

Maglev Train

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Abstract- Increasing demand of transportation due to large population and growing cities, the normal transportation system is not suffice to soothe the needs of metropolitan cities. Which gives rise to more sustainable mode of transportation with the help of electromagnetism and superconducting magnets, the MAGLEV train magnetic levitation abbreviated as maglev is an advanced technology of levitation that uses magnetic forces for the propulsion of vehicles rather than using wheel, bearing and axels. The magnetic forces are assigned to lift and propel the vehicles along the guide way. The Maglev trains promises drastic improvement in the transportation services. The phenomenal technology of magnetic levitation provides non-reliance over the frictional forces, thus providing quieter and smoother operation such as acceleration and deceleration. The power required for this technology is remarkably less as compared to the current technology being used. One of the sole purpose of power consumption in this technology is to overcome the air resistance (drag). Although the conventional wheeled transportation provides high speed transportation services, the high-speed maglev trains anytime provides environmental friendly, efficient and higher magnitudes of speed service.

Key word – Maglev train, Electromagnet, Superconductivity, Linear Induction Motor, Halbach Array.

I. INTRODUCTION

This paper is a study of the real-world feasibility of maglev trains as a transportation system. From ages ago magnetic forces were known as capable of suspending ferromagnetic particles in air, but in the 20th century, the concept of magnetically levitated trains was identified by two Americans, Robert Goddard and Emile Bachelet. Thanks to several decades of development the technical feasibility of maglev trains has been amply demonstrated. Maglev (magnetic levitation) uses magnetic levitation to propel vehicles with magnetic forces rather than with wheels, axles and bearings and they have virtually no friction which makes them incredibly efficient and silent. Because train is lifted, guided and propelled by magnetic fields a few centimeters above the guide way, which completely eliminates the physical contact between train and guide way and can achieve the speed up to 500km/h. Since past two decades, some countries including Germany, Japan & America have conducted Research & Development programs on Maglev technology. Germany and Japan have invested more than \$1billion each to develop and demonstrate Maglev train technology for High Speed Ground Transportation (HSGT). The magnetic levitation can be achieved by three techniques viz. Electro Magnetic Suspension (EMS), Electro Dynamic suspension (EDS) and Inductrack technology; and propulsion

can be achieved by using working principle of Linear Induction Motor and Linear Synchronous Motor. The motion of the train is based completely on magnetism and magnetic fields. And this magnetic field is produced by using high-power electromagnets. By using magnetic fields, the Maglev can be levitated above the guide way, and can be propelled forward. [2]

Maglev: Maglev is a transport system in which train-cart levitates above a track, supported by magnetic repulsion and propelled by the principle of linear induction motor. [1]Electromagnet: An electromagnet is a coil of insulated wire wound around an iron or steel cylinder and when current flows through the coil it produces magnetic field.[1]Faraday's Law:1st Law: - It states that whenever a conductor cuts magnetic flux, an emf is induced in that conductor.2nd Law: - It states that the magnitude of the induced emf is equal to the rate of change of flux-linkage.[3]Superconductivity: Superconductivity is a phenomenon of negligible (zero) electrical resistance and best magnetic permeability of certain materials when cooled below a characteristic critical temperature.[6]Halbach array: In this permanent magnets are arranged in alternate vertical and horizontal unique pattern so that the magnetic-field lines reinforce one another below the array but cancel one another above it.[5]

II. BASIC PRINCIPLE OF MAGLEV

Maglev is short for Magnetic Levitation in which trains float on a guide way using the principle of magnetic repulsion. Each magnet has two poles. We can see that the like poles repel whereas the unlike poles attract. This repulsive property of magnets is being used in maglev trains. However instead of using permanent magnets, strong temporary magnets are incorporated which is generated by the principle of electromagnetism. When an electric current is passed through a coil of wire, magnetic field is generated according to Faraday's law.[3] Maglev is used for both low as well as high speed transportation. The low speed Maglev is usually used for short distance travel. Birmingham, England used this low speed transportation during the years of 1984 and 1995. However, these days, engineers are more interested in creating the high-speed Maglev trains. The higher speed the train can travel is nearly 343mph or 552 km/h

IV. TYPES OF MAGLEV

There are two types of Maglev trains, electrodynamic suspension trains (EDS) and electromagnetic suspension trains(EMS).The crucial difference between the

two is that EMS trains uses only one varying magnetic field to maintain stable levitation above the track whereas EDS trains uses the magnetic field induced by both, the train and the track, thus creating a strong and absolute balance of forces. In case of EMS trains there is only one magnetic field to keep the train levitated and the magnetic force of attraction varies abruptly with distance, thus a small change in distance between the train and the track may lead the train to crash. The crash would not prove to be fatal since the train is levitating at a small height from the track but a proper levitation is need to be achieved in order to proceed with this technology. In order to overcome these difficulties EDS trains are being used. If the train is too close to the track then the magnetic field due to the track brings back the train to its original position. Although EMS train are less stable as compared to the EDS trains, EMS trains are less expensive. The EMS train are able to reach higher speed as compared to the EDS trains. Combining EMS and EDS technology As mentioned earlier EMS trains operate at higher speed but less stable than the EDS trains. If the elements of the EDS and EMS trains are combined together, then this combination would result into greater stability plus high speed operation of Maglev trains. Old dominion has already released plans including a cart called a "bogie", which runs along the undercarriage of the train providing a counterbalance to the downward magnetic force much like EDS technology, but works in tandem with the existing EMS technology. Instead of magnetizing the entire track, the bogie would able to achieve same stability between magnetic fields, but utilizing enough resource to span the undercarriage of train. [4]

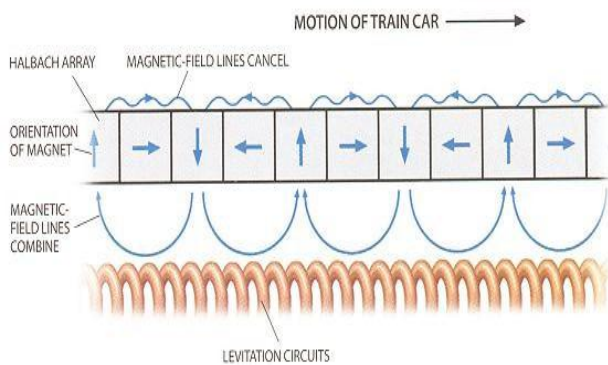


Fig.1 Halbach array

V. PROPULSION SYSTEM

The basic principle of electromagnetic propulsion is that “opposite poles attract each other and like poles repel each other.” The propulsion system in maglev train works exactly on the bases of normal motor which has a stator and rotating rotor. The interaction between the electromagnets and guide way is the actual motor of the Maglev system [3]

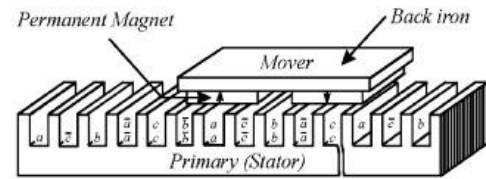


Fig.2 Linear Induction motor

Although unlike an actual motor, the Maglev’s propulsion system uses an electric linear synchronous motor or a linear induction motor. Linear Induction motor abbreviated as LIM, is a special purpose motor which is used to achieve rectilinear motion rather than rotational motion as in the case of conventional motors Space-time variant magnetic fields are generated by the primary part across the air gap and induce the electromotive force (EMF) in the secondary part, a conducting sheet. This EMF generates the eddy currents, which interact with the air-gap flux and so produce the thrust force known as Lorenz’s force.

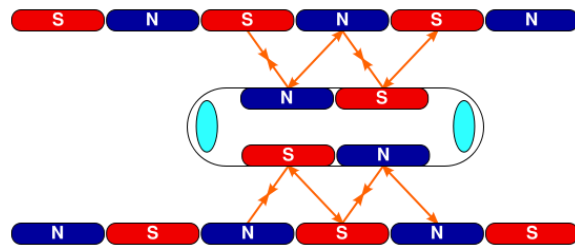


Fig.3 Propulsion of Maglev Train

The stators of the Maglev system are usually in the guideways, whereas the rotors are located within the electromagnetic system on the train. An alternating current is then produced, from the large power source, and passes through the guide way, creating an electromagnetic field which travels down the rails. The alternating current allows a pull from the magnetic field in front of the train, and a push from the magnetic field behind the train. This push and pull forces works together such that it allowing the train to reach optimum velocity more than 300 miles per hour.[7]

CONCLUSION

Overall, a Maglev train seems to be more sustainable way of transportation. Although the costs of constructing Maglev trains are much expensive but there are many other positive factors that overshadow this. Using superconducting magnets instead of fossil fuels, maglev will not emit greenhouse gases into the atmosphere and can reduce the pollution. Also the track of a Maglev train is small compared to those of conventional trains and is elevated above the ground so the track will not have a large effect on the topography of a region. Since a Maglev train levitates above the track, it will experience no mechanical friction, wear and thus will require very little maintenance. Considering everything Maglev has to offer, the transportation of our future and our children’s future is on very capable tracks.

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