Reduction of Rail Maintenance by Frictionless Transportation through Magnetically Levitated Vehicles.

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ABSTRACT: Train have been helping us move large amounts of cargo or people at one time. Steam engines were better than other modes of transportation. Diesel trains and electrical trains could carry people/cargo much faster than steam engines could. In this ever growing & more crowded and congested world of ours, we need a faster mode of land transportation our normal modes of transportation will not be able to handle these overpopulated area. The answer to this problem lies in the world of electromagnetism and superconducting magnets. Electromagnets and superconducting magnets have allowed us to create a magnetic Levitating train so called “MagLev’s”. MagLev's relies on electromagnetism and superconducting magnets principles to float above the track and achieve super high speeds. It is so called flying train. MagLev uses superconducting magnets to lift, guide and propel these vehicles.

KEY WORDS: Superconducting Magnets, MagLev, Magnetic levitation, Transrapid, lateral guidance, linear induction motor, linear synchronous motor, frictionless travel.

INTRODUCTION: Magnetic levitated trains do not have engine to pull the train, rather they use the basic principles of electromagnets. Any current carrying conductor (e.g. wire) has a magnetic field around it. It losses its magnetism when the current is turned off. Electromagnet is a coil of wire. It is usually wound on an iron core with many turns lying side by side. This is done because he strength of the magnetic force produced depends on (1).The no. of turns of the coil. (2). The amount of current.

Hence more the number of turns more is the magnetic field. The poles of the electromagnet can be changed by changing the direction of the current.

PRINCIPLE:- Every magnet has a north pole and south pole. Similar poles of two magnets repel each other. These principles govern the levitation of magnetic trains.

Permanent magnets are always magnetic. Electromagnets are magnetic only when an electric current flows through them. The north and south poles of an electromagnet are related to the direction of the current is reversed, the poles are reversed.

The train is levitate by magnetic repulsion, the train lies over the guideway. Magnets on top of the guideway are oriented to repel similar poles of magnets in bottom of the magnetic levitated train. This pushes the train upward into a hovering position. This system is designed for magnetic levitated trains that contain groups of extremely powerful superconducting electromagnets. These magnets use less electricity than conventional electromagnets. But they must be cooled to very low temperatures from -269 degrees celcius to -196 degrees celcius.

In magnetic levitated train that levitate by magnetic attraction, the bottom of the train wraps around the guideway levitation magnets on the underside of the guideway are positioned to attract the opposite poles of magnets on the wraparound section of the magnetic levitated train. This raises the train off the track. The magnets in the guideway attract the wraparound section only strongly enough to raise the train a few centimeters into a “floating” position. The wraparound section does not touch the guideway.

To know how magnetic levitated train is propelled forward, think of three bar magnets lined up on the floor. The magnet in front is pulling with an attracting (opposite) magnetic pole and the magnet in back is pushing with a repulsing (similar) magnetic pole. The magnet in the middle moves forward. A magnetic levitated trains guideway has a long line of electromagnets. These pull the train from the front and push it from behind.
The electromagnets are powered by controlled alternating currents, so they can quickly change their pull and push poles, and thus continually propel the train forward.

**WORKING:** The basis of MagLev train working is under standing magnetism & the use of magnetic propulsion. One end of a bar magnet is designated with a north pole while the other end is called the south pole. Now suppose you are given a second bar magnet, experimenting with it you will find that opposite poles attract while attractive poles repel. This simple form of attraction and repulsion is the same idea used to move those gigantic Maglev trains. Maglev train is devised using electromagnets and superconducting magnets. Electromagnets are metals with electric current running through them giving the metals a magnetic field similar to that of the bar magnets and superconducting magnets are able to induce charge, or give charge, to a material causing repulsive forces. Maglev railway has developed two types of magnetic systems for propulsion to control how the trains move. These magnetic suspension systems are designed so that the Maglev train can glide through air by levitating it above the actual rail line reducing friction between metal wheel and rail line. The transrapid system developed in Germany utilizes regular electromagnets on the undercarriage of the train to levitate the vehicle while an additional set of magnets are used to guide the train.

The electromagnetic suspension system or EDS system developed in Japan use superconducting electromagnets for the Maglev trains allowing the train to remain aloft for a while even after the electric current is turned off using the property of the metals to easily allow electrons to flow easier.

Both these systems i.e. transrapid system and EDS system control the Maglev trains Lateral guidance, Levitation system, and its propulsion.

**LATERAL GUIDANCE SYSTEM:**

The lateral guidance systems control the train’s ability to actually stay on the track. It stabilizes the movement of the train from moving left and right of the train track by using the system of electromagnets found in the undercarriage of the Maglev train. The placement of the electromagnets in conjunction with a computer control system ensures that the train does not deviate more than 10 mm from the actual train tracks. The lateral guidance system used in Japanese electromagnetic suspension system is able to use one “set of four superconducting magnets” to control lateral guidance from the magnetic propulsion of the null flux coils located on the guideways of the track. Coils are used frequently in the design of Maglev trains because the magnetic fields created are perpendicular to the electric current, thus making the magnetic field stronger. The Japanese lateral guidance system also uses a semi active suspension system. This system dampens the effect of the side to side vibrations of the train car and allows for more comfortable train rides. This stable lateral motion caused from the magnetic propulsion is a joint operation from the acceleration sensor, control device, to the actual air spring that dampens the lateral motion of the train car.

The lateral guidance system found in German tranrapid system is similar to the Japanese model. In a combination of attraction and repulsion, the Maglev train is able to remain centered on the railway. Once again levitation coils are used to control lateral movement in the German Maglev suspension system. The levitation coils are connected on both sides of the guideway and have opposite poles. The opposite poles of the guideway cause a repulsive force on one side of the train while creating an attractive force on the other side of the train. The location of the electromagnets on the transrapid system is located in a different side of the guideways. To obtain electromagnetic suspension, the transrapid system uses “the attractive forces between iron-core electromagnets and ferromagnetic rails.”

**LEVITATION SYSTEM:**

The levitation systems used in the design of the Maglev railway allow it to glide above the actual track. In electrodynamics suspension systems the actual train can be as high as 80 mm above the track while the transrapid suspension system allows it to go less than 12 mm from above the track. In the case of air drift
or a turn in the railway course causes the train to lift above the distance needed to stay on track, there is “enhanced current input into the levitation magnets to increase the magnetic force.” During this ensures that the train stays on the track with gap sensors on the rail line to detect any change in lateral shift. In order use magnetic levitation by induction, the team behind EDS had created a system that allowed five degrees of motion. The physics of the actual lift can be described in mathematical terms. The calculated voltage of the mathematically induced coils can be tabulated according to the formula:

\[ V = -N \frac{\delta \Phi_{\text{coil}}}{\delta t} \]

Where \( N \) is the no. of turns. Once voltage is found in the coils used in the induction, a formula can be derived for the coil’s current, \( i \), with respect to time is given by:

\[ \frac{\delta i}{\delta t} = \frac{1}{L} (V - R_i) \]

Knowing \( i \), Lorentz force is applied to calculate the lift force caused by the magnets.

\[ dF = i \times dl \times B \]

Using these equations and additional equations on magnetic flux, five degrees of motions in the electrodynamic suspension levitation system can be described. These degrees are levitation height, sideways displacement, yaw, pitch and roll. Each dimension contributes to the torque of the EDS Maglev train.

The electromagnetic suspension system used in the German Transrapid system levitates the train a few millimeters from the actual track. Using a system of electromagnets, the transrapid system attracts the coils found in the guideway of the Maglev train. The attraction of the magnetic forces occur because the currents found in both the train and the guideway both flow in the same direction. Since this system uses electricity to power the magnetic fields the train is always above the track unless cut from the electric current. To prevent this from happening German engineers have put in a back up battery in the actual Maglev train in case of power failure.

**PROPULSION SYSTEM:**

There are two types of propulsion systems used in current MagLev trains.

1. **Linear Induction Motor (LIM):** It is used to propel the Japanese EDS system, while,  
2. **Linear Synchronous Motor (LSM):** It is used to propel the German Transrapid system.

Both of the systems are move by the guideways themselves instead of the actual train car. Propulsion occurring in the Linear Induction Motor is caused from the sum of four individual linear motors. The motors induce voltages to the four motors. When these voltages are combined they produce a repulsive force that pushes the train car forward. The speeds for Linear Induction Motors is determined by “the ratio of length of the vehicle magnet system to the length of the energized block, the sum of the coupling coefficients between vehicle magnets and the guideway coils, applied voltage, and the current flowing in the superconducting coils.

The speed of the MagLev trains in Linear Synchronous motors are determined by the frequency of the alternating current and the magnetic field directions. Propulsion is created when the current is in “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 brake without the use of friction.
CONSTRUCTION COST:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of the Railway Line</th>
<th>Distance in Kilometres</th>
<th>Time required in minutes</th>
<th>Approximate Cost</th>
<th>Expected Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tokyo – to - Nagoya</td>
<td>286 kms</td>
<td>28.6 min</td>
<td>$ 51 Billion</td>
<td>600 kmph</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 kms</td>
<td>6 sec.</td>
<td>$ 178 million</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Nagano – to- Kanazawa</td>
<td>228 kms</td>
<td>24.8 min</td>
<td>$ 17.5 Billion</td>
<td>550 kmph</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 kms</td>
<td>6.5 sec.</td>
<td>$ 76 million</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Mumbai-to- Pune</td>
<td>200 kms</td>
<td>30 min.</td>
<td>$ 30 Billion</td>
<td>400 kmph</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 kms</td>
<td>9 sec.</td>
<td>$ 26 million</td>
<td></td>
</tr>
</tbody>
</table>

FUEL CONSUMPTION PER DAY:
Mumbai-Pune has a free way (so called as express way) where approximately 14000 vehicles travel daily, making fuel consumption at 2 million litres a day.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>No. of Vehicals</th>
<th>Distance in kms</th>
<th>Average per litre</th>
<th>Fossil fuel required in Litres</th>
<th>Amount required in Rupees @ Rs. 60 per Lit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>200 kms</td>
<td>15 kmpL</td>
<td>14 Litres</td>
<td>Rs. 840 /-</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>200 kms</td>
<td>15 kmpL</td>
<td>1400 Litres</td>
<td>Rs. 84,000 /-</td>
</tr>
<tr>
<td>4</td>
<td>1000</td>
<td>200 kms</td>
<td>15 kmpL</td>
<td>14000 Litres</td>
<td>Rs.8,40,000 /-</td>
</tr>
<tr>
<td>5</td>
<td>10,000</td>
<td>200 kms</td>
<td>15 kmpL</td>
<td>1,40,000 Lit</td>
<td>Rs. 84,00,000 /-</td>
</tr>
<tr>
<td>6</td>
<td>14000</td>
<td>200 kms</td>
<td>15 kmpL</td>
<td>1,96,000 Lit.</td>
<td>Rs. 1,17,60,000 /-</td>
</tr>
</tbody>
</table>

CONCLUSION:
MagLev’s train is better than conventional rail transportation used today. From being faster, more energy efficient, safer and more environmentally friendly, MagLev’s surpasses normal trains in almost every way.

Traditional railway systems that use metal wheels and rails and are slowed by friction, which are not so fast as compared to the MagLev’s Trains.

The main advantage of the MagLev’s trains is the low maintenance. Using superconducting magnets instead of fossil fuels, MagLev’s trains allow more energy efficiency and environmental friendliness. MagLev’s trains do not have wear and tear of contact friction, so gain greater longevity of the vehicle. MagLev will have a positive impact on sustainability. MagLev’s do not emit greenhouse gases in to the atmosphere. Energy created by magnetic fields can be easily replenished. The track of a MagLev train is small compared to those of a conventional train and are elevated above the ground so the track itself will not have a large effect on the topography of a region.

Although the relative cost of constructing maglev train s are very expensive, there are many other positive factors that overshadow this. MagLev will contribute more to our society and our planet than it takes...
away. Considering everything MagLev has to offer, the transportation of our future and our children’s future is on very capable track.

REFERENCES: