A Research Paper on High Speed Maglev with Smart Platform Technology

Sonali Yadav[1] Snehal Jadhav[2] Komal Nalawade[3] Pradnyawant Kalamkar[4]
[1,2,3]BE Student [4]Assistant Professor
[1,2,3,4]Department of Electronics & Telecommunication Engineering
[1,2,3,4]AITRC Vita, India

Abstract— The use of natural resources in our day today life is increasing which leads to shortage of these resources in the upcoming generation, mainly in transportation we are wasting a lot of crude oils and other resources which leads to global earthling. The name maglev is derived from magnetic levitation. Magnetic levitation is a highly advanced technology. It has various uses. The common point in all applications is the lack of contact and thus no wear and friction. This increases efficiency, reduces maintenance costs, and increases the useful life of the system. The magnetic levitation technology can be used as an efficient technology in the various industries. There are already many countries that are attracted to maglev systems. Many systems have been proposed in different parts of the worlds. This paper tries to study the most important uses of magnetic levitation technology. The results clearly reflect that the maglev can be conveniently considered as a solution for the future engineering needs of the world. So in this paper we're discussing about magnetic levitation and the uses in transportation.

Key words: Maglev, Levitation, Wear, Friction, Transportation

I. Introduction

Magnetic Levitation is the latest in transportation technology and has been the interest of many countries around the world. A train which is capable of floating in mid-Air without any support rather than magnetic field. This train doesn't have a motorized engine neither a diesel nor a charcoal engine but uses a theory of a linear motor for its propulsion[5]. Its maintenance cost is very low in terms of traditional engines as there is no contact between train and tracks. Since this train undergoes no friction hence this train is capable of exceeding the speed of 580km/h, thus this train is considered as flying of ground. These types of train are purely for long distance travel and a futuristic invention to reduce on travel time. If a maglev train is implemented in India then Delhi is just 3& 1/2hr away from Mumbai.

Talking about smart platforms, we came up with solution for three major issues they are as follows-

1) Wheelchair handicaps to board into the train.
2) Water clogging on railway tracks.
3) GREEN ENERGY

1. Government of India has already taken a great initiative to add a handicap boogie in a train but one thing they missed out is the platform for the wheelchair handicaps. It's a very tedious job for those handicaps to board. Hence we came up with an outstanding invention which wills revolutionaries the history. We are handing each and every wheelchair handicaps a RFID card which if they swipe in the train or on a platform, an artificial sloping platform is created on the existing platform for them to board in the boogie with zero efforts
2. In rainy season we are much familiar with water clogging on railway tracks and train delays hence we came up with an amazing invention of storing all the clogged water and rain water by rain water harvesting and clogged water in a tank and using all of it for sanitization and cleaning of trains. In this project we are using sensors to detect the water clogs and triggering the pumps relevant to it to suck all the clogs and hear by preventing train delay.
3. As we all know railway station is an extensive platform which consists of fans, upcoming train indicator, Lights, etc. which of course uses electricity. This electricity can be source to those entire gadget using solar panels which can be placed effectively over the platforms roof to generate sufficient electricity. Hence making India a better place and eco-friendly.

II. Basic Methodology

- Scope

The use of natural resources in our day today life is increasing This leads to shortage of these resources in the upcoming Generation, mainly in transportation we are wasting a lot of crude oils and other resources which leads to global earthling. A train which is capable of floating in mid-Air without any support rather than magnetic field [7]. The scope of magnetic levitation system is most important in transportation system.

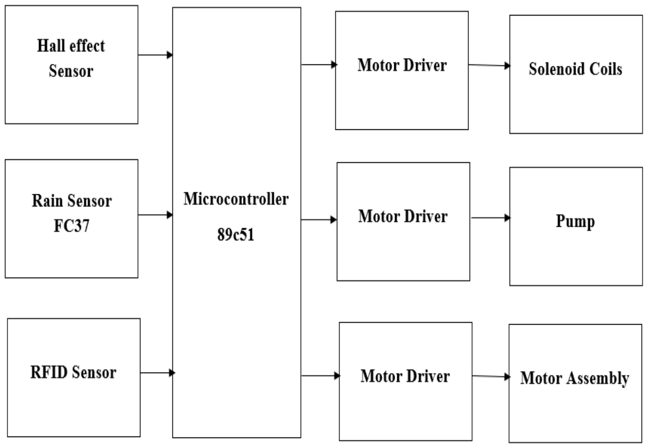


Fig.1.Block diagram.

High Speed Maglev trains are achieved by the combinations of magnetic field. This can be achieved by Levitation and Propulsion magnets which are embedded in tracks [5]. The levitation magnets help to levitate the train in midair without any support rater then magnetic fields whereas the propulsion magnets are responsible for the Too & Fro movement of the trains. Guide ways are used to keep the trains on track. RFID technology is used to create artificial platforms for wheelchair handicaps. Whereas the rain sensors and Humidity sensors are used to detect the clogged water and activate the pumps embedded in the platform to clear the clog.

A. What is maglev train and how it works?

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.

In the public imagination, "maglev" often evokes the concept of an elevated monorail track with a linear motor. Maglev systems may be monorail or dual rail and not all monorail trains are maglevs. Some railway transport systems incorporate linear motors but use electromagnetism only for propulsion, without levitating the vehicle. Such trains have wheels and are not maglevs. Maglev tracks, monorail or not, can also be constructed at grade (i.e. not elevated). Conversely, non-maglev tracks, monorail or not, can be elevated too. Some maglev trains do incorporate wheels and function like linear motor-propelled wheeled vehicles at slower speeds but "take off" and levitate at higher speeds.

The two notable types of maglev technology are:

1. Electromagnetic suspension (EMS), electronically controlled electromagnets in the train attract it to a magnetically conductive (usually steel) track.
2. Electrodynamic suspension (EDS) uses superconducting electromagnets or strong permanent magnets that create a magnetic field, which induces currents in nearby metallic conductors when there is relative movement, which pushes and pulls the train towards the designed levitation position on the guide way.

a) Electromagnetic suspension(EMS):

This system is also called trans rapid based on EMS technology. EMS technology introduced by the German scientist in its levitation is obtain electromagnetic attraction. The attractive force between the magnet balances the gravitational force and allow the train to levitate.

In electromagnetic suspension (EMS) systems, 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 portion of the arm attached to the vehicle, and the lower inside edge containing the magnets. The rail is situated inside the C, 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 – a slight divergence from the optimum position tends to grow, requiring sophisticated feedback systems to maintain a constant distance from the track, (approximately 15 mm (0.59 in)).

The major advantage to suspended maglev systems is that they work at all speeds, unlike electrodynamics 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 track layout. On the downside, the dynamic instability demands fine track tolerances, which can offset this advantage. Eric Lewthwaite was concerned that to meet required tolerances, the gap between magnets and rail would have to be increased to the point where the magnets would be unreasonably large. In practice, this problem was addressed through improved feedback systems, which support the required tolerances.

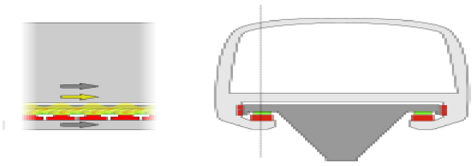


Fig.2.EMS model

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)

$= mg -(I/H)2$

G-gravitational constant.

Kt-magnetic force constant.

b) Electrodynamics suspension(EDS):

Electrodynamics suspension system is mainly based on electromagnetic repulsion and this repulsive force overcome by the gravitational force and allows 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.

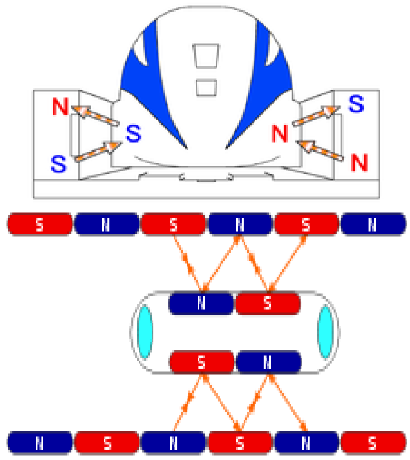


Fig.3.EDS model

In electrodynamics 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 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 (as in Induct rack). The repulsive and attractive force in the track is created by an induced magnetic field in wires or other conducting strips in the track.

However, at slow speeds, the current induced in these coils and the resultant magnetic flux is not large enough to levitate the train. For this reason, the train must have wheels or some other form of landing gear to support the train until it reaches take-off speed. Since a train may stop at any location, due to equipment problems for instance, the entire track must be able to support both low- and high-speed operation.

The drag force can be used to the electrodynamics system's advantage, however, as it creates a varying force in the rails that can be used as a reactionary system to drive the train, without the need for a separate reaction plate, as in most linear motor systems. Laithwaite led development of such "traverse-flux" systems at his Imperial College laboratory. Alternatively, propulsion coils on the guide way are used to exert a force on the magnets in the train and make the train move forward. The propulsion coils that exert a force on the train are effectively a linear motor: an alternating current through the coils generates a continuously varying magnetic field that moves forward along the track. The frequency of the alternating current is synchronized to match the speed of the train. The offset between the field exerted by magnets on the train and the applied field creates a force moving the train forward.

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.

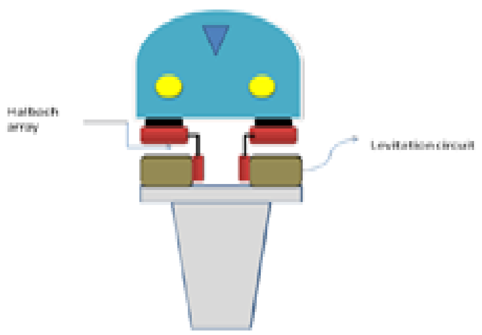


Fig.4. Inductrack model

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.

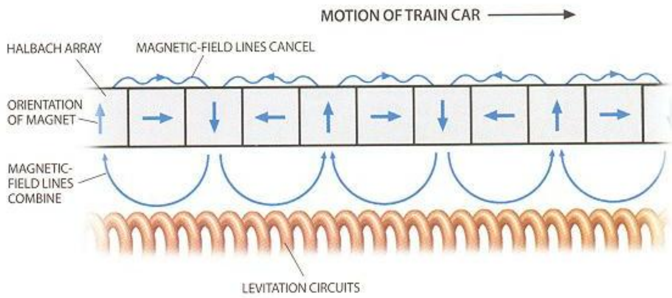


Fig.5. Concept of Inductrack

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 levitating 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. Cryomagnets also called superconductive magnet, for practical purpose this is very expensive.

i. Tracks:

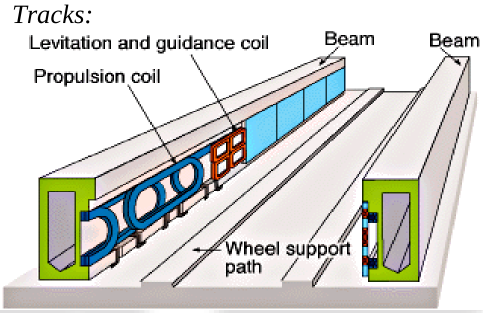


Fig.6. Track of train

The term "maglev" refers not only to the vehicles, but to the railway system as well, specifically designed for magnetic levitation and propulsion. All operational implementations of maglev technology make minimal use of wheeled train technology and are not compatible with conventional rail tracks. Because they cannot share existing infrastructure, maglev systems must be designed as standalone systems. The SPM maglev system is inter-operable with steel rail tracks and would permit maglev vehicles and conventional trains to operate on the same tracks. MAN in Germany also designed a maglev system that worked with conventional rails, but it was never fully developed.

ii. Propulsion:

EMS systems such as HSST/Linimo can provide both levitation and propulsion using an onboard linear motor. But EDS systems and some EMS systems such as Trans rapid levitate but do not propel. Such systems need some other technology for propulsion. A linear motor (propulsion coils) mounted in the track is one solution. Over long distances coil costs could be prohibitive.

iii. Stability:

Earns haw's theorem shows that no combination of static magnets can be in a stable equilibrium. Therefore a dynamic (time varying) magnetic field is required to achieve stabilization. EMS systems rely on active electronic stabilization that constantly measures the bearing distance and adjusts the electromagnet current accordingly. EDS systems rely on changing magnetic fields to create currents, which can give passive stability. Because maglev vehicles essentially fly, stabilization of pitch, roll and yaw is required. In addition to rotation, surge (forward and backward motions), sway (sideways motion) or heave (up and down motions) can be problematic. Superconducting magnets on a train above a track made out of a permanent magnet lock the train into its lateral position. It can move linearly along the track, but not off the track. This is due to the Meissen effect and flux pinning.

iv. Guidance system:

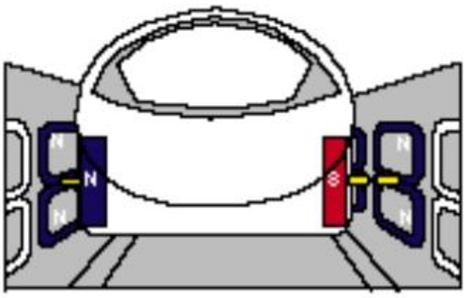
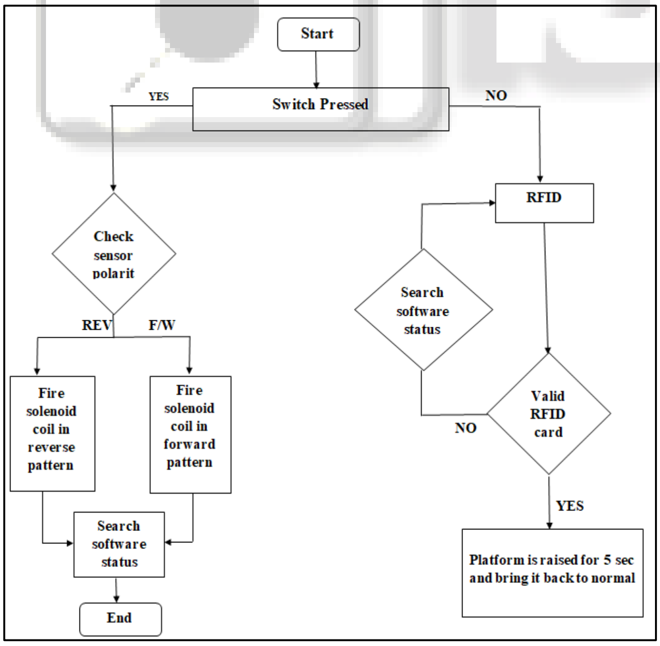


Fig.7. Guidance of system

Some systems use Null Current systems (also sometimes called Null Flux systems). These use a coil that is wound so that it enters two opposing, alternating fields, 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/pulls it back into line.

Flow chart:



III. Literature Review

In 1976, S.Yamamura proposed a Magnetic Levitation of Tracked Vehicles present status and prospects [7]. There are more than five types of magnetically levitated tracked vehicles. All these types of magnetically levitated tracked vehicles provide the contactless support and guidance to vehicles. In this paper, he proposed such system named as Magnetic Levitation System. This system has two types one is electrodynamics levitation (EDL) and another is electromagnetic levitation (EML). Electrodynamics levitation uses the repulsive force between magnet on vehicle and induced current in secondary circuit on ground. The repulsive force is produced when the superconductive magnets are moving, and so the train is not levitated at low speed. Because of this repulsive force in EDL it gives the stability problem. In this paper he proposed the EML system which uses the attracting force between the electromagnets on vehicles and rails on ground. Because of the attracting force it gives the inherently unstable levitation system.

In 1984, P. K. SINHA proposed a Design of a Magnetically Levitated Vehicle [6]. The contactless suspension of a passenger Carrying vehicle by using a principle of attractive electromagnetic forces is developed and these two full scale systems are one in Birmingham, U.K and the other in Island, it is near Hamburg, West Germany. So this paper will describe the overview of the control, magnetic and design aspects of developing such system. The operation of this vehicle is reveal in August 1974. Mechanisms of contactless suspension using magnetic forces are developed and research by using super conducting magnets (electrodynamics levitation, EDL) and controlled direct-current electromagnets (electromagnetic suspension, EMS) it is developed by the researchers in Britain, West Germany and Japan. This system is suitable for high speed transportation system, having speed of 60km/h for 5T vehicle. EMS system provides operational flexibility, low power-to-weight ratio and it is simple in design. But detailed technical comparison of the two systems EMS and EDL is not available.

In 1996, Kazuo Sawada proposed a Development of magnetically Levitated High Speed Transport System in Japan [5]. In Japan there is very large passenger traffic in a Tokyo-Osaka corridor. So their id a requirement of a one another High speed line besides Tokaido Shinkasen and this high speed magnetic levitation train has been developed by using a Superconducting materials. This train is having number of advantages as compared to other trains. This Paper will describes a need of one more high speed line and scheme of this system is history of development and outline of new Yamanashi test link project. So Tokaido Shinkasen having a speed of 270km/hr. and it covers this area in 150 minutes. But because of traffic no the all passengers can get tickets. And this will be increase year by year. So it develops a high speed line between Tokyo and Osaka. It develops JNR (Japanese National Railway). It is having advantage of Speed, Safety, Maintenance, Pollution and Future Prospect. For designing this train Superconducting Magnets (SCM) is used. In this developed system on the guide way having two types of ground coils, one is Propulsion coil and other is Levitated coil, which is guided by the Electromagnetic forces. So because the reason mentioned above the study of JNR started in 1962, JNR selected Maglev System with Superconducting magnets.

In 1996 , James R. Powell and Gordon T. Donby proposed a Maglev Vehicles [4]. Maglev as practical concept was 1st proposed by the author in 1996. The concept was based on using light weight. Very high current superconducting loops suitably positioned on a streamlined vehicle. The magnetic interaction of permanent current in the superconducting loops with induced current in the guide way loops automatically levitated. If the external force, e.g.-A wind gust, curve or change in grade acts on vehicle a magnetic force automatically and immediately develops to oppose the external force. The magnetic force pushes the vehicle back towards its normal equilibrium suspension point. Since maglev vehicle not contact with guide way, its speed is not depending on mechanical stress, friction or wear. The first generation maglev vehicle probably will travel in air, however tuning technic is developed and long distance ultra-speed maglev travel in low pressure tunnel will emerge as 2nd generation. It can't require any energy. There are two kinds. First is superconducting approach by the author and another is a modernized version of the old Ferro-magnetic suspension approach used for magnetic bearings in centrifuge. The author also proposes Linear Synchronous Motor (LSM) as means to propelling maglev vehicles. As AC power is switch into the guide way in relatively long blocks Rg mile or more in length for those blocks on which a vehicles is passengers per day and thousands of trailer truck equivalent.

In 2013 , Jaewon Lim1, Chang-Hyun Kim1, Jong-Min Lee1, Hyung-suk Han1, and Doh-Young Park1 proposed a Design of Magnetic Levitation Electromagnet for High Speed Maglev Train [3]. This paper deals with the design of levitation electromagnet for super high speed magnetic levitation (Maglev) vehicle. Electromagnetic characteristics of levitation magnet are analyzed by finite element analysis. Levitation force ripples and cogging force are reduced by adopting core separation. 4-pole cutoff model has been manufactured to verify the design. A static force experiment is carried out with test model. The need of fast & comfortable transportation is increased through the history. For the local train basically they have wheels because of the speed of train friction is accruing and also irregular crashes between wheels and rail, so they face some mechanical difficulties. So by the maglev train it is very easy because this train doesn't have wheels, so there is no any friction is accrue and no wear. Maglev is dividing in high speed and medium speed of maglev is depending on speed operation. Medium speed maglev is propelled by lateral movements is restricted by linear induction motor (LIM) & levitated by electromagnet. In high speed maglev application LIM is not suitable to operate due to end effect & transient constant of reaction plate. High speed maglev train levitated and propelled by LSM. As levitation electromagnetic, the field of LSM should be light weighted and system should be rapid response. In entry end and flux density lower than others poles. This flux unbalanced lead to local saturation of core and it is transmitted pole to pole. Most linear motors have normal force between movers and stators. LSM has alternative force it is utilizes by levitation force.

In 2017, Ding Jingfang, Long Zhiqiang, YangXin, Maglev Research Centre National University of Defense Technology Changsha, China proposed a Numerical Analysis of Eddy current Effect of EMS system for Medium-Low Speed Maglev Train [2]. In this paper the Changsha Maglev Express proposed a Medium-Low Speed Maglev Train which is based on the electromagnetic suspension (EMS) and short primary linear induction motor (SLIM) propulsion system. In May 2016, the Changsha Maglev Express was design the longest Medium-Low Speed Maglev commercial demonstration line of the world. The maximum speed of this train is 100km/h. When the train moves the eddy current effect will induced at the front of the train. This paper gives the principle of the eddy current effect and also uses the3D numerical analysis method to analyze the effect of eddy current on levitation force. In this paper author uses the professional electromagnetic simulation software Ansoft Maxwell to calculate the 3D transient magnetic field numerical solution. When train is moving the magnetic field of air gap will be established between front of electromagnet module and rail. Due to variation in the magnetic field the eddy current will be generated.

In 2018, Dajin Zhou, Lifeng Zhao, Chuan Ke, Chang Chun Hsieh, Chenyu Cui, Yong Zhang, and Yong Zhao proposed a High-Tc Superconducting Maglev Prototype Vehicle Running at 160 km/h in an Evacuated Circular Track [1]. The study of this High-Tc superconducting (HTS) and a permanent magnet is mainly done in China, Japan, Germany and Brazil. This invented HTS maglev vehicle is running on q straight or circular PMG tracks having a Speed of 50km/h, due to short length in a straight track or a weak guidance force in a circular track. By developing a side-suspended HTS-PMG maglev system, its running speed is over 100km/h in a circular track with a big curvature was reached. So by increasing its stability and optimizing the side-suspension conditions, they are increase the speed of HTS maglev vehicle up to 160km/h in a circular track with a diameter of 6.5m.

IV. RESULT

We successfully achieve the four objectives of our project i.e. high speed maglev train using different magnets and coils, artificial slope for wheelchair handicap peoples, water harvesting system for collecting water on the track and last one is making smart platform using solar panels.

Maglev train is high speed train and it is the dream of Indians any more. So, for making the high speed maglev train we use the two sets of magnets one set is used to repel the train above the track and another set is used to move the train forward and backward direction. Also for this train we use the Hall Effect sensor for giving commands to the controller for moving train forward and backward direction. We know that in our Indian train there is one special bogie for handicap peoples but there is no any facility for wheel chaired handicap peoples to enter in the train. So, for this we develop one artificial platform which is operated on RFID module. Hence, wheel chaired handicap peoples enters into the train effortlessly.

We know that in rainy season there is blockage of train because of rain water on the track so the transportation of train is stopped for some time. So, we are develop one system to remove that water on the track and store that water and reuse it.

There is lots of electricity is required on the platform for different electronic devices. So, we are using green energy instead of electricity. And for this we proposed one idea i.e. all that devices are operated on solar energy.

V. Conclusion

The maglev Train: Research on this 'Dream Train' has been going on for the last 30 odd years in various parts of the world. The chief advantages of this type train are: Non-contact non-wearing propulsion, independent of friction, no mechanical components like wheel, axel. Maintenance cost is less. A country like India could benefit very much if this were implemented here. The electro dynamic suspension and electromagnetic suspension are the techniques which are used in maglev system are systematically studies. The results are used to design and operation of magnetic levitation in a high running speed. Several conclusions are drowning from study of our system. The common point in all applications is the lack of contact and thus no wear and friction. This increases efficiency, reduces maintenance costs, and increases the useful Life of the System. The magnetic levitation technology can be used as an efficient technology in the various industries. The artificial platform with the help of RFID card is very easier and helpful for the handicapped persons. In addition with this water harvesting on the track is done for avoiding the blockage of train and the solar energy is used to save electricity on the platform.

VI. Future scope

We can use wireless technology for making this maglev train instead of wired connection. We can control this train using remote control, Bluetooth. Instead of wood material for making track, one can design track by using acrylic material, that will help to resolve the balancing and spacing problems. If we use high power magnets, it will help to achieve high speed. That high power magnet will be used to carry entire circuitry within train bogie; also one can add some extra bogies as a future scope. One can implement his/her ideas for making curve shape of track with tunnel also. As a demo model we have designed this project with driver, but in real time this maglev train concept implemented without driver. Implementation of train without driver would be the huge area that one can use his/her own ideas. Now a day's people demands to reach at destination so soon, journey in the high speed maglev train having speed of 580 Km/Hr. is the dream of Indians anymore. So by looking at this expectation if we highly focus on this new concept of train i.e. Maglev Train then it would be a great innovation.

References

[1] Dajin Zhou, Lifeng Zhao, Chuan Ke, Chang Chun Hsieh, Chenyu Cui, Yong Zhang, and Yong Zhao , "High-Tc Superconducting Maglev Prototype Vehicle Running at 160 km/h in an Evacuated Circular Track" IEEE Journals and Magazines, vol.. 28, no. 3600504, 2018.
[2] Ding Jingfang, Long Zhiqiang, YangXin, Maglev Research Centre National University of Defense Technology Changsha, China, "Numerical Analysis of Eddy current Effect of EMS system for Medium-Low Speed Maglev Train". 2nd International Conference on Robotics and Automation Engineering, 2017.
[3] Jaewon Lim1 ,Chang-Hyun Kim1 ,Jong-Min Lee1 , Hyung-suk Han1 , Doh-Young Park1 * 1 Dept. of Magnetic Levitation and Linear Drive, Korea Institute of Machinery & Materials, Korea , "Design of Magnetic Levitation Electromagnet for High Speed Maglev Train" 2013 International Conference on Electrical Machines and Systems, Oct. 26-29, 2013, Busan, Korea, no. 14042491.
[4] K. Sawada, "Development of magnetically levitated high speed transport system in Japan," IEEE Trans. Mag., vol. 32, no. 4, pp. 2230–2235, Jul. 1996.
[5] J. R. Powell and G. T. Danby, "Maglev vehicles-raising transportation advances of the ground," IEEE Potentials, vol. 15, no. 4, pp. 7–12, Oct.-Nov. 1996.
[6] P. SINHA, "Design of a magnetically levitated vehicle," IEEE Trans. Mag., vol. MAG-20, no. 5, pp. 1672–1674, Sep. 1984.
[7] S. Yamamura, "Magnetic levitation technology of tracked vehicles present status and prospects," IEEE Trans. Mag., vol. MAG-12, no. 6, pp. 874–878, Nov. 1976.

