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Introduction & Overview of Magnetic Levitation (MAGLEV) Train System

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***Abstract* - In this paper, we will discuss about Basics of magnetic levitation train system , its components and working. Basically, the MAGLEV train stands for magnetic levitation train and is a system of high speed transportation as compared to conventional train system.**

The term "MAGLEV" refers not only to the vehicles but to the railway system as well specially design for magnetic levitation and propulsion. The important concept of this system is to generate magnetic field obtained by using either permanent magnets or electromagnets. As compared to conventional train, maglev train system has no moving parts, the train travels along its guideway of magnets which controls the train stability and speed therefore the maglev train are quiter and smoother than conventional trains and have the potential for much higher speed. As per safety point of view, maglev can accelerate and decelerate much faster than conventional trains; practical limitation is the safety and comfort of passenger. The power requirement for levitation is not in large quantity of the overall energy consumption of high speed maglev system. Maglev train systems are much expensive than conventional train system, but it is simple in construction and also as per manufacturing and maintenance point of view maglev train system is more economical. Maglev train creates no direct pollution emissions, also it has no noise problem because there is no friction between trolley and pantograph as compared to the conventional train system.

***Keywords* - Maglev, Levitation, Conventional, Guide way, Propulsion, Train, Linear motor.**

I. INTRODUCTION

A German inventor named "Alfred Zehden" was awarded by United States Patent for a linear motor propelled train. The inventor was awarded U.S. Patent 782,312 on 14 February 1905 and U.S. Patent RE 12,700 on 21 August 1907. An Electromagnetic transportation system was discovered and developed in 1907 by F.S. Smith. In between 1937 & 1941 Herman Kemper was awarded by serious of German patents for magnetic levitation train propelled by linear motors.

Maglev is derived from magnetic levitation which means to lift a vehicle without any mechanical support with the help of magnetic field generated by either permanent magnets or electromagnets. There are 2 sets of magnets used in maglev train system. One set of magnet is used to levitate train body from train track & another set is used to propel the vehicle with the help of attraction and repulsion.

There are guide ways in the form of magnets which gives more stability & directional control to moving body of levitated train. The magnetic field generated by these guide way magnets restrict it to move beyond its magnetic field range. That's why maglev train is more effective than conventional train in the sense of stability and working. There is no direct contact between train tracks and train body which makes it frictionless process as well as there are no moving parts. The maglev train does not have an engine which is powered by magnetic field created by electrified coils.

There are three primary types of maglev technologies:

- Electromagnetic suspension (EMS) uses the attractive magnetic force of magnet beneath a rail to lift the train up. In this system, electronically controlled electromagnets in the train attract it to a magnetically conductive (usually steel) track.
- Electrodynamic suspension (EDS) uses a repulsive force between two magnetic fields to push the train away from the rail. In this system, superconducting

electromagnets or strong permanent magnets that create a magnetic field, which induces currents in nearby magnetic conductors when there is a relative movement which pushes and pull the train towards the designed levitation position on the guide way.

- Stabilized permanent magnet suspension (SPM) uses opposing arrays of permanent magnet to levitate the train above the rail.
- Another experimental technology, which was designed, proven mathematically, peer reviewed and patented but is yet to built, is the magneto dynamic suspension (MDS), which uses the attractive magnetic force of a permanent magnet array near a steel track to lift the train and hold it in place.

II. DEVELOPMENT OF MAGLEV TRAIN

As we mentioned above, the maglev system facing continuous development from 19th century to 20th century. The evolution of maglev train system started from 1904 and continued still today's date.

In 1904, Robert Goddard wrote a paper which proposed about a frictionless travelling system which would work by raising a train body from the train track or rail by using electromagnetic repulsion system. On basis of this theory he claimed that the train would travel at super fast speeds.

In 1910, Emile Bachelet was applied for a patent on a rail car which was levitated by using electromagnets powered by alternating current and solenoids placed at particular interval along a road bed for propulsion of train or vehicle. But this concept made by Bachelet was not able to complete a successful chase down towards his dreams due to more power required for conventional magnets.

In 1969, two Americans Gordon Damby and James Powell successfully completed their work on design of a magnetically levitated train and granted a first patent for this kind of a design work related to maglev train.

In 1970, Germany and Japan started investing money for research on maglev technology. Also United State Federal Railroad Administration studied high speed ground transportation in that same year.

A. GERMAN DEVELOPMENT

In 1969 the German government sponsored the first full scale model of maglev train. They named their version as trans rapid01. The German company Munich's Krauss Maffei, build improved version of Trans Rapid.

Germany's first large scale demonstration of Trans Rapid was in 1979 at the International Transportation Fair in Hamburg. At that time the test track was built to test the system in real word condition. The track was 19mile and was built from 1979 to 1987 in Northern German. This route was planned from Hamburg to Berlin in 1992.

In 1998, the joint company was formed under the system houses Adtranz, Siemens and Thyssen. The new joint company was called Trans Rapid International.

In 2000, the government said that the Berlin Hamburg route will not be realized and Trans Rapid International proposed 5 alternating routes where the trans rapid can built. None of the route were accepted and Trans Rapid International looking for outside interest to save billion dollars and 30 years experiences.

On 23 January 2001, China build a line between Shanghai and its airport of maglev system with the help of German maglev technology after analyzing and statistical gathering.

B. JAPANESE DEVELOPMENT

Japan is known for their innovation and advance technologies in various sectors like automation in train technologies and they have world's best railway network in world at all. They are currently running their high speed bullet trains at 350km/hr to 450km/hr and now they are working on maglev train project seriously with 650km/hr target.

Now, back to the history, in 1964 "The Tokaido Shinkansen" was the first high speed train of japan and since then has expanded considerably. On the basis of its successful construction and working, west countries were also developed in high speed train sector. But Japanese were not satisfied with this speed and demanded for more high speed train as compared to previous train. The shinkasen was nothing but a conventional train had same design work with motor, body structure and power required for working was supplied from overhead wires, wheels running on rail tracks as like others made it impossible to increase the speed more than requirement. Other factors like greater size, weight lied on train tracks, increased friction between rail wheels and rail track, electric power cut-offs were also responsible for wheel slipping and accidental conditions. For all the problems they were facing found only one solution and that was "Electromagnetism".

The maglev research and development was conducted by Japanese national railway (JNR) in 1970. In 1970, They had made a prototype model of maglev named ML-500 tested on the "Miyazaki" test track was built in southern Japan scored a speed of 517 km/hr on 7 km track which proved maglev had great future potential for high speed transportation. The track was built in a U-shaped to analyse more real world track curves.

The MLU001 was the first government approved and funded maglev train by Japan which was tested on Miyazaki test track but they had faced some problems with it. This track was short in size with one guide way without tunnels and inclines or declines are not included. With some limited experimental data that test track was not able to satisfy its commercial potential and use.

After privatization of JNR in 1987, a 100 km

(approximately) "Yamanashi" track was made in Tamanshi, west side of Tokyo, for increment in passenger who made their project commercially possible at every stage.

For determination of commercial feasibility of maglev train Yamanashi test line was built which was 18.4 km long with 16 km of tunnels and open section of 1.5 km long in middle of the track where substations for power conversion and other facilities were provided.

In April 1997, trial began on Yamanashi test line with the cars driven at low speeds on rubber tyres which weren't levitated. After confirmation received that there were no problems, then original levitated car operated at the end of may 1997.

To monitor car movement and verify braking performance the speed was increased incrementally. The only problem that remained was air vibration that rattled the windows of buildings when maglev train enters or leaves a tunnel at high speed. The ground vibration measurements were well within limits and there were no environmental problems.

In 1984 First commercial maglev "people-mover" was officially opened in Birmingham, England. They operated it on an elevated 600-metre (2000ft) section of track between Birmingham international airport and Birmingham international railway station.

With 431 km/hr top speed having total distance 30 km covered in just 7 min 30 seconds, German made shanghai maglev train of china is currently best working maglev train which is travelling from shanghai city to shanghai airport. This train is working on electromagnetic suspension system whereas Japan is currently working on electrodynamic suspension system.

III. WORKING PRINCIPLE

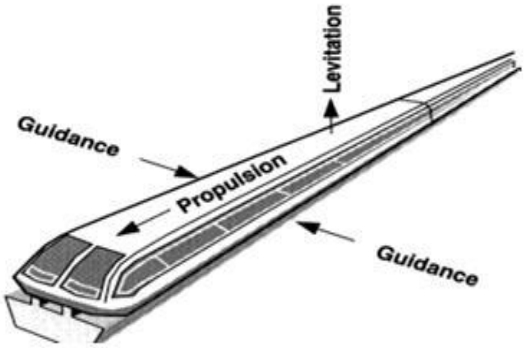

Fig (A) :- Primary function of maglev

A maglev system is known for his high speed transportation with non contacting characteristics which is causes friction free working. Basically, magnetic levitation is defined as "to levitate the transportation medium without any mechanical support with the help of magnetic flux generated by either permanent magnets or electromagnets and propelled it with the help of attraction and repulsion built by electric coil which is nothing but a electromagnets."

In magnetic levitation the working is divided into three main parts :-

1) To levitate the vehicle
2) To give propulsion and achieved high speed
3) To give guidance

The working principle of maglev system is depends on the following terms :-

1) Magnetic field generated though permanent magnets or electromagnets.

2) the magnetic poles of magnets or electromagnets

The working principle of maglev train states that

"Due to magnetic field generated by respective power source whether it may be permanent magnets or electromagnets causes levitation to vehicle or object if the same pole of respective power source faces to each other and propulsion of vehicle causes due to attraction or repulsion action of magnetic field generated by another same power source as their opposite poles faces to each other."

IV. CONSTRUCTION OF MAGLEV SYSTEM

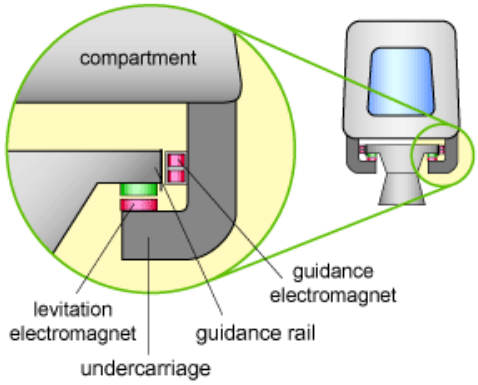

Fig. (B):- Construction of maglev train system

1) Figure shows constructional details of basic maglev train system which makes it to understand the basic details of maglev train system.
2) It consists of a levitation electromagnets and guidance electromagnet. The one thing need to clarify that permanent magnets are also use as per convenience for levitation and propulsion & for guidance.
3) Also figure shows the compartment and undercarriage parts.
4) In EMS, electromagnets are used whereas in EDS system superconductors are used and in MSD system permanent magnets are used in the form of permanent magnet array in which magnets are rotated in anticlockwise direction at 90^0 to each other which gives more stable levitation as compared to other.
5) The permanent magnets used for these type of

constructions are as follows:-

a. Neodymium Iron Boron (NdFeB)
b. Samarium Cobalt (SmCo)
c. Alnico
d. Ceramic or Ferrite

From above magnets Neodymium Iron Boron (NdFeB) are commonly used magnet.

6) The rail track and train body is made up by steel.

V. WORKING OF MAGLEV TRAIN

As we mentioned above, its working is divided into three parts namely levitation, propulsion and guidance. but the point is that to understand above three concepts briefly. Now first of all let's move on to the basics behind these concepts.

A magnet is a material or object that produces a magnetic field which is invisible. The overall strength of magnets is measured in terms of total magnetic flux it produces. Magnets are divided in two types which are either permanent magnets or electromagnets. Every magnetic object has two poles generally named as North pole and south pole. A region at each end of a magnet at which external magnetic field is strongest is called as Magnetic pole. Whenever a magnet comes with a contact of earth's magnetic field, it orients itself in north and south direction by which we can easily identify the poles of magnets. So naturally same poles of two magnets repel each other and unlike poles attract each other.

Now coming to the important point what is levitation and how it achieved in this system.

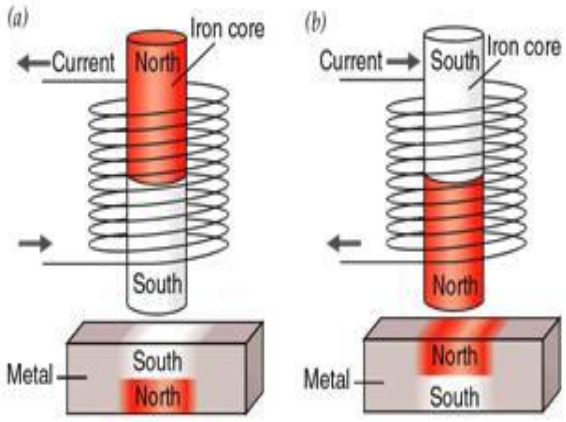

Fig. (C) Theory of levitation

Figure shows that same poles of magnet repelling each other. Whenever a magnetic field is created in magnet it flows from North pole to South pole outside of magnet. This flow causes generation of magnetic field around the magnetic material or object or magnet. As we know that every atom in nature have positive protons in centre called nucleus and negative electrons spinning around this nucleus. A magnetic material electron are revolved around the nucleus and makes a strong positive and strong negative side in the magnets which makes north and south pole of magnets. Now this difference makes high attraction on one side and strong repulsive action on the other side. When the different poles of magnets are connected to each other it makes it a one single magnets and the two magnetic fields are become unite due to attraction. So this united field causes flow of electrons in one direction. Similarly whenever the unlike poles place close to each other flow of electrons became opposite to each other. The forces generated by these electrons are too stronger which cause of attraction and repel action of magnetic objects. So **"when a magnetic material available in track and below the train body faces to other with like poles generated by magnetic material causes levitation because of movement of electrons are spinning in opposite direction to each other."**

Now let's move on propulsion system of maglev train system shown in below figure.

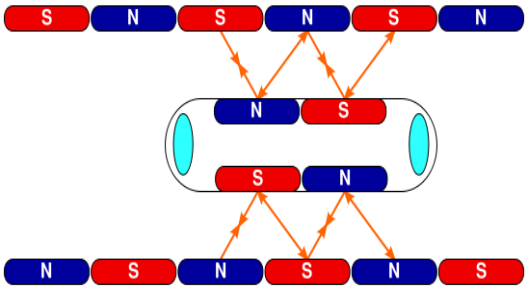

Fig.(D) Propulsion system of maglev train

The propulsion system is depends upon attraction and repel action cause by magnetic material which may be either permanent magnets or electromagnets. The electromagnet is in the form of coils. There are two types of propulsion system which are used in currently maglev train. The Linear Induction Motor(LIM) is used to propel the Japanese EDS system while the Linear Synchronous Motor(LSM) propels the German Trans rapid system.

It is important to know that the speed of maglev trains in linear synchronous motor is determined by the frequency of the alternating current and the magnetic field direction. Propulsion is created when the current is 'synch' with the frequency allowing for forward propulsion. In order for the train car to brake and slow down, the field simply has to be reversed allowing the train car to back without the use of friction.

Also it important to know about LIM and LSM. Basically Linear Induction Motor is an AC powered asynchronous motor, works same as an induction motor used to directly produce motion in a straight line with a finite primary and secondary length which causes end effect rather than conventional induction motor in which arrangement of an endless loop is provide. The working of Linear Synchronous motor is same as LIM but the only difference is that LSM has an active winding on one side of air gap and an array of alternate pole magnets on the other side. These magnets are

either permanent magnets or electromagnets.

We are Taking attention on superconductors used in Japanese train for levitation called as "Superconductor Levitation" in this point. So, what is superconductor levitation? A material has zero electrical resistance when cooled below a particular temperature say critical temperature called as "Superconductor." Resistance is a property that holds back the flow of electricity. So an object with zero resistance would conduct electricity perfectly. Superconductors have tremendous ability of conduction without any resistance. Superconductivity was discovered in 1911. It is explained by quantum mechanics and is a state where the inside of the conductor contains no magnetic field lines; it's a sudden change that occurs exactly when you hit a particular temperature in the process of cooling a metal. Superconductors are considered as perfect diamagnetic. A diamagnets is a material that shows repel magnetic effect when it is put inside a magnetic field. So the superconductors are more diamagnetic in nature so you can use them to levitate things easily. Superconductors expel magnetic field, and hence repel magnets. This repulsion can be stronger than gravity which leads to levitation. A superconductor is immersed in liquid nitrogen to provide cooling below the critical temperature. A magnet is placed in their in the air and left there levitating.

The third part of maglev train system was guiding mechanism. Some systems use Null current system. These use a coil that is wound so that it enters two opposing, alternating field, so that the average flux in the loop is zero. When the vehicle is in the straight ahead position, no current flows, but any moves off-line create flux that generates a field that naturally pushes or pulls it back into line.

VI. ADVANTAGES AND LIMITATIONS OF MAGLEV TRAIN

A. Advantages

1. A non contacting characteristic of maglev train makes it faster and smoother than conventional train. Also it is responsible for Frictionless operation.
2. As per Environment concern, conventional trains which are working on fuels like coal and diesel make them Noise as well as Air pollution responsible. Both of these problems overcome in maglev train as no moving parts are directly involved and magnetic field is used as power source. So we can say that maglev train is Green Energy Technology at all.
3. As mentioned above maglev has no moving parts at all so it is simple in design and it has no worry about wear and tear of parts which ensures that periodically replacements of parts are avoided.
4. A Guide coils are used in this system protects train from derailing phenomenon which take accidental chances at minimum level at close dimensional curves, inclinations.

B. Limitations

I. It is one of toughest task in maglev train to get a perfect position for levitation as too much of complicated analysis are required.

II. Cost of maglev train in the sense of manufacturing, maintenance and process costs are much more than a conventional train.

III. As high magnetic field included and when it is playing a major role in maglev train working process a human safety concerns are very important. So isolations are required to overcome with this problem. If in case any accidental activity related to this obtained, it may cause of unrecoverable loss as human life value is involved in it.

IV. For a maglev train, completely new train tracks and new land are necessary which increases cost.

V. If electromagnets are used for levitation and propulsion purpose, as higher quantity of electricity passing through windings lauds the requirement of proper isolation to avoid direct contact of living and non living things which can causes of serious disturbance in maglev train's working.

VI. A Maglev train has a track and body dimensional restrictions regarding to its length specially. Also passenger limit is accounted which is preferable in current transpiration considerations as world required.

VII. CONCLUSION

A high speed transportation system is a necessary for human with a safety, economical and environmental point of view. A Maglev train may be fulfil these all the requirements in future but now a days it looks like slightly difficult due to higher cost requirements for his maintenance and production. In this paper we are tried to discuss about its feature, working principle, construction and working and about Future Scope of Maglev train. From our study we were faced some other facts related to superconductors and induction motor.

REFERENCES

[1] Manish Dhingra, Rakesh Sharma and Mahir Salmani, An introduction and overview to magnetically levitated train, journel of science, vol.5, 11/2015/ PP 1117-1124

[2] Shweta Singh and Aradhana Singh, International Journal Of Advanced Research in Computer Science and Software Engineering, Vol.4 (10), 2014, PP 386-388

[3] M. Vignesh, R. Vigneshwaran and V. Vijay, Design of Magnetic Levitation Train, International Journal of Innovative Research in Science, Engineering Technology, Vol. 4, 2/2015, PP 2347-6710

[4] Prayash B. Bhutt and Sunita R. Yewale, Future Potential for Magnetic Levitation Train, International

Journal of Scientific Engineering and Technology Research, Vol. 4, PP 3281-3287

[5] Monika Yadav, Nivritti Mehta, Aman Gupta, Akshay Chaudhari and D. V. Mahindru, Review of magnetic levitation (MAGLEV): A technology to propel vehicles with magnets, Global Journal of Research in Engineering Mechanical and Mechanics, Vol. 13, 2013, PP 2249-4596