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Analysis of Magnetic Levitation and Maglev Trains

Narayan Dutt Pandey [1], Manikant Kumar[2], Dr.Pratibha Tiwari[3]
*M.Tech scholor Department of electrical engineering Sam Higginbottom Institute of Agriculture and technology Science, Allahabad (India)
** Ph.D scholor Department of electrical engineering Sam Higginbottom Institute of Agriculture and technology Science, Allahabad (India)
** * Assistant Professor Department of electrical engineering Sam Higginbottom Institute of Agriculture and technology Science, Allahabad (India)

Abstract-

Today India's fastest growing economy and in other hand cities become more congested and populated day by day, so transportation need to be improve, this problem is overcome by magnetic levitation. In this paper, we will discuss about maglev train with the help of magnetic levitation and future of these train India. There are three model electrodynamics suspension (EDS), electromagnetic suspension (EMS) and Inductrack. In this paper we describe method and molding of maglev train and its application.

Keywords- magnetic levitation,EDS, EMS, INDUCTRAC model, maglev trains.

I. INTRODUCTION

Magnetic levitation (maglev) is a highly advanced technology. It is used in the various cases, including clean energy (small and huge wind turbines: at home, office, industry, etc.), building facilities (fan), transportation systems (magnetically levitated train, Personal Rapid Transit (PRT), etc.), weapon (gun, rocketry), nuclear engineering (the centrifuge of nuclear reactor), civil engineering (elevator), advertising (levitating everything considered inside or above various frames can be selected), toys (train, levitating spacemen over the space ship, etc.), stationery (pen) and so on. The common point in all these applications is the lack of contact and thus no wear and friction. This increases efficiency, reduce maintenance costs and increase the useful life of the system. The magnetic levitation technology can be used as a highly advanced and efficient technology in the various industrial. There are already many countries that are attracted to maglev systems. In 1904, Robert Goddard, wrote a paper proposing a form of frictionless travel using electromagnetic repulsion roadbeds.[1]Today this system is most popular in Japan, Germany, China and U.S.A., electrodynamics suspension system is frequently used in Japan. In this paper has been focused and trying to explain working of magnetic levitation system based different type of model.

Maglev trains move more smoothly and somewhat more quietly than wheeled mass transit systems. Their non-reliance on friction means that acceleration and deceleration can surpass that of wheeled transports, and they are unaffected by weather. The power needed for levitation is typically not a large percentage of the overall energy consumption most of the power is used to overcome air resistance (drag), as with any other high-speed form of transport. Although conventional wheeled transportation can go very fast, maglev allows routine use of higher top speeds than conventional rail, and this type holds the speed record for rail transportation. Vacuum tube train systems might hypothetically allow maglev trains to attain speeds in a different order of magnitude, but no such tracks have ever been built.

Fig 1- Maglev high speed train.

MAGLEV HIGH SPEED TRAIN

The Magnetic levitation (MAGLEV) technology was first tested in the 1970s, but it has never been in commercial operation on long-distance routes. The technology relies on electromagnetic forces to cause the vehicle to hover above the track and move forward at theoretically unlimited speeds. In practice, the aim is for an operation speed of 500 kph (Taniguchi, 1993). In 2003, a MAGLEV test train achieved a world record speed of 581 kph (Takagi, 2005 [5]. The special infrastructure required for MAGLEV trains means high construction costs and no compatibility with the railway network. The MAGLEV is mostly associated with countries like Japan and Germany where MAGLEV test lines are in operation. In Japan, the test line will eventually be part of the Chuo Shinkansen between Tokyo and Osaka connecting the cities in about 1 hour compared with the present 2.5 hours. In China, a short MAGLEV line was opened in December 2003 connecting Shanghai Airport and the city's Pudong financial district with trains running at maximum speed of 430 kph. However, plans to adopt MAGLEV technology for the planned Beijing– Shanghai route were abandoned in favour of a conventional steel wheel-on-steel rail HST. The future of the MAGLEV, it seems, depends on its success in Japan, in the same way the development of the HST depended largely on the success of the first Shinkansen line.

II. Description

Magnetic levitation- Maglev is a system in which the vehicle runs levitated from the guide way (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. Magnets interact when opposite polarity and repels at same polarity, this repulsive and attractive forces cause of levitation. Magnetic Levitation is described by FARADAY'S and LENZ'S LAW, negative of rate of change of flux with respect to time is equal to electromotive force induced in close circuit.[2]

[A] Electrodynamics suspension system (EDS) - Electrodynamics suspension system is mainly based on electromagnetic repulsion and this repulsive force overcome by the gravitational force and allow it to levitate. EDS system in maglev train frequently used by Japanese engineers. In some configurations, the train can be levitated only by repulsive force. In the early stages of maglev development at the Miyazaki test track, a purely repulsive system was used instead of the later repulsive and attractive EDS system. The magnetic field is produced either by superconducting magnets (as in JR–Maglev) or by an array of permanent magnets. The repulsive and attractive force in the track is created by in wires or other conducting strips in the track. A major advantage of EDS maglev systems is that they are dynamically stable – changes in distance between the track and the magnets creates strong forces to return the system to its original position. In addition, the attractive force varies in the opposite manner, providing the same adjustment effects. No active feedback control is needed.

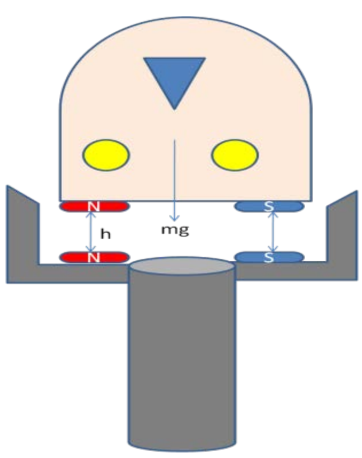


Fig2. EDS model

At balance position both forces are equal that mean electromagnetic repulsive force is equal to gravitational force towards downward [3].

Net force = Gravitational force (downward) – electromagnetic force (upward)

$$= mg - kt(I/H)2$$

G-gravitational constant

Kt-magnetic force constant

[B] Electromagnetic suspension system- This system is also called transrapid based on EMS technology. EMS technology introduced by the German scientist in it levitation is obtain electromagnetic attraction. The attractive force between the magnet balances the gravitational force and allow the train to levitate.[4]

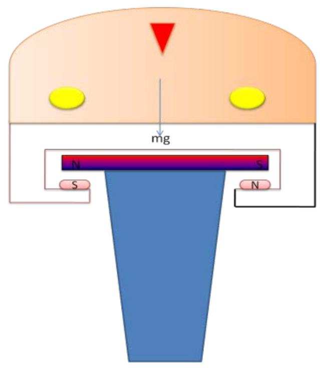


Fig 3. EMS model

At balance position both forces are equal that mean electromagnetic attractive force is equal to gravitational force towards downward.

Net force = Gravitational force (downward) – electromagnetic force (upward)

$$= \text{mg} - kt(I/H)2$$

G-gravitational constant

Kt-magnetic force constant

[C] INDUCTRACK-It is the concept of passive magnetic levitation system uses permanent magnet made of magnetic material NbFeB. This more efficient model than other, it can be used in maglev trains and racket lunching.[5]

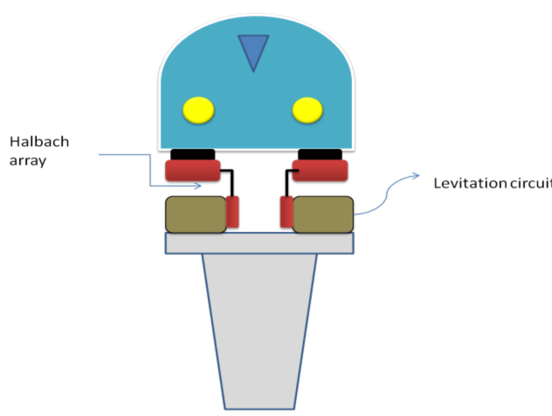
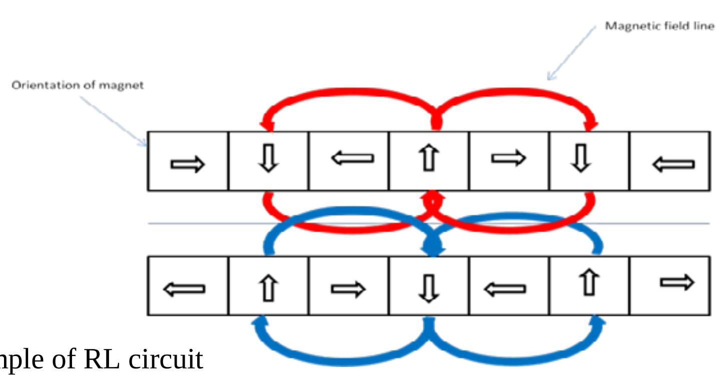


Fig 3. Inductrack model

Halbach array as, pioneered by Kalous Halbach for practical accelerator application. This array shows how to efficient use the permanent magnetic, material to developing the periodic magnetic field[6].



Let us take the example of RL circuit

$$\phi = \phi_0 \sin\omega t$$

Where $\phi_0 = \frac{wB_0}{k} e^{-ky}$

$$V = \frac{Ldi}{dt} + iR = -\omega\phi_0 \cos\omega t \quad (2)$$

The steady state solution of the equation is

$$i(t) = \frac{V}{R}\left[1 - e^{-\frac{Rt}{L}}\right] = -\frac{\omega\phi_0\cos\omega t}{R}\left[1 - e^{-\frac{Rt}{L}}\right]$$

This equation may also written in this from

$$i(t) = \frac{\phi_0}{L}\left[\frac{sin\omega t \ + \frac{Rcos\omega t}{\omega L}}{1 + (\frac{R}{\omega L})^2}\right]$$

$\omega = \frac{2\pi v}{\lambda}$

ω= excitation frequency

v=velocity (m/s)

λ=wavelength of Halbach array field

R= track resistance

L=track induction

Vertical forces of halbach array that is also called drag forces. Lift force is perpendicular force , allows levitate the train. The ratio of the lift to drag greater in maglev trains than Aircraft, L/D ratio is depend on speed and increase monotonically with speed. Typically at operating speedit approaches to 200:1 in maglev trains[5].

$$Fx \ = \frac{\phi^2 K}{2L}\left[\frac{1}{1+\left(\frac{R}{\omega L}\right)^2}\right] \qquad \text{……………. (3)}$$

$$Fy \ = \frac{\phi^2 K}{2L}\left[\frac{\frac{R}{\omega L}}{1+\left(\frac{R}{\omega L}\right)^2}\right] \qquad \text{…………….(4)}$$

If we divide equation 3 & 4 we get,

$$\frac{Fx}{Fy} = \frac{Lift}{Drag} = \frac{\omega L}{R}$$

Magnetic levitation is requirement of future because in magnetic levitation train fly in the air, balancing by lift and drag forces. According to this there is no contact between track and wheel, so frictional loss in drive is negligible. Magnet that use in magnetic levitation may be permanent magnet or electromagnet. Permanent magnet uses where weight that required to levitate in the air is low but for heavy weight application electromagnet is required. Some time we can use cryomagnets that offer zero resistivity to flow the current but it requires helium coating around -260 degree centigrade. Cryomagnet also called superconductive magnet, for practical purpose this is very expensive.

CONCLUSION

The present review paper is concluded that the train is best levitated in canter position. The modern HST was developed mainly to substantially increase railway capacity on the route. This was achieved, in part, through high-speed operation. Travel time: Maglev, despite higher top speeds and greater acceleration, has little travel time advantage in real-world applications. The conclusion of this comparison is that. the advantages of Maglev over high speed rail are few and they are very small. They are far outweighed by the advantages of HSR, particularly in system network and compatibility characteristics and investment cost the limitation on networking and incompatibility with other transportation systems makes Maglev extremely inconvenient for integration in intermodal systems, which actually represent the “transportation system of the future.”

FUTURE SCOPE AND APPLICATIONS FOR MAGLEV

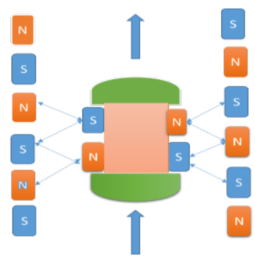
Transportation

Maglev stands for magnetic levitation. That means that these trains won't have to touch the tracks in order to move. That will mean they will travel frictionless. That creates the potential for speeds faster than all the conventional rail travel used today. These conventional trains operating speed 100 to 300 km/h. Maglev vehicles are designed for operating speeds up to 500 km/h. That is a tremendous speed advantage of Maglev trains. [7]

Magnetic levitation does not burn oil but instead uses electricity, which can be produced from coal, nuclear, hydro, wind, or solar power plants. Maglev requires only .4 mega jule per passenger per mile when travelling on 280 km/h.

Maglev lift:

We can use the property of maglev to levitating the lift in such a way attraction and repulsion of magnet by controlling the magnetic force from controlling the current in coil of electromagnet.



Maglev rail gun:

In maglev rail gun sliding armature is move by electromagnetic projectile launcher. Electromagnet is energized by current and sliding armature accelerated by this electromagnetic effect. in this phenomenon we obtained very high kinetic energy for projectile.[8]

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Author's Profile

Narayan Dutt Pandey Completed B.Tech. in Electrical and Electronics Engineering in 2015 from Sam Higgan Bottom Institute Of Agriculture, Technology And Sciences-Deemed University, M.Tech in control & instrumentation In Sam Higgan Bottom Institute Of Agriculture, Technology And Sciences-Deemed University (formerly AAI-DU) Allahabad, India. Area of interest includes control & instrumentation.E-mail id ndp3888@gmail.com.

Manikant Kumar Completed B.Tech. in Electrical Engineering in 2012 from VPS purvanchal, M.Tech in Power Electronice in 2014 from Sam Higgan Bottom Institute Of Agriculture, Technology And Sciences-Deemed University Allahabad and Ph.D From In Sam Higgan Bottom Institute Of Agriculture, Technology And Sciences-Deemed University Allahabad, E-mail id: manikant28412@gmail.com

Dr. Prathiba Tiwari Completed B.Tech. in Electrical & Electronics Engineering in 2002 from VPS purvanchal, M.Tech in control & instrumentation in 2006 from Motilal Nehru National Institute Of Technology Allahabad And Ph.D In 2015 From In Sam Higgan Bottom Institute Of Agriculture, Technology And Sciences-Deemed University Allahabad, Working As Aassitant Professor In Sam Higgan Bottom Institute Of Agriculture, Technology And Sciences-Deemed University (formerly AAI-DU) Allahabad, India. Area of interest includes control & instrumentation.E-mail id: pratibha.tiwari@shiats.edu.in.