MECHANICAL ENGINEERING

PANIMALAR
ENGINEERING COLLEGE
AN AUTONOMOUS INSTITUTION

PECMEC '22

APRIL 2022

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- Student Achievements
- Articles

PECMEC'22

MECHANICAL ENGINEERING

PANIMALAR ENGINEERING COLLEGE

An Autonomous Institution

[JAISAKTHI EDUCATIONAL TRUST]

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All Eligible UG Programs are Accredited by NBA

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Congratulations to the editorial team for all oftheir hard work and attention in putting the magazine together.

I am pleased to report that the Mechanical Engineering Department contributes to society by producing competent and innovative professionals.

"Imagination is more important than knowledge," Einstein famously observed.

"Logic will take you from point A to point B, but imagination will take you everywhere."

Develop your imagination!

Dr. C. SAKTHIKUMAR, M.E., Ph.D.,

DIRECTOR

PECMEC'22 demonstrates the students' ability. The goal ofthe college magazine is to bring out hidden talents and abilities, as well as providing a forum for studentsto show...case their literary ability.

I'd want to offer my heartfelt gratitude to all of the contributors to this issue's pieces. This publication is available because of people's willingness to share their expertise, & perspectives with others

VISION

The Department of Mechanical Engineering will be globally recognized as a pioneer in Under Graduate Engineering Programs through itsexcellence in teaching and research, catering to the significant and evolving societal needs.

MISSION

Mission 1: To serve the society by developing competent engineers with outstanding leadership qualities and ethical values.

Mission 2: To address the progressive needs of the society and industry using modern engineering tools and cutting edge technologies.

Mission 3: To inculcate the importance of professional development within budding engineers through sustained learning.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO 1: Graduates will contribute to the industrial and societal needs as per the recent developments using knowledge acquired through basic engineering education and training.

PEO 2: Graduates will be able to demonstrate technical knowledge and skills in their career with systems perspective, analyze, design, develop, optimize, and implement complex mechanical systems.

PEO 3: Graduates will be able to work in multidisciplinary environment developing complex mechanical systems.

PEO 4: Graduates will work as a team or as an individual with utmost commitment towards the completion of assigned task using apt communication, technical and management skills.

PEO 5: Graduate will recognize the importance of professional development by pursuing higher studies in various specializations.

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PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

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PEO 5:Graduate will recognize the importance of professional development by pursuing higher studies in various specializations.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Fundamental Domain Knowledge: Design mechanical systems in various fields of machine elements, thermal, manufacturing, industrial and inter disciplinary fields using engineering/technological tools.

PSO2: Usage of software programs: Resolve new challenges in Mechanical Engineering using modern computer tools and software programs.

PSO3: Continual learning and Research: Develop intellectual and technical solution to complex mechanical problems through continual learning and research.

DEPARTMENT ACTIVITIES

BAJA SAE is an intercollegiate design engineering competition for undergraduate engineering students. This competition simulates real-world engineering design projects and their related challenges. Each team is competing to have its design accepted for manufacture by a fictitious firm.

Students Participating in SAE BAJA EVENT

Our students team comprising of the following members participated in the virtual round held at Chitkara University Chandigarh on 13th and 14 th July 2018.

Team Members:

DAMODARAN B
DASSPRAKASH R
AKASH P
ANVITH KUMAR S
BALACHANDER M
GOPINATH P

STUDENT ARTICLES

TRANSIT ELEVATED BUS

- A.ABISHEK
(III Mech)

Nearly 40 years ago, US architects Craig Hodgetts and Lester Walker envisioned for New York City an elevated, wide-body “bus” that straddles ordinary road traffic. The radical idea garnered some media attention but never became a reality until, that is, this month in China’s Hebei province.

Beijing-based TEB technology development took its transit-elevated bus (TEB) on its first road test in the city of Qinhuangdao on August 2, reported state newswire Xinhua.

China conducts road test for homegrown transit elevated bus that can carry 300 people.It differs in a number of key ways from the idea dreamed up by Hodgetts and Walker, who envisioned a much larger vehicle that normal buses could enter. Still, the TEB is similar in that it, too, straddles traffic.

Moving along specialized tracks making it more like a train than a bus, actually the TEB features an elevated midsection that glides over two lanes. Receiving electricity through the tracks, the vehicle travels at 40 km to 60 km (25 miles to 37 miles) per hour. It could be powered partly by solar energy. According to the company’s website (link in Chinese), the final version will have four sections, with a total length of 58 m to 62 m (190 ft to 203 ft).

The idea is to reduce air pollution and traffic jams in China’s most congested cities. Fifteen of the world’s 50 most congested cities are in China, according to the Dutch navigation company TomTom. Four of them Tianjin, Nanyang, Shenyang, and Zhoukou plan to run pilot projects of the road-straddling bus, along with Qinhuangdao, according to TEB

Technology Development. Various nations have also expressed an interest in the system, among them France, Brazil, India, &Indonesia.

But not everyone is on board with the idea. Many worry about safety, especially in terms of how the TEB and regular traffic will interact. Others question the practicality of introducing it in cities that already have well-establishedtransportation infrastructure.

Quartz shared some articles on the TEB with Hodgetts, now an architecture professor at the University of California in Los Angeles. He said it appeared be an “immature project” with some “fundamental problems.”

Questions about the project’s readiness also linger in China, where the concept behind the TEB was received with a flurry of publicity when it was first unveiled in 2010. Yin Zhi, an urban planning professor at Beijing’s Tsinghua University, recently told the Global Times: “The idea of the road-straddling bus was shot down six years ago by a panel for its impracticality. Yet it was brought back to the public again.” Concerns about the TEB’s impact on regular traffic include:

Too low. The space underneath the TEB is just 2.1 m (6.9 ft) high. That means trucks could, as Wired notes, get stuck between the road and the underbelly of the TEB. And let’s face it: People load all kinds of things atop their vehicles, in all manner of ill-advised ways.

Too tight. The TEB-1 tightly confines two lanes of traffic. But sometimes while driving it becomes necessary to swerve, even if just slightly—perhaps to avoid a loose object. If you’re under the TEB when the need arises, good luck doing so safely, especially if the other lane is occupied. The tight space could also have a psychological effect on drivers, Hodgetts noted, making them nervous and more prone to braking.

Visibility. Drivers under the TEB will have difficulty seeing signs and traffic lights, as noted by Wang Zhaoyang, a Qinhuangdao local and self-claimed Beijing Jiaotong University graduate, on Zhihu, China’s answer to Quora.

Signaling. How will drivers know when the TEB is approaching from behind? What if traffic is stuck and they choose the wrong moment to open a car door for whatever reason? What if they're driving but just about to turn, swerve, or change lanes, Wang asked.

Turning. How will the TEB affect the ability of regular vehicles to turn? Its sides could prevent turns, as noted (link in Chinese) by another Zhihu user ("hat600"), self-described as a Tsinghua University architect graduate.

There are other questions about the vehicle's practicality:

Too high. The vehicle's height is 4.5 m (14.8 ft). That's tall enough to be an issue with some overpasses in China, Sun Zhang, a rail expert at Shanghai Tongji University, noted to the Global Times.

Exposed electric tracks. "It takes at least 1,500 volts—high-voltage electricity—to power the whole bus," Wang Lin, a former railway engineer with 16 years experience, wrote to Quartz. "An exposed electric railway with 1,500 volts looks like a time bomb to me. To lay an electronic railway on the road is a very outdated technology that was used in the 1890s, when electricity just came into use."

Too heavy. The bus in its final form will have four 15-ton sections (link in Chinese), each capable of holding 300 passengers. That means the entire vehicle would weigh over 150 tons at maximum capacity, assuming an average passenger weight of 70 kg (154 lbs). Over time, noted engineer Wang, such a load would, at the very least, shorten road life.

Maneuverability. Considering its length, the vehicle would have difficulty making turns, especially without affecting other traffic, as engineer Wang observed in a June editorial (link in Chinese) in the Beijing Daily. Not every city has long stretches of straight road in the places that most need public transportation.

Cost. With each TEB costing about $4.5 million (paywall), the economics of it come into question. Adapting infrastructure (such as raising some overpasses) would also require city spending. Might zero-emission buses be a simpler solution? Hodgetts believes it would make more sense to deploy the TEB in a city "where the traffic system is not so established yet," such as Urumqi, the capital of Xinjiang.

TEB Technology Development declined to respond to repeated requests for a comment about the project and the concerns it raises.

MAGLEV

- K. BUVANESH
(IV Mech)

Maglev trains move more smoothly and more quietly than wheeled mass transit systems. The power needed for levitation is typically not a large percentage of its overall energy consumption; most goes to overcome drag, as with other high-speed transport. Maglev trains hold the speed record for trains.

Compared to conventional trains, differences in construction affect the economics of maglev trains, making them much more efficient. For high-speed trains with wheels, wear and tear from friction from wheels on rails accelerates equipment wear and prevents high speeds. Conversely, maglev systems have been much more expensive to construct, offsetting lower maintenance costs.

Despite decades of research and development, maglev transport systems are in operation in just three countries (Japan, South Korea and China). In April 2004, Shanghai's Transrapid system began commercial operations. In March 2005, Japan began operation of its relatively low-speed HSST "Linimo" line in time for the 2005 World Expo. In its first three months, the Linimo line carried over 10 million passengers. South Korea became the world's fourth country to succeed in implementing maglev technology with the Incheon Airport Maglev beginning regular operation on February 3, 2016. While the Transrapid in Shanghai was primarily based on German technology, China has started its own program for low speed maglev with the Changsha Maglev in operation in Changsha and the S1 Line in Beijing under construction. In Japan a new high speed maglev line, the Chuo Shinkansen is planned to become operational in 2027, with construction starting 2017.

Development

In the late 1940s, the British electrical engineer Eric Laithwaite, a professor at Imperial College London, developed the first full-size working model of the linear induction motor. He became professor of heavy electrical engineering at Imperial College in 1964, where he continued his successful development of the linear motor. Since linear motors do not require physical contact between the vehicle and guideway, they became a common fixture on advanced transportation systems in the 1960s and 70s. Laithwaite joined one such project, the tracked hovercraft, although the project was cancelled in 1973.

The linear motor was naturally suited to use with maglev systems as well. In the early 1970s, Laithwaite discovered a new arrangement of magnets, the magnetic river, that allowed a single linear motor to produce both lift and forward thrust, allowing a maglev system to be built with a single set of magnets. Working at the British Rail Research Division in Derby, along with teams at several civil engineering firms, the "transverse-flux" system was developed into a working system.

The first commercial maglev people mover was simply called "MAGLEV" and officially opened in 1984 near Birmingham, England. It operated on an elevated 600 m (2,000 ft) section of monorail track between Birmingham Airport and Birmingham International railway station, running at speeds up to 42 km/h (26 mph). The system was closed in 1995 due to reliability problems.

HISTORY

First maglev patent

High-speed transportation patents were granted to various inventors throughout the world. Early United States patents for a linear motor propelled train were awarded to German inventor Alfred Zehden.The inventor was awarded U.S. Patent 782,312 (14 February 1905) and U.S. Patent RE12,700 (21 August 1907). In 1907, another early electromagnetic transportation system was developed by F. S. Smith.[10]A series of German patents for magnetic levitation trains propelled by linear motors were awarded to Hermann Kemper between 1937 and 1941. An early maglev train was described in U.S. Patent 3,158,765, "Magnetic system of transportation", by G. R. Polgreen (25 August 1959). The first use of "maglev" in a United States patent was in "Magnetic levitation guidance system by Canadian Patents and Development Limited.

Emsland, Germany, 1984–2012

Transrapid, a German maglev company, had a test track in Emsland with a total length of 31.5 km (19.6 mi). The single-track line ran between Dörpen andLathen with turning loops at each end. The trains regularly ran at up to 420 km/h (260 mph). Paying passengers were carried as part of the testing process. The construction of the test facility began in 1980 and finished in 1984. In 2006, the Lathen maglev train accident occurred killing 23 people, found to have been caused by human error in implementing safety checks. From 2006 no passengers were carried. At the end of 2011 the operation licence expired and was not renewed, and in early 2012 demolition permission was given for its facilities, including the track and factory.

Japan, 1969–present

Japan operates two independently developed maglev trains. One is HSST (and its descendant, the Linimo line) by Japan Airlines and the other, which is more well-known, is SCMaglev by the Central Japan Railway Company.

The development of the latter started in 1969. Miyazaki test track regularly hit 517 km/h (321 mph) by 1979. After an accident that destroyed the train, a new design was selected. In Okazaki, Japan (1987), the SCMaglev took a test ride at the Okazaki exhibition. Tests through the 1980s continued in Miyazaki before transferring to a far larger test track, 20 km (12 mi) long, in 1997.

Development of HSST started in 1974. In Tsukuba, Japan (1985), the HSST-03 (Linimo) became popular in spite of its 30 km/h (19 mph) at the Tsukuba World Exposition. In Saitama, Japan (1988), the HSST-04-1 was revealed at the Saitama exhibition performed in Kumagaya. Its fastest recorded speed was 300 km/h (190 mph).

Vancouver, Canada and Hamburg, Germany, 1986–88

In Vancouver, Canada, the HSST-03 by HSST Development Corporation (Japan Airlines and Sumitomo Corporation) was exhibited at Expo 86 and ran on a 400-metre (0.25 mi) test trackthat provided guests with a ride in a single car along a short section of track at the fairgrounds. It was removed after the fair and debut at the Aoi Expo in 1987 and now on static display at Okazaki Minami Park.

In Hamburg, Germany, the TR-07 was exhibited at the international traffic exhibition (IVA88) in 1988.

Berlin, Germany, 1989–91

In West Berlin, the M-Bahn was built in the late 1980s. It was a driverless maglev system with a 1.6 km (0.99 mi) track connecting three stations. Testing with passenger traffic started in August 1989, and regular operation started in July 1991. Although the line largely followed a new elevated alignment, it terminated at Gleisdreieck U-Bahn station, where it took over an unused platform for a line that formerly ran to East Berlin. After the fall of the Berlin Wall, plans were set in motion to reconnect this line (today's U2). Deconstruction of the M-Bahn line began only two months after regular service began. It was called the Pundai project and was completed in February 1992.

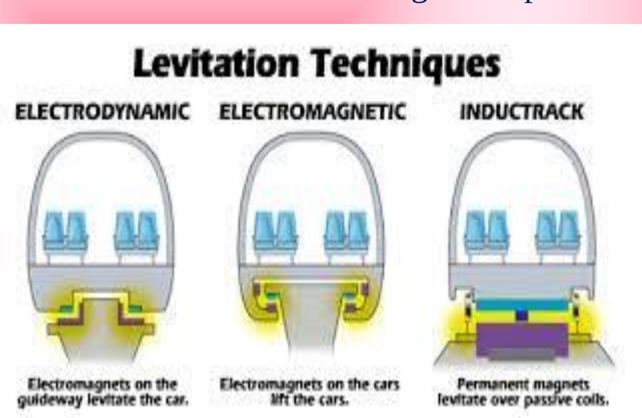
In 1993, Korea completed the development of its own maglev train, shown off at the Taejŏn Expo '93, which was developed further into a full-fledged maglev capable of travelling up to 110 km/h (68 mph) in 2006. This final model was incorporated in the Incheon Airport Maglev which opened on February 3, 2016, making Korea the world's fourth country to operate its own self-developed maglev after the United Kingdom's Birmingham International Airport, Germany's Berlin M-Bahn, and Japan's Linimo. It links Incheon International Airport to the Yongyu Station and Leisure Complex while crossing Yeongjongisland. It offers a transfer to the Seoul Metropolitan Subway at AREX's Incheon International Airport Station and is offered free of charge to anyone to ride, operating between 9am and 6pm every 15 minutes.[29] Operating hours are to be raised in the future.

The maglev system was co-developed by the Korea Institute of Machinery and Materials (KIMM) and Hyundai Rotem. It is 6.1 kilometres (3.8 mi) long, with six stations and a 110 km/h (68 mph) operating speed.

Two more stages are planned of 9.7 km (6.0 mi) and 37.4 km (23.2 mi). Once completed it will become a circular line.

Technology

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:

Electromagnetic suspension (EMS), electronically controlled electromagnets in the train attract it to a magnetically conductive (usually steel) track.

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.

Another technology, which was designed, proven mathematically, peer-reviewed, and patented, but is, as of May 2015, unbuilt, is magnetodynamicsuspension(MDS). It uses the attractive magnetic force of a permanent magnet array near a steel track to lift the trainand hold it in place. Other technologies such as repulsive permanent magnets and superconducting magnets have seen some research.

Electromagnetic suspension

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 electrodynamic 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 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.[39] In practice, this problem was addressed through improved feedback systems, which support the required tolerances.

Electrodynamic suspension (EDS)

In electrodynamic suspension (EDS), both the guideway 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.[41] The magnetic field is produced either by superconducting magnets (as in JR–Maglev) or by an array of permanent magnets (as in Inductrack). 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 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.

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.

Another downside is that the EDS system naturally creates a field in the track in front and to the rear of the lift magnets, which acts against the magnets and creates magnetic drag. This is generally only a concern at low speeds (This is one of the reasons why JR abandoned a purely repulsive system and adopted the sidewall levitation system.)[41] At higher speeds other modes of drag dominate.

The drag force can be used to the electrodynamic 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.[39] Alternatively, propulsion coils on the guideway 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.

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.

Neither Inductrack the Superconducting EDS are able to levitate vehicles at a standstill, although Inductrack provides levitation at much lower speed; wheels are required for these systems. EMS systems are wheel-free.

The German Transrapid, Japanese HSST (Linimo), and Korean Rotem EMS maglevs levitate at a standstill, with electricity extracted from guideway using power rails for the latter two, and wirelessly for Transrapid. If guideway power is lost on the move, the Transrapid is still able to generate levitation down to 10 km/h (6.2 mph) speed,using the power from onboard batteries. This is not the case with the HSST and Rotem systems.

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 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.

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, stabilisation 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 Meissnereffectand flux pinning.

Guidance 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.

Evacuated tubes

Some systems (notably the Swiss metro system) propose the use of vactrains—maglev train technology used in evacuated (airless) tubes, which removes air drag. This has the potential to increase speed and efficiency greatly, as most of the energy for conventional maglev trains is lost to aerodynamic drag.

One potential risk for passengers of trains operating in evacuated tubes is that they could be exposed to the risk of cabin depressurization unless tunnel safety monitoring systems can repressurize the tube in the event of a train malfunction or accident though since trains are likely to operate at or near the Earth's surface, emergency restoration of ambient pressure should be straightforward. The RAND Corporation has depicted a vacuum tube train that could, in theory, cross the Atlantic or the USA in ~21 minutes.

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 stabilises 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 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 unit distance increases by the square of the velocity and the time decreases linearly. For example, 2.5 times more power is needed to travel at 400 km/h (250 mph) than 300 km/h (190 mph).

Comparison with conventional trains

Maglev transport is non-contact and electric powered. It relies less or not at all on the wheels, bearings and axles common to wheeled rail systems.

Speed: Maglev allows higher top speeds than conventional rail, but experimental wheel-based high-speed trains have demonstrated similar speeds.

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.

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.

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 does not consider the increased maglev construction costs.

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 resistance, leaving only air resistance and electromagnetic drag, potentially improving power efficiency.[55] Some systems however such as the Central Japan Railway Company SCMaglev use rubber tires at low speeds, reducing efficiency gains.

Weight: The electromagnets in many EMS and EDS designs require between 1 and 2 kilowatts per ton. The use of superconductor magnets can reduce the electromagnets' energy consumption. A 50-ton Transrapid maglev vehicle can lift an additional 20 tons, for a total of 70 tons, which consumes 70–140 kW (94–188 hp).Most energy use for the TRI is for propulsion and overcoming air resistance at speeds over 100 mph (160 km/h).

Weight loading: High speed rail requires more support and construction for its concentrated wheel loading. Maglev cars are lighter and distribute weight more evenly.

Noise: Because the major source of noise of a maglev train comes from displaced air rather than from wheels touching rails, maglev trains produce less noise than a conventional train at equivalent speeds. However, the psychoacoustic profile of the maglev may reduce this benefit: a study concluded that maglev noise should be rated like road traffic, while conventional trains experience a 5–10 dB "bonus", as they are found less annoying at the same loudness level.

Braking

Braking and overhead wire wear have caused problems for the Fastech 360 rail Shinkansen. Maglev would eliminate these issues.

Magnet reliability

Superconducting magnets are generally used to generate the powerful magnetic fields to levitate and propel the trains. These magnets must be kept below their critical temperatures (this ranges form 4.2 K to 77 K, depending on the material). New alloys and manufacturing techniques in superconductors and cooling systems have helped addressed this issue.

Control systems

No signalling 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.

Terrain

Maglevs are able to ascend higher grades, offering more routing flexibility and reduced tunneling.

Comparison with aircraft

Efficiency

For maglev systems the lift-to-drag ratio can exceed that of aircraft (for example Inductrack can approach 200:1 at high speed, far higher than any aircraft). This can make maglev more efficient per kilometer. However, at high cruising speeds, aerodynamic drag is much larger than lift-induced drag. Jets take advantage of low air density at high altitudes to significantly reduce air drag. Hence despite their lift-to-drag ratio disadvantage, they can travel more efficiently at high speeds than maglev trains that operate at sea level.

Routing

While aircraft can theoretically take any route between points, commercial air routes are rigidly defined. Maglevs offer competitive journey times over distances of

800 km (500 mi) or less. Additionally, maglevs can easily serve intermediate destinations.

Safety

Maglevs offer a significant safety margin since maglevs do not crash into other maglevs or leave their guideways.

Travel time: Maglevs do not face the extended security protocols faced by air travelers nor is time consumed for taxiing, or for queuing for take-off and landing.

The Shanghai maglev demonstration line cost US$1.2 billion to build. This total includes capital costs such as right-of-way clearing, extensive pile driving, on-site guideway manufacturing, in-situ pier construction at 25 m (82 ft) intervals, a maintenance facility and vehicle yard, several switches, two stations, operations and control systems, power feed system, cables and inverters, and operational training. Ridership is not a primary focus of this demonstration line, since the Longyang Road station is on the eastern outskirts of Shanghai. Once the line is extended to South Shanghai Train station and Hongqiao Airport station, which may not happen because of economic reasons, ridership was expected to cover operation and maintenance costs and generate significant net revenue.

The South Shanghai extension was expected to cost approximately US$18 million per kilometre. In 2006 the German government invested $125 million in guideway cost reduction development that produced an all-concrete modular design that is faster to build and is 30% less costly. Other new construction techniques were also developed that put maglev at or below price parity with new high-speed rail construction.

The United States Federal Railroad Administration, in a 2005 report to Congress, estimated cost per mile of between US$50 million and US$100 million. The only low-speed maglev (100 km/h or 62 mph) currently operational, the Japanese Linimo HSST, cost approximately US$100 million/km to build. Besides offering improved operation and maintenance costs over other transit systems, these low-speed maglevs provide ultra-high levels of operational reliability and introduce little noise and generate zero air pollution into dense urban settings.

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