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Feasibility Study of Maglev Trains on Existing Indian Railways Infrastructure

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ABSTRACT: Maglev trains have become a very growing phenomenon in the world and work on the principle of magnetic levitation. This study explores the feasibility of these trains in Indian Railways Infrastructure. The technical specifications required have been contrasted with the available technical infrastructure of the existing Indian Railways. Moreover the economic aspects have also been studied such as capital investment, affordability of Indian commuters, etc. In addition to this, the Maglev trains have been compared with other high speed means of transportation such as Air Transport.

Keywords: Magnetic levitation, Maglev

I. INTRODUCTION

MAGLEV is derived from the word "magnetic levitation". It is a system of transportation .It uses magnetic levitation to suspend, guide and propel vehicles with magnets. By using magnets, a vehicle is levitated a short distance away from the guide way to create both lift and thrust. High-speed maglev trains are better than other type of transportation system. Environmental temperature change doesn't affect it .It moves more smoothly and more quietly than other mass wheeled transit systems. For levitation, the power needed is not a large percentage of the overall energy consumption. Maglev is the fastest train among all the available trains. It holds the speed record for all rail transportation. The construction of maglev trains is different from conventional wheeled trains. It is much more expensive than other but its maintenance and outgoing costs are less.

There are presently only two commercial maglev transport systems in operation after long research and development and others two are under construction. Shanghai began high-speed trans-rapid system operation in April 2004.Japan began low-speed HSST "Linimo" line in March 2005.Linimo carried over 1 million passengers in its first three months.

II. EVOLUTION OF MAGLEV TRAINS

The development of rails and trains began in the early 1800s.The conventional trains were not much faster; they ran at speed of 110mph so it reached at the end phase of their development.

After reaching the end phase of development of conventional trains, France, Germany, Japan have developed "high-speed" or "bullet" trains which are capable of running at speeds of 150-180 mph.

Table1: Comparison of Maglev with Conventional wheel-on-rail trains.

	Maglev System	Iron Wheel-on-Rail System
Vibration & Noise	No mechanical contact 60~65 [dB]	Contact between wheels and rails, 75~80 [dB]
Safety	No possibility of derailment	Derails from a minor defect
Guideway	Light vehicle & distributed load → light-weight	Heavy & concentrated load → Hardy structure
Maintenance	Very little	Periodic replacement of wheels, gear, rails, etc
Grade	About 80~100/1000	About 30~50/1000
Curve	In 30 [m] in radius	In 150 [m] in radius

But these trains are more expensive and maintenance is also time-consuming so it also reached to the end phase of their development. It is the mechanical friction between wheels and metal tracks that limit this technology. This leads us to the development of maglev trains that has no friction. In these trains, there is no physical contact between the rails and trains by which there is no friction to obtain higher speeds and low maintenance.

III. TECHNOLOGY OF MAGLEV TRAINS

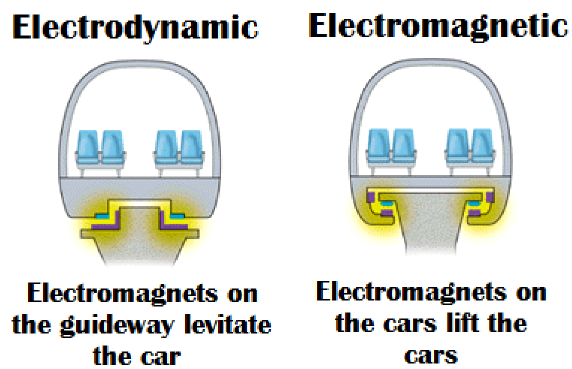
There are two different concepts of maglev technology:
1. The Electro-magnetic suspension (EMS) uses electromagnets on the train body which are attracted to the iron rails. The vehicle magnet wrap around the iron guide ways and the upward attractive force lifts the train.
2. The Electro-dynamic suspension (EDS) uses superconducting electromagnets or strong permanent magnets that induce currents in the conductive guide ways that levitates the trains by the repulsive forces.

In current electromagnetic suspension systems (EMS), the train levitates above a steel rail while electromagnets, attached to the train, are oriented toward the rail from below. The system is typically arranged on a series of C-shaped arms, with the upper of the arm attached to the vehicle, and the lower inside edge containing the magnets. The rail is situated between the upper and lower edges.

Magnetic attraction varies inversely with the cube of distance, so minor changes in distance between the magnets and the rail produce greatly varying forces. These changes in force are dynamically unstable – if there is a slight divergence from the optimum position, the tendency will be to exacerbate this, and complex systems of feedback control are required to maintain a train at a constant distance from the track, (approximately 15 millimeters (0.59 in).

The major advantage to suspended maglev systems is that they work at all speeds, unlike electro dynamic systems which only work at a minimum speed of about 30 km/h (19 mph). This eliminates the need for a separate low-speed suspension system, and can simplify the track layout as a result. On the downside, the dynamic instability of the system puts high demands on tolerance control of the track, which can offset, or eliminate this advantage. In electro-dynamic suspension (EDS), both the guide way and the train exert a magnetic field, and the train is levitated by the repulsive and attractive force between these magnetic fields. In some configurations, the train can be levitated only by repulsive force. In the early stages of JR-Maglev development in Miyazaki test track, a purely repulsive system was used instead of the later repulsive and attractive EDS system. There is a misconception that the EDS system is purely a repulsive one, but that is not true. The magnetic field in the train is produced by either superconducting magnets (as in JR–Maglev) or by an array of permanent magnets (as in Induce track).The repulsive and attractive force in the track is created by an induced magnetic field in wires or other conducting strips in the track.

A major advantage of the EDS maglev systems is that they are naturally stable – minor narrowing in distance between the track and the and the train exert a magnetic field, and the train is levitated by the repulsive and attractive force between these magnetic fields.



IV. INFRASTRUCTURE OF INDIAN RAILWAYS

India has one of the largest train networks in the world. But Indian railways don't have any train running on the speed more than 160 kmph. High speed corridors have been proposed but still not Implemented. Highest speed train in India is Bhopal Shatabdi runson 150kmph. In this technical era, when lots of technologies are available for the increment in the speed and safety, we should improve our railways system. All the equipment used in communication and signal ingare outdated.

In India, thousands of people travel daily in metro cities like Delhi to Mumbai, Delhi to Kolkata, Delhi to Bangalore etc. keeping in mind the need of passengers, increasing air traffic and fuel price hiking , we should focus on any alternative which can improve and help us travelling between the cities in minimum time, more convenient and safer way. Rail transport creates least problems to the environment as compared to other transport system. Maglev doesn't use any fossil fuel, it uses magnets to run. As fossil fuels are available in limited amount, so the unavailability of fuel will not harm maglev transport system. Rail transport is energy efficient and prevailing average speeds it consumes about 1/6th of the energy required for transport for carrying one ton of freight traffic over a distance of one kilometer and 1/30thenergy as compared to air transport. In case of passenger traffic, it consumes 1/50thto 1/15thof energy per upon the size of car. It takes ¼th of the energy consumed by a bus and 1/7thto 1/18thby an aircraft depending upon its size. The requirement of land is also much less as compared to road transport for carrying the same amount of traffic.

V. REASONS TO ADOPT MAGLEV TRANSPORT SYSTEM

Considering the existing Indian Railways Infrastructure, maglev transport is suitable under following conditions:

1. Traffic density should be high. It is suitable for mass movement of passengers and bulk movements of goods.
2. The freight traffic should be preferably be in train loads from the point of origin to the destination for detachment and attachment of wagons reroute should be avoided or kept down to the minimum.
3. Rail transport is also suitable for mass transport of passengers' even for short distance as in case of suburban services.
4. Railways are suitable for long distance passenger traffic as they provide sleeping accommodation.

VI. QUALITY OF SERVICE

Railways have to do a lot of work to improve its quality of service to the rail users and to develop capacity in such a manner that it is always ahead of demand. Few areas of country are not adequately covered by railway lines and there is need for constructing new railway lines in these areas. It has an inadequate capacity even for handling the present level of passengers and freight traffic. In case of freight traffic, even long distance bulk traffic is moving by roads due to inability of railways to lift all the traffic which is offered. There is also uncertainty about the time which may be taken to reach the goods to the destination. We should discontinue the system of moving goods train on open timing and they should follow a time table as in case with passengers' trains. This would be possible if we have dedicated freight corridors.

Raising the speed of the passenger and freight trains also require serious consideration. People want to cut short their journey time and to reach the destination as early as possible. However, there is a cost associated with the higher speed and one should take into account the technical feasibility and economics of raising the speed of train while taking a decision.

VII. TECHNICAL FEASIBILITY OF MAGLEV TRAINS

Technical feasibility has been established to raise the speed of the existing tracks and using vehicles already in use. Even at these speeds (155- 160 kmph) there are many restrictions to sharp curves. For Higher speeds on the existing track there will be many more speed restrictions and if higher speeds are to be introduced in Indian railways then it would be necessary to lay new tracks having mild curves and no speed restrictions over bridges and station yards.

Another problem which has to be faced is the maintenance of tracks which is to be maintained according to the speed restrictions for the high speed trains.

Maglev train requires steel rails, installation cost of these rails is very high but the maintenance cost is very low. Once the rails are installed we do not need to pay any cost for its inspection or maintenance.

For deciding the maximum speed of the passenger, it is necessary to consider the economics of high speed operation. The hauling power required to haul a train at higher speed increases in proportion of the cube of speed, other parameter remaining constant. The energy consumption at higher speed per ton-kilometer of traffic moved in proportion of square of the speed. Thus the energy consumption for raising the speed to 145kmph is more than the double of that for the speed of 100kmph. So energy required to raise the speed of trains by 350kmph, energy required will be 12- 15 times that of 100kmph which will be higher than the energy required by the large airplanes. The higher energy results in higher cost and higher cost. The fare of these trains will be more than the air fare and these trains will be beyond the reach of common man. Not only the operating cost is high but also the cost of production of high speed lines, which has to be mild curves and cannot avoid costly land near cities and will have long tunnels and tall bridges in hilly terrain, is very high.

VIII. COMPARISON OF MAGLEV TRAINS WITH AIRCRAFTS

Lift to drag ratio of maglev is more than that of aircrafts. This ratio can exceed up to 200:1. This makes maglev more efficient than the aircrafts. At the very high cruising speed aerodynamic drag is quite larger than that of lift induced drag. At cruising speed at high latitudes drag of aircrafts is reduced due to low air densities, but maglev runs efficiently at high speeds at sea level.

Due to weather change problems, hundreds of flights are postponed every year which creates lots of problems for the passengers in reaching their destinations timely. Maglev is the best way to eliminate this problem. It doesn't get affected by weather conditions. It can run at the same speed in all seasons. Maglev fares are not affected by the variations in oil markets. Travelling by maglev also reduces the chances of crash into others maglev's, as the chances of leaving the track of maglev are negligible. Aircraft fuel is also dangerous during the time of takeoff or landing accidents.

IX. PROPOSED ROUTES FOR MAGLEV TRAINS IN INDIA

Pune to Mumbai: Indian ministry has got a new proposal to start Maglev in India. The cost of this project has been estimated for this process which is about to be $30 billion. A US based company has sent this proposal. This proposed project if completed will take 3 hours to complete this journey which presently takes 16 hours. Mumbai is planning to have first Maglev which will take 30 minutes for 200 km distance. This is planned near Hinjewadi IT Park in Pimple Saud agar. On Pune-Mumbai Highway approximately 14000 vehicles travel daily which consumes 2 million liters a day. So this project can reduce the fuel consumption between these two cities.

Mumbai to Delhi: Distance between Delhi and Mumbai is 1394 km. It takes 19 hrs. and 30 minutes by train to travel between these two cities, Maglev can reduce this time by 1/3.

Mumbai to Nagpur: The state of Maharashtra has also approved Maglev project between Nagpur and Maharashtra which are about 1000 km distance apart. It plans to connect the main areas between Mumbai and Nagpur. Chennai – Bangalore-Mysore: The cost of this project is expected to be $26 million per kilometer of railway track. It will run at a speed of 350kmphand will take 30 minutes to reach to Mysore from Chennai via Bangalore.

X. CONCLUSION

The Maglev train is considered for both urban transportation and intercity transportation systems. Scientists are sure that this technology can be utilized for not only train application but also aircraft and spacecraft launching systems. The need for a new and better transportation system has encouraged many countries to be interested in an attempt to develop the Maglev train. However, even though the Maglev train has been studied and developed for approximately half a century, only a few countries have the knowledge and expertise to do so. This review paper tried to describe the present complete system in detail and summarize foundational core technologies of the Maglev train. It is certain that this review paper will be helpful for persons who are interested in this matter to assimilate the Maglev train technologies including magnetic levitation, propulsion, guidance, and power supply system.

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