Magnetic Levitation Train

Akshay Kelwadkar  
BE Student  
Department of Electrical Engineering  
KDK College of Engineering, Nagpur, Maharashtra, India

Rajat Wairagade  
BE Student  
Department of Computer Engineering  
KDK College of Engineering, Nagpur, Maharashtra, India

Mayuri Boke  
BE Student  
Department of Electrical Engineering  
KDK College of Engineering, Nagpur, Maharashtra, India

Himanshu Balapure  
BE Student  
Department of Electrical Engineering  
KDK College of Engineering, Nagpur, Maharashtra, India

Prashant Ganer  
BE Student  
Department of Electrical Engineering  
KDK College of Engineering, Nagpur, Maharashtra, India

Abstract

Maglev system represent a promising evolution in high-speed ground transportation, offering speed in excess of 500 mph along with the potential for low operating costs and minimum environmental impact. The goal of this effort is to investigate the feasibility and viability of maglev systems in the Japan. The emergence of a sophisticated technology such as maglev requires a need for a co-ordinated research test program and the determination of test requirement to identify mitigate development risk and maximum use of domestic resources. The study is directed towards the identification and characterization of maglev system development risks tied to preliminary system architecture. Research objective are accomplished by surveying experiences from previous maglev development program both foreign and domestic, and interviews with individuals involved with maglev research and testing.

Keywords: Electromagnetic Suspension, Electromagnets, Guideways

I. INTRODUCTION

Maglev is a transport method that uses magnetic levitation to move vehicles without touching the ground. With maglev, a vehicle travels along a guide way using magnets to create both lift and propulsion, thereby reducing friction and allowing higher speeds. Maglev trains move more smoothly and more quietly than wheeled mass transit systems. They are relatively unaffected by weather. The power needed for levitation is typically not a large percentage of its overall energy consumption.
wear and prevents higher speeds. Conversely, maglev systems have been much more expensive to construct, offsetting lower maintenance costs.

II. WORKING OF MAGLEV

A maglev train floats about 10 mm above the guide way on a magnetic field. It is propelled by the guide way itself rather than an onboard engine by changing magnetic fields. Once the train is pulled into the next section, the magnetism switches so that the train is pulled on again. The electromagnets run the length of the guide way. The electromagnets on the underside of the train pull it up to the ferromagnetic stators on the track and levitate the train. The magnets on the side keep the train from moving from side to side.

A computer changes the amount of current to keep the train 1 cm from the track. The operation is very smooth and it does not create any noise. Electrodynamics involving the interaction of electrical currents and magnetic forces, state-of-art computers and microprocessors maintain guidance (vertical and horizontal spacing) during travel. Low-speed Maglev travels up to 60 mph. In Pittsburgh's case, top speed will be about 40 mph.

III. MAGLEV TECHNOLOGY

A. Electromagnetic Suspension
Electromagnetic suspension (EMS), electronically controlled electromagnets in the train attracts it to a magnetically conductive (usually steel) track. Electromagnetic suspension (EMS) is used to levitate the Transrapid on the track, so that the train can be faster than wheeled mass transit systems. 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 rather, requiring sophisticated feedback systems to maintain 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 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 Laithwaite was concerned that in order to meet the 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.

B. Tracks
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.
C. 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 Transrapid levitate but 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.

D. Stability
Earnshaw'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.

E. Guidance
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.

F. Energy use
Energy for maglev trains is used to accelerate the train. Energy may be regained when the train slows down via regenerative braking. It also levitates and stabilizes the train’s movement. Most of the energy is needed to overcome “air drag”. Some energy is used for air conditioning, heating, lighting and other miscellany. At low speeds the percentage of power (energy per time) used for levitation can be significant consuming up to 15% more power than a subway or light rail service. For short distances the energy used for acceleration might be considerable. The power used to overcome air drag increases with the cube of the velocity and hence dominates at high speed. The energy needed per mile increases by the square of the velocity and the time decreases linearly. For example, two and half times as much power is needed to travel at 400 km/h than 300 km/h.
IV. RESULT AND DECISION

A. Comparison of Maglev Train
1) Speed: Maglev allows higher top speeds than conventional rail, but experimental wheel-based high-speed trains have demonstrated similar speeds.
2) Maintenance: Maglev trains currently in operation have demonstrated the need for minimal guideway maintenance. Vehicle maintenance is also minimal (based on hours of operation, rather than on speed or distance traveled). Traditional rail is subject to mechanical wear and tear that increases exponentially with speed, also increasing maintenance.
3) Weather: Maglev trains are little affected by snow, ice, severe cold, rain or high winds. However, they have not 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 guideway or the slope of the grade because they are non-contact systems.
4) Track: Maglev trains are not compatible with conventional track, and therefore require custom infrastructure for their entire route. By contrast conventional high-speed trains such as the TGV are able to run, albeit 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. John Harding, former chief maglev scientist at the Federal Railroad Administration claimed that separate maglev infrastructure more than pays for itself with higher levels of all-weather operational availability and nominal maintenance costs. These claims have yet to be proven in an intense operational setting and do not consider the increased maglev construction costs.
5) Efficiency: Conventional rail 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, leaving only air resistance and electromagnetic drag, potentially improving power efficiency. Some systems however such as the Central Japan Railway Company SC Maglev use rubber tires at low speeds, reducing efficiency gains.
6) Wheel loading: High speed rail requires more support and construction for its concentrated wheel loading. Maglev cars are lighter and distribute weight more evenly.
7) Braking: Braking and overhead wire wear have caused problems for the Fastech 360 rail Shinkansen. Maglev would eliminate these issues. When the alternating current is reversed, the train brakes.
8) Magnet reliability: At higher temperatures magnets may fail. New alloys and manufacturing techniques have addressed this issue.
9) Control systems: No signaling systems are needed for high-speed rail, because such systems are computer controlled. Human operators cannot react fast enough to manage high-speed trains. High speed systems require dedicated rights of way and are usually elevated. Two maglev system microwave towers are in constant contact with trains. There is no need for train whistles or horns, either.
10) Safety and Maintenance:
   a) The trains are virtually impossible to derail because the train is wrapped around the track.
   b) Collisions between trains are unlikely because computers are controlling the trains movements.
   c) There is very little maintenance because there is no contact between the parts.

B. Future Plans in India
1) Mumbai–Delhi
   A project was presented to Indian railway minister (Mamta Banerjee) by an American company to connect Mumbai and Delhi. Then Former Prime Minister Manmohan Singh said that if the line project was successful the Indian government would build lines between other cities and also between Mumbai Central and Chhatrapati Shivaji International Airport.
2) Mumbai–Nagpur
   The State of Maharashtra approved a feasibility study for a maglev train between Mumbai and Nagpur, some 1,000 km (620 mi) apart.
3) Chennai–Bangalore–Mysore
   A detailed report was to be prepared and submitted by December 2012 for a line to connect Chennai to Mysore via Bangalore at a cost $26 million per kilometer, reaching speeds of 350 km/h.

C. Advantages
1) Despite the speeds up to 500 km/hour, passengers can move about freely in the vehicles at all times.
2) Maglev vehicle carries no fuel to increase fire hazard
3) The materials used to construct maglev vehicles are non-combustible, poor transmitters of heat, and able to withstand fire penetration.
4) In the unlikely event that a fire and power loss occurred simultaneously, the vehicle is automatically slowed down so that it stops at a predefined emergency power station.
5) A collision between two maglev trains is nearly impossible because the linear induction motors prevent trains running in opposite directions or different speeds within the same power tectonically reduce travel time.
6) Maglev uses 30% less energy than a high-speed train travelling at the same speed (1/3 more power for the same amount of energy).

D. Disadvantages
1) There are several disadvantages with maglev trains. Maglev guide paths are bound to be more costly than conventional steel railways.
2) The another disadvantage is that, it is lack with existing infrastructure.

V. CONCLUSION

Maglev trains use magnets to levitate and propel the trains forward. Since there is no friction these trains can reach high speeds. It is a safe and efficient way to travel. Governments have mixed feelings about the technology. Some countries, like China, have embraced it and others like India have balked at the expense.

ACKNOWLEDGMENT

We take the immense pleasure in expressing our humble note of gratitude to Mr. Sandeep Mude, Assistant Professor, Department of Electrical Engineering, KDK College of Engineering, Nagpur, Maharashtra, India, for this remarkable guidance and suggestions, which helped us in completion of paper.

REFERENCES