 –200</td>
</tr>
<tr>
<td>Upto 5 floors</td>
<td>200 – 300</td>
</tr>
<tr>
<td>6 to 10 floors</td>
<td></td>
</tr>
<tr>
<td><strong>4. Office buildings:</strong></td>
<td>250 – 450</td>
</tr>
<tr>
<td>Upto 10 floors</td>
<td>400 –800</td>
</tr>
<tr>
<td>10th floor and above</td>
<td></td>
</tr>
</tbody>
</table>

1.17 LOCATION OF ELEVATOR MACHINE

Q. Location of elevator machine.

Q. List the types and essential features of elevator machines.

Mostly the elevator machine is installed in a room called the pent house which is located at the top of the building. Only in some exceptional cars the machine is installed in the basement. Basement installations are objectionable because they require much longer hoisting cables and more idler sheaves than for overhead machines, they occupy valuable space in the basement.

1.18 TYPES OF ELEVATOR MACHINES AND POWER TRANSMITTING GEARS

Q. State types of elevator machines.

Q. List the types and essential features of elevator machines.

There is a variety of types of power unit or elevator machines employed to drive electric elevators. With respect to the method of transmitting the power to the car ropes, elevator machines are divided into two general classes:

1. Drum
2. Traction.
• An elevator machine consists essentially of a motor, drum or traction pulley, brake and motor-drum drive.
• The drive may consist of a direct shaft connection between the motor and drum or it may be trough gearing system.

1.18.1 Drum Elevator Machines

• It consists of a drum which is in the form of a spool on which the ends of ropes are attached and around which they are wound and unwound in the operation of the car.
• There are generally two types of drums used. The drum here means a winding drum. The other drum used is a traction drum which is simply a type of pulley sheave. In construction, grooves are provided on both types of drum, the grooves being spiral for drum elevator and straight for traction elevators.

![Diagram of Winding Drum and Traction Pulley](image)

**Fig. 1.29: Drum, Traction Elevators**

• In the operation of a drum elevator machine, power when applied to the driving gear, turning it in one direction winds the ropes upon the drum and causes the car to ascend and when the power is reversed, the drum turns in the opposite direction, paying out the ropes and causing the car to descend.
• The weight of the car is balanced by a counter weight, thus reducing the energy to be expended in operating the car. Automatic devices are used to ensure proper and safe control of the movements of the car.
• With respect to location there are two types of machines known as:
  1. Over mounted
  2. Under mounted.
According to whether the machine is placed above the hoistway or in the basement.

![Diagram of Over Mounted and Under Mounted Machine]

**Fig. 1.30: Over Mounted and Under Mounted Machine**

- The over mounted machine gives direct transmission, that is no pulleys are required between drum and car, also the drum may be so located that one face is over the centre of the car and the other face over the counter balance, thus allowing the car ropes to be fastened at one end of the drum and the counter balance ropes at the other end of the drum grooves. The car ropes occupy the entire surface of the drum when the car is up and the counter balance rope is suspended as shown. This arrangement requires minimum length of rope.

- If the drum type machine be installed overhead, it will give remarkably long rope life because there is no possible rope creepage and the bending is always in one direction. However, if the machine be installed in the basement, reverse bends are necessary in the ropes and this material reduces rope life.

- One reason for the decreased use of the drum machine is because it requires a modification of the machine for each installation, as the length of travel determines the length of the winding drum. Another bad feature is that if overtravel limit switches fail to stop the car at the terminals, the machine may continue to travel and finally pull the ropes from their socket.

### 1.18.2 Traction Elevators

- In this type, the motion is obtained by means of traction i.e. through the friction existing between the driving pulley and hoisting ropes.
• The ropes are not wound on a drum, but a continuous rope from car to the counter weight passes over a driving pulley.

• The traction machine carries the hoist ropes over the hoisting sheave and down to the counter weight and relies on the grip of the ropes on the sheaves to give enough traction to lift the load.

1.19 ELEVATOR MOTORS

Q. State the requirement of elevator motor. State with reason best suitable motor for elevator. [W-03]
Q. Give suitable motors for each type of elevator machine. [W-08, 10: S-10]
Q. State the requirement of elevator motor. State with reason best suitable motor for elevator. [W-11]

• In order to ensure rapid acceleration and retardation, the inertia of moving parts must be kept as low as possible. For this reason motors for elevator service are designed with armatures of comparatively small diameter slow speed motor are preferable.

• Generally, the motor speed should not exceed 900 revolutions per minute.

Power Calculations:

• In order to determine the size of motor required for a given installation three factors must be considered:
  1. Load or net weight to be hoisted.
  2. Speed of the car.
  3. Efficiency.

• While calculating the load to be hoisted, it is necessary to consider that the load of the car and part of the load is counter balanced by the counter weight. So only the unbalanced load must be taken into account.

• The efficiency is the overall efficiency which considers various frictional and electrical losses. H.P. required can be found out by using the formula:

\[
H.P = \frac{L \times S}{E \times 33,000}
\]

Starting Torque Requirements:

• An elevator requires greater starting torque than is necessary to keep the same elevator running at its rated speed and load. This is mainly due to static friction. A motor therefore, to be suitable for elevator work, should be capable of developing from \(\frac{3}{2}\) to 3 times as much starting torque as is represented by its horse power rating (i.e. full-load torque).

• The motor builders do not design all their motors with the same ratio of starting torque to full-load torque. In some cases, in rush current, limitations are placed which cut down the amount of starting torque which could otherwise be obtained.
D.C. Motors:
- The type of D.C. motor which is best suited to elevator service depends to a considerable extent on the type of service, that is the speed and frequency of slopes.
- The elevator motor must not only raise and lower the load, but one of its principal duties is to accelerate and decelerate the car rapidly. This must be accomplished smoothly without jerks which might cause discomfort to the passengers. The starting torque should be at least 225% of the rated full-load torque. Motors having more than 15% variation in speed from no load to full load are not recommended for elevator service.
- Single-phase motors of self starting repulsion induction type may also be used for elevator service.
- For freight service, compound wound motors are recommended. The series winding provides a high starting torque, an essential factor for heavy duty work.
- For passenger service, either compound wound or shunt wound motors give satisfactory results.
- Most direct current motors, whether shunt or compound wound have suitable commutating pole winding so as to ensure sparkless commutation in both directions of rotation.

A.C. Motors:
- The two general types of A.C. motors suitable for elevator service are:
  (i) Squirrel cage motor
  (ii) Slip ring motor.
- The squirrel cage motor is used extensively up to about 20 hp because of its simplicity and because it requires only a relatively simple form of controller.
- The power consumption of squirrel cage motor is slightly higher than that of the shipping machine, but due to the lack of slip rings and fewer controller parts it is somewhat more reliable.
- The slip ring motor of same rating is more expensive and has a somewhat lower power factor than the squirrel cage motor. A.C. motors of low speed type are now available and are being used successfully on elevators whose car speeds are as high as 400 ft. per minute. As in D.C. service all A.C. elevator motors should specially for elevator work.

Elevator Control System
- The elevator control systems are broadly divided into two groups:
  1. Rheostatic control.
  2. Variable voltage control.
- In rheostatic control method, rheostat is included in the field and armature circuit of motor, and speed control can be achieved by varying it.
- In variable voltage control, the input voltage applied to motor is changed by some means and speed control is achieved.
1.20 SAFETY IN ELEVATORS

Q. What are different safety and protective devices used in electric elevator? State function of each device.  
Q. Write six safety precautions to be observed in an elevator.  
Q. State any four safety measures used in electric lifts.  
Q. What are the different safety and protective devices used in elevators? Also state functions of each device.

Safety and Protective Devices:

These may be classified as electrical and mechanical.

The principal safety devices are:
2. Overspeed governor with governor switch.
3. Car operating switch.
5. Terminal limit switches.
6. Over travel limit switches.
7. Slack cable switch.
8. Door switches.
10. Buffers and air cushions.

1. Guide Grips and Overspeed Governor: The mechanism is mounted below the car with a small winding drum which is connected to the overspeed governor by a steel rope. The governor is arranged with a grip so that if normal speed of the elevator exceeds, it holds the governor rope and forces the grips against the guide rails so as to stop the car.

2. Car Operating Switch: The car can be automatically set to different speeds. If operator's hands are removed from lever it returns to 'off' position.

3. Car Safety Switch: This switch for the purpose of stopping the car in emergency in case of the failure of the car operating switch.

4. Terminal Limit Switches: These are for bringing the car smooth rest on landing.

5. Over Travel Switches: Its function is to stop the car in case of the failure of the regular terminal stop.

6. Slack Cable Switch: Ordinarily this is used on a drum type elevator to open the control circuit in case of slack rope caused by the car or counter weight being caught in the guides.

7. Door Safety Switches: These switches in combination with door locks, prevent the car operating unless all doors are closed and locked.

Protective Devices:

1. Main line service switch and fuses: They are mounted in an accessible location in the elevator machine, room and usually enclosed in a metal cabinet.
2. **Circuit breaker and overload relay:** Overload relays are used in order to secure protection against overloading of the elevator itself. They are normally set below fuse rating.

3. **Overspeed slowdown relay:** Overspeeding of the elevator in either direction will cause the relay to operate and thus automatically retard the speed.

4. **Phase failure protective relay:** The failure of any phase causes the relay to open the controller circuit and thus disconnect the motor from the supply lines.

5. **Phase reversal protective relay:** The reversal of phases immediately opens the controller circuit and prevents the elevator motor being connected to the lines until the relation of phases is corrected.

### Important Points

- **Drive:** In simple words, drive is a device that has to do required motion for useful work. Drive can be mechanical and electrical type.
- Examples of mechanical drive are: steam turbines, water turbines, wind mills, IC engines.
- **Electric drive:** The combination of an electric motor, energy transmitting shaft and control devices, for controlling the performance of motor (motion control) is known as electric drive.
- **Individual drive:** Individual machine is fitted with its own motor. e.g. drilling machine, lathe machine etc. Each operator has complete control on his machines.
- **Multimotor drive:** In multimotor drive, separate motors are used for operating different parts of same mechanism. e.g. in case of overhead crane, different motors are used for hoisting (up and down motion), long travel motion and cross travel motion.
- **Direct drive:** The motor shaft (driving member) is directly connected to the driven member. e.g. Motor-generator set in electrical lab.
- **Indirect drive:** The mechanical power available at source is transmitted through some medium like gear, chain etc.
- **Belt drive:** This is a simple and cheap drive. Following types of belts are used: Leather belt, nylon belt, terylene belt, rubberized cotton ply belt, hair belt.
- **Flat belt drive:** It is a long distance drive. The belt is generally made up of leather.
- **V-belt drive:** It is suitable for motors with rating upto 450 kW.
- **Gear drive:** It is a short centered positive drive. Proper alignment is very essential. otherwise, motor shaft may bend.
- **Noise:** Noiseless operation of motor is very much important in domestic theatre, hospital applications. The motor noise may cause vibrations in the surrounding structure and may cause resonance.
- **Continuous loading:** The load is constant for long duration of time.
- **Short time loading:** The load is present at regular intervals. In between the intervals motor is OFF.
- **Long time (Intermittent) loading:** It is that way similar to previous type but frequency of occurrence of load is more in intermittent load.
- **Continuous Operation with Short Time Load:** In continuous operation with short time load, there is no OFF time. But during short time load, motor runs at no-load condition.
- **Continuous Rating with Long Time Loading:** It is similar to intermittent operation except that OFF period is replaced by no-load operation of motor.