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Development of Elevator based on Electromagnetism

B. R. Chaudhari, Prasad Purushottam Patki, Sudarshan More, Aniket Nagnath Rajmane, Pratik Tanaji Mohite

Abstract— An elevator lift is a vertical transport machine that effectively moves peoples and goods between the floors of a building. They are generally powered by electric motor, traction cables and counter eight systems, or pump hydraulic fluid to raise a cylindrical piston. They are also used for conveying materials in factories, warehouses and mines. Conventional elevators pose quite disadvantages i.e. they occupy large floor area, need a lot of repairs and regular maintenance and find operational difficulties in high rise buildings. The study focuses on countering these disadvantages by replacing the mechanical systems with electromagnetic systems. The report comprises of designing of elevator mechanism using electromagnets, lined on the wall of the shaft of elevator, and permanent magnets attached to the cabin of elevator, study of factors affecting it and calculation of forces and design of components. The polarity of electromagnets is controlled to generate a synchronized push-pull force that will elevate the cabin.
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1 Introduction

An elevator or lift is a type of cable-assisted, roller-track assisted, or hydraulic cylinder-assisted machine that vertically transports people or freight between floors, levels, or decks of a building, vessel, or other structure. They are typically powered by electric motors that drive traction cables and counterweight systems such as a hoist, although some pump hydraulic fluid to raise a cylindrical piston like a jack.

In agriculture and manufacturing, an elevator is any type of conveyor device used to lift materials in a continuous stream into bins or silos. Several types exist, such as the chain and bucket elevator, grain auger screw conveyor using the principle of Archimedes' screw, or the chain and paddles or forks of hay elevator Languages other than English, such as Japanese, may refer to elevators by loanwords based on either *elevator* or *lift*. Due to wheelchair access laws, elevators are often a legal requirement in new multistory buildings, especially where wheelchair ramps are not possible.

Some elevators travel laterally in addition to the usual vertical motion.

- Some disadvantages the elevator of today face are
- Conventional elevators find operational difficulties in high-rise buildings.
- They occupy large building space to accommodate engine room, counter weight etc.
- They need lot of repairs and regular maintenance.
- They are comparatively slow and less comfortable.
- The elevators use is limited to one at a time.

Problem

Conventional elevators involve cables, hydraulic or pneumatic systems which require regular maintenances and repairs. They occupy more space. So to overcome the above problems we are going to make an elevator lifting mechanism using the principles of electromagnetism and magnetism that can replace the conventional systems and its demerits.

Objectives

The main objective of the project is to design a alternative mechanism for a elevator in and to form of small scale project model. To replace conventional mechanisms with electromagnetic systems. To minimise travel time. To minimise maintenance work.

Methodology

Study of elevators and their mechanism
Calculation of the Designing parameters
Design
Testing & Calculation
Result Analysis
Conclusion

Structure of Elevator

An elevator is essentially a platform that is either pulled or pushed up by a mechanical means. A modern-day elevator consists of a cab (also called a "cabin", "cage", "carriage" or "car") mounted on a platform within an enclosed space called a shaft or sometimes a "hoist way". In the past, elevator drive mechanisms were powered by steam and water hydraulic pistons or by hand. In a "traction" elevator, cars are pulled up by means of rolling steel ropes over a deeply grooved pulley, commonly called a sheave in the industry. The weight of the car is balanced by a counterweight. Sometimes two elevators

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are built so that their cars always move synchronously in opposite *Fig.1.1. A elevator system in a building* directions and are each other's counterweight.

The friction between the ropes and the pulley furnishes the traction which gives this type of elevator its name.

Hydraulic elevators use the principles of hydraulics (in the sense of hydraulic power) to pressurize an above ground or in-ground piston to raise and lower the car (see *Hydraulic elevators* below). Roped hydraulics use a combination of both ropes and hydraulic power to raise and lower cars. Recent innovations include permanent magnet motors, machine room-less rail mounted gearless machines, and microprocessor controls.

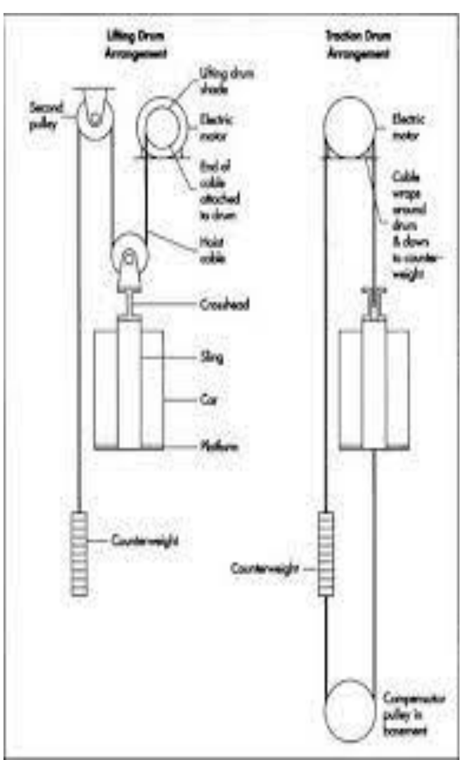
The technology used in new installations depends on a variety of factors. Hydraulic elevators are cheaper but installing cylinders greater than a certain length becomes impractical for very-high lift hoist ways. For buildings of much over seven floors, traction elevators must be employed instead. Hydraulic elevators are usually slower than traction elevators.

IMPORTANCE OF ELEVATOR TODAY

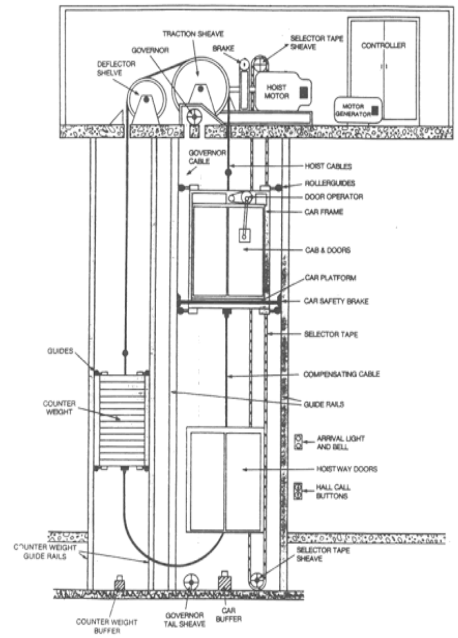
Elevators are a candidate for mass customization. There are economies to be made from mass production of the components, but each building comes with its own requirements like different number of floors, dimensions of the well and usage patterns.

Types of elevators

- Geared and Gearless Traction Elevator



Traction Elevator



Schematic diagram of cable operated lift

This elevator has ropes that pass over a wheel attached to an electric motor located above the shaft. The main function of the ropes is to raise and lower the elevator car. It can be used for both mid and high-rise applications and can travel much faster than hydraulic elevators.

GEARED TRACTION ELEVATOR

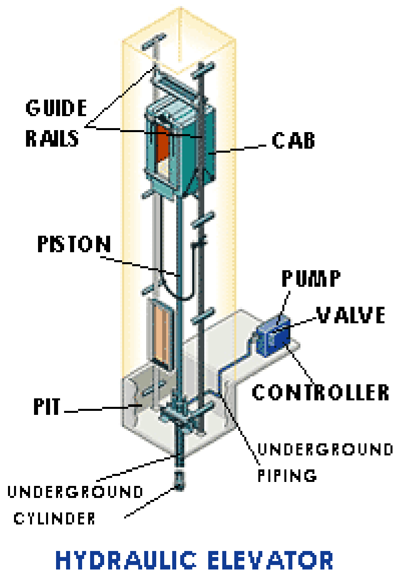
The geared elevator is made up of a motor that has a gearbox attached to it. The main function of the gears is to power the wheel that moves the ropes. This type of elevator can travel up to speeds of up to 500 feet per minute. The maximum distance it can travel is 250 feet.

GEARLESS TRACTION ELEVATOR

Gearless elevators don't have a gear for speed regulation. This explains why they can move as fast as 2,000 feet per minute and can also travel a maximum of 2,000 feet. They are the best option for skyscrapers.

- Hydraulic Elevator

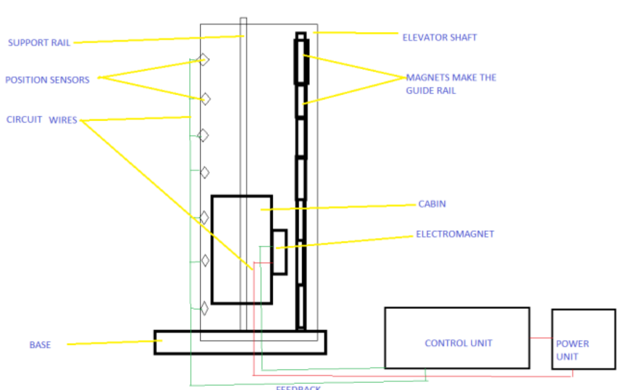
Hydraulic elevators are normally given support by a bottom-placed piston. The purpose is to push the elevator car up while an electric motor forces hydraulic fluid down the piston. When it's time for the elevator to come down, the valve releases the hydraulic fluid from the piston. This type of elevator is mostly used in 2 to 8 story buildings and can only travel at a maximum speed of 200 ft per minute.



- Machine-Room-Less (MRL) Elevator

Most elevators are designed with a machine room located above the elevator shaft. This type of elevator has a machine fitted in the override space, and it can only be accessed through the top of the elevator car whenever maintenance is required. This type of elevator can only travel a distance of 250 feet with speeds of up to 500 feet per minute.
MRL elevators are gaining popularity with mid-rise buildings because they conserve energy and require less room during construction.

Concept



Working Principle

- Laws of magnetism

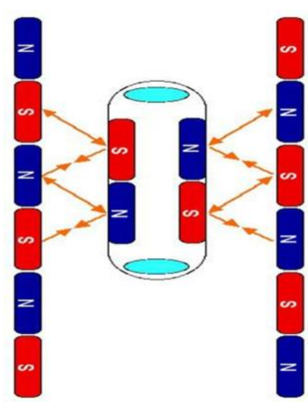
When the north pole of a magnet is brought closer to the south pole of another magnet, there is an attractive force that brings the magnets together. If the magnet ator is turned so that two north poles or two poles are brought closer, they will repel each other.

- Coulomb's Law of Magnetic Force

known as Coulomb's Inverse Square Law of magnetic force or Coulomb's Law of magnetic force. He represented the quantitative expression of force for two isolated point poles.

Mathematically,
$F \propto m_1 m_2$ and $F \propto 1/r^2$
$F = K\,(m1m2) / \mu r^2$

Inspired the principle and technology of the maglev trains, the elevator mechanisms can be made based on principles of propulsion of maglev trains.
The mechanism is vertical consisting of a shaft, support rails, guide rails on to which magnets of alternate polarity are arranged linearly, the cabin(load), electromagnet mounted on cabin, the position sensors, the power unit and a control unit which will process and execute the mechanism.
The idea is to generate opposite poles, one at the electromagnet which is same as adjacent magnet but opposite to next magnet in the line of motion.



Picture of working of maglev train

The automated switching of poles of electromagnets can be achieved by establishing a electronic control system using Arduino, sensors, relay etc. The system can energize electromagnets at desired time to generate a vertical lift motivated by forces of attraction between opposite poles. A flowchart for the control of system is as below

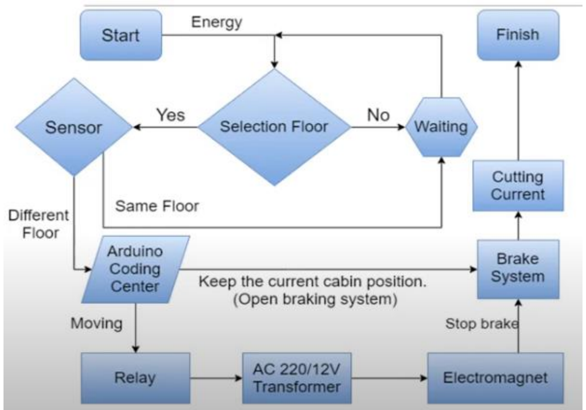


Figure 1 : Flowchart

For electromagnet

magnitude of that force by plugging the dimensions and other properties of the magnet based into a simple equation: $F = (n \times i)^2 \times$ magnetic constant $\times a / (2 \times g^2)$. Passing an electrical current through the solenoid results in a magnetic field that exerts force on nearby ferromagnetic objects, such as pieces of iron or steel.

$F = (n \times i)^2 \times$ magnetic constant $\times a / (2 \times g^2)$

Where, F = force, i = current, g = length of the gap between the solenoid and a piece of metal, a = Area, n = number of turns in the solenoid, and the magnetic constant = $4 \times PI \times 10^{-7}$

For wire

we will be using a Standard Wire Gauge (SWG) table to find the gauge of suitable wire.

AWG	Dia mm	SWG	Dia mm	Max Amps	Ohms / 100 m
11	2.30	13	2.34	12	0.53
12	2.05	14	2.03	9.3	0.67
13	1.83	15	1.83	7.4	0.85
14	1.63	16	1.63	5.9	1.07
15	1.45	17	1.42	4.7	1.35
16	1.29	18	1.219	3.7	1.70
18	1.024	19	1.016	2.3	2.7
19	0.912	20	0.914	1.8	3.4
20	0.812	21	0.813	1.5	4.3
21	0.723	22	0.711	1.2	5.4
22	0.644	23	0.610	0.92	6.9
23	0.573	24	0.559	0.729	8.6
24	0.511	25	0.508	0.577	10.9
25	0.455	26	0.457	0.457	13.7
26	0.405	27	0.417	0.361	17.4
27	0.361	28	0.376	0.288	21.8
28	0.321	30	0.315	0.226	27.6
29	0.286	32	0.274	0.182	34.4
30	0.255	33	0.254	0.142	43.9
31	0.226	34	0.234	0.113	55.4
32	0.203	36	0.193	0.091	68.5
33	0.180	37	0.173	0.072	87.0
34	0.160	38	0.152	0.056	110.5
35	0.142	39	0.132	0.044	139.8

Table: - Standard Wire Gauge (SWG) chart

CALCULATIONS

Selection Of Wire For Electromagnet
Material of wire – copper
Max. amp. Limit of wire – 1.5 A
Selection of wire from std wire gauge(SWG) chart
Grade of wire – 2 i.e. with medium coating
req. wire of gauge – 21
Wire dia. – 0.8120mm
ohms/100m – 4.3

Selection of Core Of Electromagnet
Type of core – Iron core
Selected shape of core – cylindrical for circular winding
Diameter of core – 20mm
Length of core – 15mm

Calculation of turns on electromagnet

Weight of cabin of elevator, W = mg = 300g approx. = 3 N
So we have to design an electromagnet which can develop the force grater than 3 N
For finding force (F) at a distance (g) we have the formula
$F = (n * I)^2 \mu A / (2 g^2)$
μ = magnetic constant = 4*π*10^-7
Area = $A = \pi r^2$
$= 314 \text{ mm}^2$
so,
$F = (n * I)^2 \mu A / (2 g^2)$
$3 \leq (n * 1)^2 * 4 * \pi * 10^{-7} * 314 / (2 (5)^2)$
$n \geq 617$
hence, we have to take the no. of turns greater than 617 consider as 620

RESULTS

For electromagnet: -
diameter of wire: - 0.8120mm
gauge number of wire: - SWG 21
number of turns of coil: - 620

The size of electromagnet is determined.

CONCLUSION

An alternative mechanism for vertical lift, based on the principles and applications of electromagnetism is developed that can replace mechanical systems of conventional elevators to eliminate their disadvantages.

ACKNOWLEDGMENTS

It gives us great pleasure to present a project report on 'Development of elevator and its mechanism based on electromagnetism'. In preparing this project report number of hands helped us directly and indirectly. Therefore, it becomes my duty to express my gratitude towards them.

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FUTURE SCOPE

This elevator could shape the cities of the future. They go up and they go down. They take people from one floor of a building to the exact same spot on another floor.

A new technology has the potential to break elevators free from their vertical prisons, allowing them to move side to side, at an angle, even go outside into a city. They can go wide, add multiple towers or go in unusual directions, and make room for green spaces that otherwise would have been an inconvenience. A single elevator can run from the East side of the first floor to the far West side of the 30th, no transferring or walking necessary. The advent of magnetic elevators goes beyond merely making our lives more convenient but could seriously aid building developers in more easily constructing larger and more cost-effective buildings. This development could represent a seminal moment in modern technology.

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