MAGLEV MONORAIL

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Abstract- The paper titled 'MAGLEV MONORAIL' accomplishes a research on developing discipline of magnetic levitation and its application to transportation through trains. The concept of magnetically levitated vehicle is not new but recent advanced in technologies have made it possible for maglev vehicle to be successfully implemented. From aspect of scientific value, technical feasibility and economical efficiency, this paper reviews practical demonstration of transport projects related to application of different maglev technologies. The paper provides information of maglev science and its progression. High speed magnetically levitated ground transportation is a new surface mode of transportation, in which vehicles glide above their guide ways, suspended, glided and propelled by magnetic force. This paper tries to explain the complexities involved in this technologies in a simple but precise manner, so that all the methods implemented in it are understood by the reader. This paper tries to compare the conventional modes of transport with maglev trains in various aspects such as safety, durability, speed, comfort and much more. Thus providing the advantages and disadvantages of the trains. Further, it can be a substitution for short-haul air trips and thus releasing capacity for more efficient long-haul service at crowded airports. Finally our paper gives brief information about the maglev technology used in monorail.

Keywords-Magnetic Levitation, Monorail, Propulsion, Electromagnetic Suspension, Electrodynamic Suspension

I. INTRODUCTION

The definition of monorail is: A single rail serving as a track for passenger or freight vehicle. In most cases rail is elevated, but monorail can also run at grade, below grade or in subway tunnels. Vehicles are either suspended from or straddle a narrow guide-way. Monorail vehicle are wilder than the guide-way that supports them. The Federal Railroad Administration defines Maglev as "an advanced technology in which magnetic forces lift, propel, and guide a vehicle over a guide-way." So what is a Maglev Monorail? Simply put, maglev monorail follows the guide-way as conventional monorail does, but powerful magnets provide propulsion and lift. With most maglevs, there are no wheels touching the track surface, the train "floats" instead of rolling. There are different types of maglevs in development. The Monorail Society focuses on those that share the same type of guide-way that of monorails, one that is narrower than the train. We use the term "maglev monorail" as opposed to maglev to draw a distinction from systems with large trough-like guide-ways.

(i) Why Maglev Monorail?
Imagine a train that doesn't touch its track and think of the potential for lower guide-way maintenance costs as a result and a train that speeds much faster than anything on the highway with a ride as smooth as silk. Imagine that trains being capable of speed higher than any other ground based transportation system .This speed can be provided by maglev trains which can directly compare with airline travels. As stated by American maglev technology "Maglev means magnetically levitated and propelled vehicles." The advantage of maglev is that it can achieve very high speed and acceleration/deceleration performance because the vehicle essentially "fly" at very low altitude and doesn't have any type of surface contact or friction to slow them down. More speed = more passengers. Only when we have real revenue-producing systems in operation will be able to prove whether this is true or not.

Our paper titled 'MAGLEV MONORAIL' is an informative paper 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 which can achieve velocities nearer to an aircraft or a turboprop. Our paper aims at providing knowledge about the various aspects of this new emerging automotive technology called maglev monorail.

Fig. 1.1 Maglev Monorail

II. BASIC PRINCIPLE OF MAGLEV TRAINS

The force between two magnetic bodies is inversely proportional to their distance is the main physical property and the method of supporting and transporting object or vehicle. This magnetic force is generally used to counterbalance the gravitational pull, with which stable and contactless suspension between a magnet (magnetic body) and a fixed guide-way (magnetized body) may be obtained. In magnetic levitation (Maglev), also known as magnetic suspension, this basic principle is used to suspend (or levitate) vehicles weighing 40 tons or more by generating a controlled magnetic force. Because of removing friction these vehicles can travel at speed higher than wheeled trains, with considerably higher propulsion efficiency (thrust energy/input energy) and reduce noise. In Maglev vehicles, chassis-mounted magnets are either suspended underneath a ferromagnetic guide-way (track) or levitated above an aluminum track.

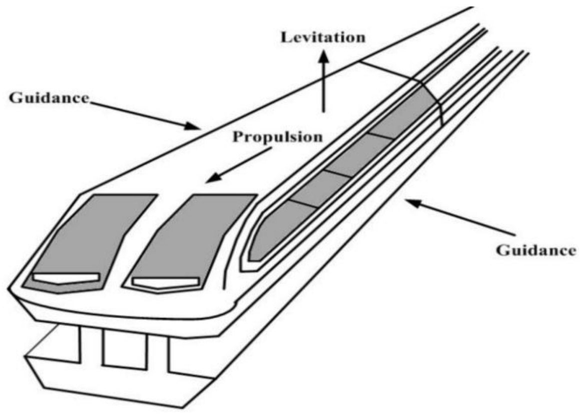

Fig. 2.1 Primary functions of Maglev

(i) Magnetic Levitation
The levitation coils shape like number "8" are installed on the sidewalls of the guideway. The on-board superconducting magnets when pass at a high speed about several centimeters below the center of these coils, an electric current is induced within the coils, which then acts as electromagnets temporarily As a result, there generates forces which push the superconducting magnets upwards and once which pull them upwards simultaneously, which causes levitation of Maglev vehicle.

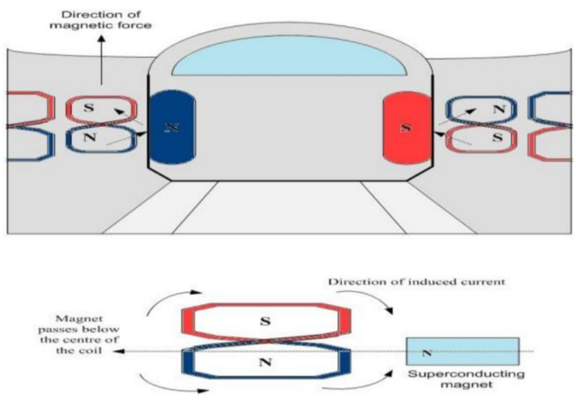

Fig. 2.2 Magnetic Levitation

(ii) Lateral Guidance
The levitation coils which are facing each other connected under the guide-way, constituting a loop. When a running Maglev vehicle, that is a superconducting magnet, displaces laterally from them, an electric current is induced in the loop, which results in a repulsive force acting on the levitation coils of the side from the car and an attractive force acting on the levitation coils of the side farther apart from the car. Thus, a running car is always located at the centre of the guide-way.

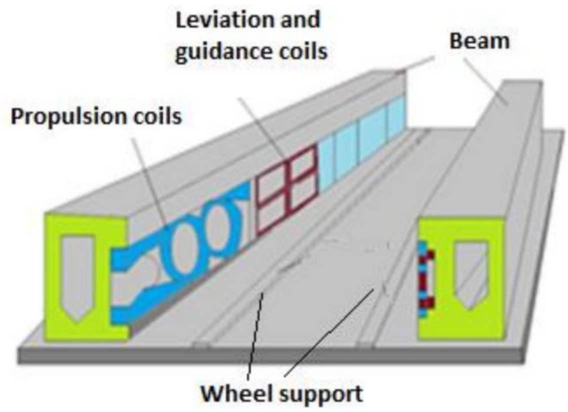

Fig. 2.2 Lateral Guidance

(iii) Propulsion Coil
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 and are energized by a three-phase alternating current from a substation, creating a shifting magnetic field on the guideway. The onboard superconducting magnets are attracted and pushed by the shifting field and propelling the Maglev vehicle.

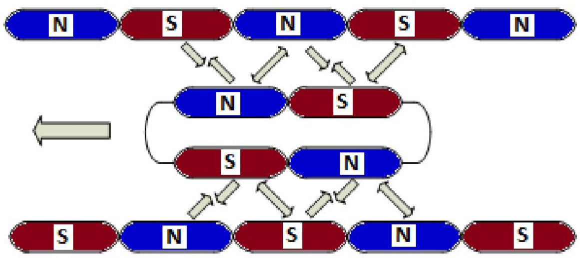

Fig. 2.4 Propulsion Coil

III. WORKING AND DIFFERENT TECHNOLOGIES OF MAGLEV TRAINS

In the attraction-type system, a magnet-guide-way geometry is used to attract a direct-current electromagnet toward the track. This system, also known as the electromagnetic suspension (EMS) system, is suitable for low- and high-speed passenger-carrying vehicles and a wide range of magnetic bearings. The electromagnetic suspension system is inherently nonlinear and unstable, requiring an active feedback to maintain an upward lift force equal to the weight of the suspended magnet and its payload or weight of vehicle. In the repulsion-type system, also known as the electro dynamic levitation system (EDS or EDL), a superconducting coil operating in persistent-current mode is moved longitudinally along a conducting surface (an aluminium plate fixed on the ground and acting as the guide-way) to induce circulating eddy currents in the aluminium plate.

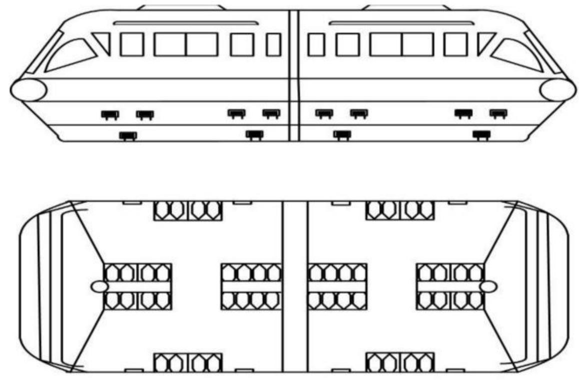

Fig. 3.1 Schematic Arrangement of MMR

These eddy currents create a magnetic field which, by Lenz's law, opposes the magnetic field generated by the travelling coil. This interaction produces a repulsion force on the moving coil. At lower speeds, this vertical force is not sufficient to lift the coil (and its payload), so supporting auxiliary wheels are needed until the net repulsion force is positive. The speed at which the net upward lift force is positive (critical speed) is dependent on the magnetic field in the airgap and payload, and is typically around 80 km/h (50 m/h). For the production of high flux from the traveling coil, hard superconductors with relatively high values of the critical field (the magnetic field strength of the coil at 0 K) are used to yield airgap flux densities of over 4 Tesla. With this choice, the strong eddy current induced magnetic field is rejected by the superconducting field, giving a self-stabilizing levitation force at high speed (through additional control circuitry is required for adequate damping and ride quality.

Each implementation of the magnetic levitation principle for train-type travel involves advantages and disadvantages. Time will tell us which principle, and whose implementation, wins out commercially.

(i) EMS (Electromagnetic suspension)
Electromagnetic Suspension (EMS) is the magnetic levitation of an object achieved by constantly altering the strength of a magnetic field produced by electromagnets using a feedback loop. In most cases the levitation effect is mostly due to permanent magnets as they don't have any power dissipation, with electromagnets only used to stabilize the effect. According to Earns haw's theorem a Para magnetically magnetized body cannot rest in stable equilibrium when placed in any combination of gravitational and magneto static fields. In these kinds of fields an unstable equilibrium condition exists. Although static fields cannot give stability, EMS works by continually altering the current sent to electromagnets to change the strength of the magnetic field and allows a stable levitation to occur. In EMS a feedback loop which continuously adjusts one or more electromagnets to correct the object's motion is used to cancel the instability.

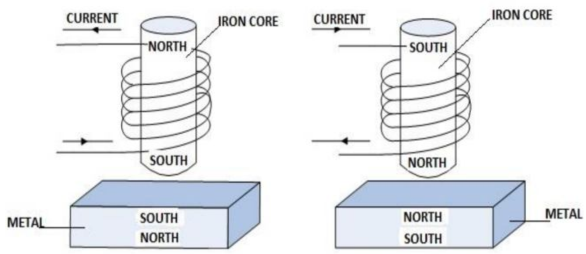

Fig 4.1 EMS Suspension system

(ii) EDS (Electrodynamic Suspension)
An electrodynamic suspension (EDS) system, which is based on the repelling force of magnets. Super-cooled, superconducting electromagnets. This kind of electromagnet can conduct electricity even after the power supply has been shut off. In the EMS system, which uses standard electromagnets, the coils only conduct electricity when a power supply is present. By chilling the coils at frigid temperatures, EDS system saves energy. However, the cryogenic system uses to cool the coils can be expensive.

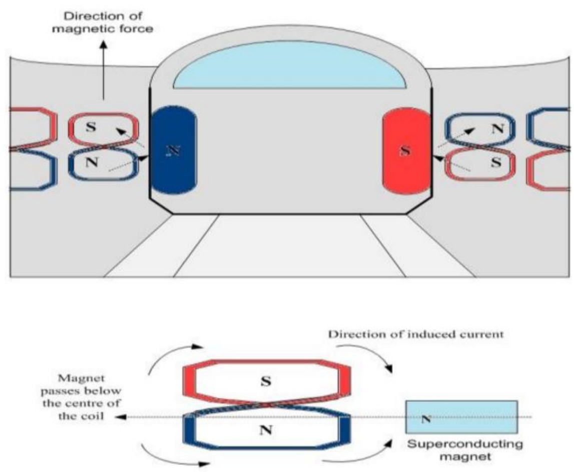

Fig 4.2 EDS Suspension system

(iii) Inductrack
The Inductrack is a newer type of EDS that uses permanent room-temperature magnets to produce the magnetic fields instead of powered electromagnets or cooled superconducting magnets. Inductrack uses a power source to accelerate the train only until begins to levitate. If the power fails, the train can slow down gradually and stop on its auxiliary wheels.

There are two Inductrack designs: Inductrack I and Inductrack II. Inductrack I is designed for high speeds, while Inductrack II is suited for slow speeds. Inductrack trains could levitate higher with greater stability. As long as it's moving a few miles per hour, an Inductrack train will levitate nearly an inch (2.54 centimeters) above the track. A greater gap above the track means that the train would not require complex sensing systems to maintain stability.

Neither Induct rack nor the Superconducting EDS are able to levitate vehicle at standstill, although Inductrack provides levitation down to a much lower speed; but the wheels are required for these systems. EMS are basically a wheel-less system.

IV. COMPARISON WITH CONVENTIONAL TRAINS

Maglev transport is non-contact, electric powered. It does not rely on the wheels, bearings and axles common to mechanical friction-reliant rail systems.
(i) Maintenance Requirements of Electronic Versus Mechanical Systems: Maglev trains currently in operation have demonstrated the need for nearly insignificant guide-way maintenance. Their electronic vehicle maintenance is minimal and more closely aligned with aircraft maintenance schedules based on hours of operation, rather than on speed or distance traveled. Traditional rail is subject to the wear and tear of miles of friction on mechanical systems and increases exponentially with speed, unlike maglev systems. The running costs difference is a cost advantage of maglev over rail and also directly affects system reliability, availability and sustainability.
(ii) All-Weather Operations: While maglev trains currently in operation are not stopped slowed, or have their schedules affected by snow, ice, severe cold, rain or high winds, they have not been operated in the wide range of conditions that traditional friction-based rail systems have operated. Maglev vehicles accelerate and decelerate faster than mechanical systems regardless of the slickness of the guide-way or the slope of the grade because they are non-contact systems.
(iii) Backwards Compatibility: Maglev trains currently in operation are not compatible with conventional track, and therefore require all new infrastructure for their entire route, but this is not a negative if high levels of reliability and low operational costs are the goal. By contrast conventional high-speed trains such as the TGV are able to run at reduced speeds on existing rail infrastructure, thus reducing expenditure where new infrastructure would be particularly expensive (such as the final approaches to city terminals), or on extensions where traffic does not justify new infrastructure. However, this "shared track approach" ignores mechanical rail's high maintenance requirements, costs and disruptions to travel from periodic maintenance on these existing lines. It is claimed by maglev advocates most notably, Dr. John Harding, former chief maglev scientist at the Federal Railroad Administration that the use of a completely separate maglev infrastructure more than pays for itself with dramatically higher levels of all-weather operational reliability and almost insignificant maintenance costs, but these claims have yet to be proven in an operational setting as intense as many traditional rail operations, and ignore the difference in maglev and traditional rail initial construction costs. So, maglev advocates would argue against rail backward compatibility and its concomitant high maintenance needs and costs.
(iv)Efficiency: Conventional railway is probably more efficient at lower speeds. But due to the lack of physical contact between the track and the vehicle, maglev trains experience no rolling resistance, leaving only air resistance and electromagnetic drag, potentially improving power efficiency.

Some systems however such as the Central Japan Railway Company SCMaglev use rubber tires at low speeds.
(v) Weight: The weight of the electromagnets in many EMS and EDS designs seems like a major design issue to the uninitiated. A strong magnetic field is required to levitate a maglev vehicle. For the Trans rapid, this is between 1 and 2 kilowatts per ton. Another path for levitation is the use of superconductor magnets to reduce the energy consumption of the electromagnets, and the cost of maintaining the field.

However, a 50-ton Tran's rapid maglev vehicle can lift an additional 20 tons, for a total of 70 tons, which consumes between 70 and 140 kW.

Most energy use for the TRI is for propulsion and overcoming the friction of air resistance at speeds over 100 mp.

(vi) Weight Loading: High Speed Locomotives requires more support and construction for its concentrated wheel loading. Maglevs on the other hand is not only lighter than its conventional counterparts, its weight is also more evenly distributed.
(vii) Noise: Because the major source of noise of a maglev train comes from displaced air, maglev trains produce less noise than a conventional train at equivalent speeds. However, the psychoacoustic profile of the maglev may reduce this benefit: a study concluded that maglev noise should be rated like road traffic while conventional trains have a 5–10 dB "bonus" as they are found less annoying at the same loudness level.
(viii) Control Systems: There are no signalling systems for high or low speed maglev systems. There is no need since all these systems are computer controlled. Besides, at the extremely high speeds of these systems, no human operator could react fast

enough to slow down or stop in time. This is also why these systems require dedicated rights of way and are usually proposed to be elevated several metres above ground level. Two maglev system microwave towers are in contact with an EMS vehicle at all times for two-way communication between the vehicle and the central command centre's main operations computer. There are no need for train whistles or horns, either.

VI. ADVANTAGES AND DISADVANTAGES

(i) Maglev uses 30% less energy than a high-speed train traveling at the same speed (1/3 more power for the same amount of energy).
(ii) The operating costs of a maglev system are approximately half that of conventional long-distance railroads.
(iii) Research has shown that the maglev is about 20 times safer than airplanes, 250 times safer than conventional railroads, and 700 times safer than automobile travel.
(iii) Maglev vehicle carries no fuel to increase fire hazard.
(iv)The materials used to construct maglev vehicles are non-combustible, poor penetration transmitters of heat, and able to withstand fire.
(v) Loss of power supply.
(vi) Loss of synchronization could cause serious accidents.

VII. OTHER APPLICATIONS

(i) NASA plans to use magnetic levitation for launching of space vehicles into low earth orbit.
(ii) Boeing is pursuing research in Maglev to provide a Hypersonic Ground Test Facility for the Air Force.
(iii) The mining industry will also benefit from Maglev.
(iv)There are probably many more undiscovered applications.

CONCLUSION

(i) The Maglev Train: Research on this ‘dream train' has been going on for the last 30 odd years in various parts of the world.
(ii) Non-contact and non-wearing propulsion, independent of friction, no mechanical components like wheel, axle.
(iii) Maintenance costs decrease
(iv) The Maglev offers a cheap, efficient alternative to the current rail system. A country like India could benefit very much if this were implemented here. Further possible applications need to be explored.

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.”

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