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Research Paper

Engineering

Design and Analysis of Maglev Trains

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ABSTRACT

Our report titled 'MAGLEV TRAINS' is an informative report which explains about Magnetic levitation or Maglev, as a form of transportation that suspends, guides and propels vehicles via electromagnetic force. This method can be faster than wheeled mass transit systems potentially reaching velocities comparable to an aircraft or a turboprop. Our report aims at providing knowledge about the various aspects of this new emerging automotive technology called maglev trains.

KEYWORDS : Maglev, Transportation, Electromagnetic force, /guideway

INTRODUCTION

Maglev is a system in which the vehicle runs levitated from the guideway (corresponding to the rail tracks of conventional railways) by using electromagnetic forces between superconducting magnets on board the vehicle and coils on the ground. The following is a general explanation of the principle of Maglev.

MAGNETIC LEVITATION

The levitation coils are installed on the sidewalls of the guide way. When the on-board superconducting magnets pass at a high speed about several centimeters below the center of these coils, an electric current is induced within the coils, which then act as electromagnets temporarily. As a result, there are forces which push the superconducting magnet upwards and ones which pull them upwards simultaneously, thereby levitating the Maglev vehicle.

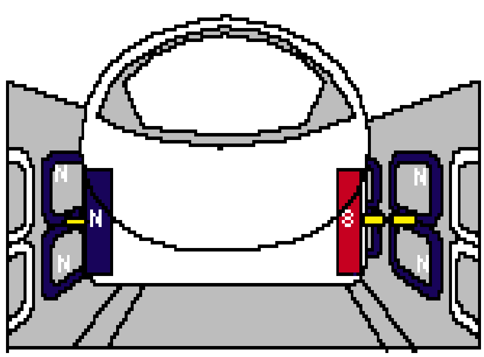

Fig.1 Guideway

1.2 LATERAL GUIDANCE

The levitation coils facing each other are connected under the guide way, constituting a loop. When a running Maglev vehicle, that is a superconducting magnet, displaces laterally, an electric current is induced in the loop, resulting in a repulsive force acting on the levitation coils of the side near the car and attractive force acting on the levitation coils of the side farther apart from the car. Thus, a running car is always located at the center of the guide way.

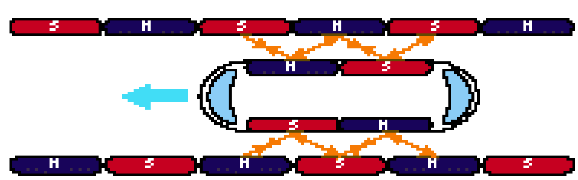

Fig.2 Floatation

1.3 PROPULSION

A repulsive force and an attractive force induced between the magnets are used to propel the vehicle (superconducting magnet). The propulsion coils located on the sidewalls on both sides of the guide way are energized by a three-phase alternating current from a substation, creating a shifting magnetic field on the guideway. The on-board superconducting magnets are attracted and pushed by the shifting field, propelling the Maglev vehicle.

1.4 FLOATATION

The electrodynamics, repulsion-type maglev system, originally patented by American scientists in the 1960s, is the focus of the development program of the Japan Railway Technical Research Institute. In this approach, levitation magnets on the top of a guideway or as is the case with present Japanese prototype designs, in the guideway sidewalls push away superconducting magnets grouped underneath or at the bottom sides of the vehicles. Linear synchronous propulsion coils in the guideway propel the vehicles.

This type of system allows for a large air gap (about 15 cm) between opposing magnets. In the electromagnetic, or attraction-type, Maglev developed by Transrapid International in Germany, conventional iron-core magnets in the vehicle's wraparound arms are pulled up to magnets under the guideway. A relatively small air gap (1 cm) separates the vehicle and guideway magnets. Although not part of the present Transrapid design, superconducting magnets can be incorporated in attraction-type Maglev systems.

1.5 PROBLEMS WITH CURRENT SCENARIO
2. TECHNOLOGY
2.1 EMS (Electromagnetic suspension)
The separation between the vehicle and the guideway must be constantly monitored and corrected by computer systems to avoid collision due to the unstable nature of electromagnetic attraction; due to the system's inherent instability and the required constant corrections by outside systems, vibration issues may occur.

2.2 EDS (Electrodynamic)
Strong magnetic fields onboard the train would make the train inaccessible to passengers with pacemakers or magnetic data storage media such as hard drives and credit cards, necessitating the use of magnetic shielding; limitations on guideway inductivity limit the maximum speed of the vehicle; vehicle must be wheeled for travel at low speeds.

2.3 Inductrack System (Permanent Magnet EDS)
Requires either wheels or track segments that move for when the vehicle is stopped. New technology that is still under development (as of 2008) and as yet has no commercial version or full scale system prototype.

. Fabrication of Demo Model

Materials Use: board of wood for track, Pine wood for train

• Permanent magnets of area 2*1 cm2

Construction of Demo Model

• Build a magnetic base track of length 30 cm

• Remove material with the help of chisel

• Stick permanent magnets at a distance of 1.5 cm each

• 5 magnets are placed on each side of the track

• Make guide rails to prevent the train from slipping sideways

• Make the train of pine wood and stick the magnets on them also in the same way and maintain equal distance.

Procedure for Assembly
• Place the track on flat base of board wood.

• The two tracks should be placed in such a way that the magnets of the two tracks are not in the same line.

• Now place the guide rails on each side of the tracks in such a way that it prevents the sideward motion of the train.

• After that place the train in centre position.

• Remove 1 guide rail after the train has levitated.

• Place some weight on the levitating train.

• Check if the weight is balanced by the magnetic levitation force.

3. ANALYSIS
§ For Motor
Power = V*I = 2πNT/60
12*2 =2*3.14*4400*T/60
T= 0.0521 N-m
§ For the track
Length of track = 2*n + total gap between magnets (n= number of magnets)
Total gap between magnets= (n-1)*1
Thus, Total length of track= 2*30 + (30-1)*1= 89cm =.89m
§ For Train
Mass of the bogie=41.7gm=.0417kg
Force between the bogie and track,
F=AB^2/2μ0 =mg
A-Total area of the magnets under the bogie
B-Flux density
We have,
A=area of one bar * no. of bars under bogie and track
A= .02*.01*8= .0016
B=3.1*10^{-2} T
F= AB^2/2μ0=.6118 N
Now we have,
Weight of the bogie, W= .0417*9.81=.409N
As, F>W so bogie is balanced by the magnetic force and thus the bogie is levitated.
Thrust calculation-
1. Voltage = 12V , Current = 1.9Amp
x= 9.2-7.8
= 1.4cm
h= x (Sh / S□ -1)
= (1.4/100) (1750/1000 -1)
= (1.4/100) X 0.75
= 0.0105 m
=1.05 cm
Velocity of air:
V = Cv 2gh
Let, Cv = 1
V = √2 × 9.81 × 0.0105
= 0.45388 m/sec
Thrust force:
Thrust = (dm/dt) × V
Mass flow rate (dm/dt) = ρav
So, Thrust = $\rho\rho$av v = ρav2
= 1.75× 1000 × ($\pi\pi$/4) × 0.08^2 × 0.45388
= 1.8114 N
2. Voltage = 12V, Current = 1.7 Amp
x = 9- 7.8
= 1.2 cm
h = x (Sh/ So -1)
= 0.75 (1.2/100)
= 9 10-3 m
Velocity of air:
V = √2ggh
= √2 × 9.81 × 0.009
= 0.4202 m/sec
Thrust force:
Thrust = (dm/dt) × V
Mass flow rate (dm/dt) = ρav
Thrust = $\rho\rho$av2
= 1.75× 1000 × ($\pi\pi$/4) × 0.082× 0.42022
= 1.5532 N
3. Voltage = 12V , Current = 1.5 Amp
x = 8.75 – 7.8
= 0.95 cm
h = x (Sh/ So -1)
= 0.75 × (0.95/100)
= 7.125× 10-3 m
Velocity of air:
V =√2ggh
V = √2 × 9.81 × 0.007125
= 0.3738 m/sec
Thrust force:
Thrust = (dm/dt) × V
Mass flow rate (dm/dt) = ρav
Thrust = $\rho\rho$av2
= 1.75× 1000 × ($\pi\pi$/4) × 0.08^2 × 0.37382
= 1.2296 N
4. Voltage = 12 V , Current = 1.3Amp
x= 8.6- 7.8
= 0.8cm
h=x (Sh/So -1)
= 0.75× (0.8/100)
= 6× 10-3 m
Velocity of air:
V =√2ggh
V =√2 × 9.81 × 0.006
= 0.34310 m/sec
Thrust force:
Thrust = (dm/dt) × V

Mass flow rate (dm/dt) = ρav
Thrust = $\rho\rho$av2
= 1.75× 1000 × ($\pi\pi$/4) × 0.08^2 × 0.343102
= 1.0355N
5. Voltage = 12V , Current = 1.1Amp
x = 8.45-7.8
= 0.65cm
h= x (Sh/So -1)
= 0.75× (0.65/100)
= 4.875× 10-3m
Velocity of air:
V =√2ggh
V = √2 × 9.81 × 0.004875
= 0.3092 m/sec
Thrust force:
Thrust = (dm/dt) × V
Mass flow rate (dm/dt) = ρav
Thrust = $\rho\rho$av2
= 1.75× 1000 × ($\pi\pi$/4) × 0.08^2 × 0.3092^2
= 0.84135N
6. Voltage =12 V, Current= 1.08Amp
x= 8.2-7.8
= 0.4 cm
h= x (Sh/So -1)
= 0.75× (0.4/100)
= 3× 10-3 m
Velocity of air:
V =√2ggh
V=√2 × 9.81 × 0.003
= 0.2426 m/sec
Thrust force:
Thrust = (dm/dt) × V
Mass flow rate (dm/dt) = ρav
Thrust= $\rho\rho$av2
= 1.75× 1000 × ($\pi\pi$/4) × 0.08^2 × 0.2426^2
= 0.51775N
Calculation for the speed of bogie at different angles of inclination:
1. Angle of elevation is 00:
Speed = [0.17× (1/5.6) × (18/5)]
= 0.10928 m/sec
2. For angle of 120 :
a) While running down the plane
Inclination ($\theta\theta$) = 12°
Speed = [(9.2/100) × (1/7.21)× (18/5)]
= 0.0459 m/sec
3. For various angles while going up the plane:
i. Inclination ($\theta\theta$) = 12°
Speed = 0.036 m/sec
ii. Inclination = 11.5°
Speed = 0.04001 m/sec
iii. Inclination = 11°
Speed = 0.03912 m/sec
iv. Inclination = 10.5°
Speed = 0.0385 m/sec
v. Inclination = 10°
Speed = 0.0386 m/sec
Multiple Regressions
Formulae of multiple regressions:
y= a+ bx+cz
∑y= na+ b∑x+ c∑z
∑xy= a∑x+ b∑x2+ c∑xz
∑zy = a∑z+ b∑xz+c∑z^2
Where,
y= Speed of bogie (m/sec)
x= Thrust (N)
z= Inclination (degrees) Putting the values from the table in the equations:
0.20213= 5a+6.411b+0.9641c Equation1
2.655= 6.411a+8.4854b+1.223c Equation 2
0.039= 0.9641a+1.223b+0.187c Equation 3
After solving equations 1, 2 and 3
We get,
a = -78.576
b = 22.089
c = 260.84
e = error
y = 22.089x+260.84z-78.576+e

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