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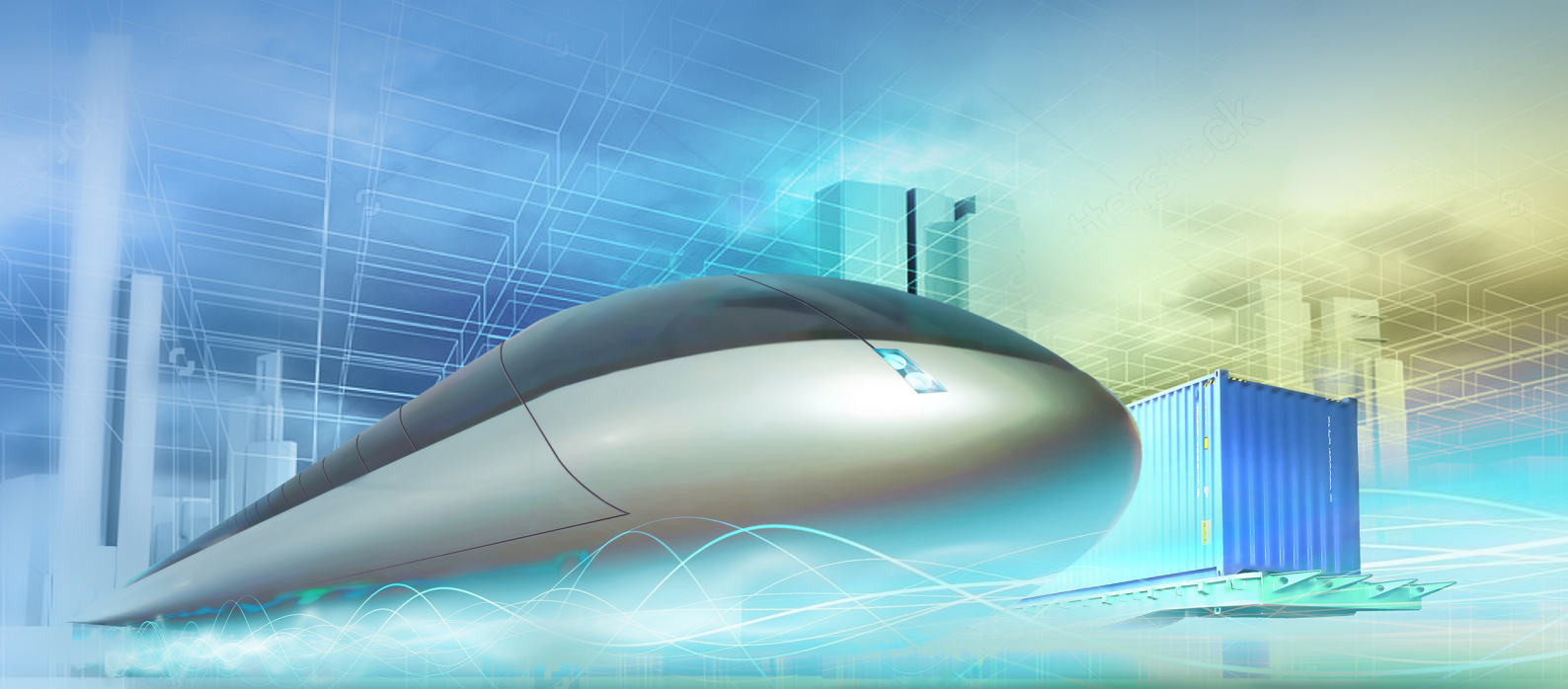

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CONTENT

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1 High-Speed Maglev, Presentation

Dzungaria VMLT- Corridor: Lost Opportunities or Weighted Optimism?

V.A. Bogachev
Co-Authors: Y.A. Terentyev, V.V. Koledov, T.V. Bogachev

Short Description / Abstract

A set of issues arising when considering possible options for the implementation of Eurasian transcontinental high-speed ground transport corridors operating on the basis of vacuum magnetic levitation technologies is analyzed. The paper gives a rational explanation as to why in modern geoeconomic and geopolitical conditions the exclusivity of Russia's geographical position substantially consists in the fact that it is through this territory that China can be directly linked by these corridors to Western Europe and also to North America. Possible routes connecting Beijing and Shanghai with Moscow are analyzed. The historical area of Dzungaria is considered as the location of the main intermediate terminal. The economic, political, logistical, geographical, technical and technological aspects of these projects are discussed. Transport highways of a truly innovative type will solve the urgent task of geopolitical level, that is to organize the states located on the Eurasian continent in a qualitatively new civilizational construction.

After the creation of a sufficiently informative and detailed informal picture, the basics of the corresponding mathematical models are constructed. Optimization methods are used, in particular, the calculus of variations.

The research was conducted with the support of the Russian Foundation for Basic Research (RFBR), grant number 17-20-04236.

Keywords

High-speed ground transport corridors, Magnetic levitation technologies, Optimization methods, the Problem of the calculus of variations

1 High-Speed Maglev, Presentation

Magnetically Levitated Train's Longitudinal Motion (Simulation Results)

Vladislav Polyakov
Co-Author: Nicholas Hachapuridze

Short Description / Abstract

In the previous works of the authors, an analytical model of the magnetically levitated train's longitudinal motion under the control of its linear synchronous motor was constructed. The components of its traction force were determined as a result of armature's and excitation winding's fields interaction, that is as Ampere forces. The dynamic equations of the circuits under consideration, as well as the expressions for the components of their currents' fields, were compiled for this purpose. The change in the dynamic state of the train was provided by the amplitude-frequency regulation of the motor armature's voltage supplying. The train's mechanical subsystem design scheme was adopted as a single-mass.

The components of the train's weight (on slopes), as well as the forces of its motion resistance (aerodynamic and others) can influence it. The analytical model of the motion was transformed into an appropriate computer model.

The computer experiments with the latest model were conducted using the computer mathematical system "Mathematica". The modes of start-up, acceleration, run-out and electrodynamic braking were considered. The oscilloscope charts of the values that characterize the behavior of the train as a controlled electromechanical system were obtained in various modes considered.

Keywords

Magnetically levitated train, Longitudinal motion, Modeling

1 High-Speed Maglev, Presentation

Conceptual Design of the High-Temperature Superconducting Maglev System

Fang Jiarong
Co-Authors: Bruce Montgomery, Guobin Lin

Short Description / Abstract

A novel high-speed Maglev train using high-temperature superconductors (HTS) is designed to fill a niche in the intercity transportation market between the high-speed trains and airplanes.

Based on the 1992 “Magplane” system, the new high-speed HTS Maglev train will be an electrodynamic levitation system. The conceptual design of high-speed Maglev trains and track will be described in the full paper. The aerodynamic damping, and lift pad mechanical and magnetic manipulation will also be presented. The system is designed to carry a capacity of 12,000 passengers per hour per direction. The initial subscale model will be built and tested in 2018.

The system trade-offs, conceptual design, passenger capacity, power consumption and test results of initial subscale HTS Maglev.

Keywords

Superconducting maglev, HTS, Electrodynamic levitation, Aerodynamic damping

1 High-Speed Maglev, Presentation

Energy Consumption of High-Speed Systems: Maglev Systems Compared to Wheel Rail Systems

Fritz Eckert
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Short Description / Abstract

The energy consumption of a High-Speed System is an important part of operational costs. In this paper the secondary energy demand of different Wheel Rail Systems, such as ICE, TGV, Shinkansen, and Maglev Systems, such as Transrapid, Chuo Shinkansen, will be compared.

In the past energy often values of systems with different conditions (train configuration, dimension, capacity, maximum speed) were compared. The comparative value was often represented by the specific energy consumption based on passenger capacity and line-kilometer.

The challenge is to find a way to compare the specific energy consumption of different High-Speed Systems without any distortion of results. Hence a comparison of energy values based on normative usable areas inside the High-Speed Systems will be described and evaluated in this paper. This procedure transforms the results to a more distortion-free comparison of energy consumption of different High-Speed Systems. The results show the energy consumption as an important characteristic parameter of transportation systems based on an objective comparison and give ranges of expected energy demand of different High-Speed Systems dependent on level of maximum speed.

Keywords

Energy consumption, High-Speed, Maglev System, Wheel Rail System, Specific energy demand

1 High-Speed Maglev, Presentation

Pulsar: an Alternative Future

Hamilton-Williams Colin

Short Description / Abstract

We are losing... When the rail mode of transport first came into existence, it quickly grew to be the fastest, most glamorous, efficient, most convenient and comfortable mode of transport. The evolution of the jet engine, combustion engine and manufacturing processes has allowed other industries to catch up and even surpass the rail market share in some cases.

The long distance traveller typically bases their travel choice on three criteria:

- Cost
- Convenience
- Time

The main threat to the high speed rail industry comes in the form of the aircraft. With cruising speeds in the region of 900 km/h and no infrastructure between airports, the aircraft is both faster and more versatile than the train. Rail hubs tend to be in the centre of big cities unlike airports and as such it is hard to match their convenience. However, cost is coming under increased pressure from cheap air fares and car sharing alike. The relative speed of air travel versus high speed rail limits the effective competitive distance. If we do not evolve, the guided transport industry may lose its validity in this arena all together.

The only way we can reverse the modal shift of passengers is to do more for less. In this paper, the Pulsar Maglev is proposed to provide significant improvements in the cost and time of travel whilst still delivering the convenience benefits of the rail mode of transport.

The Pulsar Maglev is an alternative regional Maglev system that utilises a low cost modular semi-vacuum infrastructure design which provides the levitation and drive from a hybrid linear induction motor. The infrastructure is mated with specifically designed magnetic bogies to realise a potent and scalable ultra high speed transportation technology.

The Pulsar concept is compatible with both freight and passenger services and is theoretically capable of delivering airline beating speeds in excess of 1000 km/h. This paper explores the limitations of conventional wheel-rail systems and presents the existing Maglev design principles. Furthermore, the design and development of the Pulsar Maglev system is described, and the performance of the system is evaluated through simulations.

Keywords

Maglev, High speed, Ultra high speed, Freight, Hyperloop

1 High-Speed Maglev, Presentation

Multicriteria Evaluation of HS (High Speed) Transport Systems - MAGLEV, HSR (High Speed Rail) and HL (Hyperloop)

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Short Description / Abstract

The paper deals with the multicriteria evaluation of the TRM (Trans Rapid Maglev), HSR (High Speed Rail) and HL (Hyperloop) system operating along a given passenger transport corridor. The evaluation criteria are obtained from the multidimensional examination of performances of these systems implying their analysis and analytical modeling. The considered performances are infrastructural, technical/technological, operational, economic, environmental, and social. The analysis and modelling of these performances enable their estimation in both absolute and relative terms while assuming operation of three systems according to the "what-if" scenario approach.

The infrastructural performances generally relate to the dimensions, layout, and materials used for building the TRM guideways, and HSR and HL lines.

The technical/technological performances relate to the power supply system, supporting facilities and equipment, and rolling stock/vehicles of the considered systems.

The operational performances include the infrastructure capacity, quality of services, transport work, and technical productivity. The economic performances relate to the systems' capital/investment and operating costs on the one side and the revenues obtained from charging users-passengers on the other. The differences between the revenues and costs reflect the systems' profitability. The environmental performances embrace the energy/fuel consumption and related emissions of GHG (Green House Gases), and land use. Finally, the social performances include congestion, noise, and incidents/accidents (safety).

The applied multicriteria evaluation methods are SAW (Simple Additive Weighting), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), and AHP (Analytical Hierarchy Process), enabling comparison of their evaluation features in the given case.

Keywords

Maglev, HSR (High Speed Rail), TRM (Trans Rapid Maglev), Performances, Multicriteria evaluation

1 High-Speed Maglev, Presentation

The Russian Version of the Transport System “Hyperloop”

Konstantin Kim

Short Description / Abstract

Nowadays we watch a revival of interest in the idea of the vacuum transport. It supposes that the passenger capsules move with a speed of 500-1000 km/h in the tube in which the technical vacuum was created. The limitations connected with the minimizing the tube volume, in which it is necessary to create a vacuum and the desire to use the tube cross section to the maximum (which determines the capacity of this system), will inevitably lead to the minimum clearances between the outer surface of the capsules and the inner surface of the tube. In this regard, it is reasonable to hold the capsule in all the coordinates by the forces of the electromagnetic field.

When the capsule moves, the edge air flow is formed on its surface. The causes of different origin trigger the appearance of small movements, disturbing the edge air flow. These perturbations lead to the appearance of turbulent spots, which subsequently transfer almost the edge air flow in a turbulent condition which leads to the sharp increase of the aerodynamic drag of the capsule, to the appearance of disturbing forces and moments influencing the capsule. This leads to the necessity to increase the power of the drives and other devices which carry out the spatial magnetic holding of the capsules, to increase the stress on the capsule, and, consequently, to the necessity to strengthen the capsule design, i.e. to the deterioration of its mass-dimensional indicators.

In order to avoid partially the effects of turbulence of the edge air flow, it is possible to use a perforated frontal part of the capsule. We carry out the suction of incipient turbulent spots of the edge air flow through holes. Mostly, the edge air flow retains a laminar character. This leads to reduction of the aerodynamic drag of up to 30 %. The air flow passing through the perforated holes is spent on the air conditioning and cooling current carrying elements of the capsule.

Keywords

Tube, Capsule, Edge air flow, Turbulent spots, Perforated frontal part, Suction

1 High-Speed Maglev, Presentation

Development Prospect of High Speed Maglev after High Speed Rail Era

Liu Wanming
Co-Authors: Jinxin Li, Yifan Dai, Chaoshuai An

Short Description / Abstract

In 2001, China started to construct the world's first high-speed maglev line, Shanghai Maglev Demonstration Line, by introducing German technology. Five years later, a feasibility study of high-speed maglev in Shanghai-Hangzhou traffic corridor was been sponsored. However, the government finally decided to build a high-speed railway system in this corridor in 2008. By the end of 2017, with the mileage of high-speed railway reaching 25,000 km, China has the world's largest high-speed railway network. Although China's research in the field of high-speed maglev traffic technology has never been stopped since 2001, are there still prospects for the application of high-speed maglev in China?

This paper proposes that high-speed maglev system can be designed into the upgrading product of high-speed railway system to achieve a significant increase in the speed of the railway network. In the upgrading process of high-speed railway system in the future, this paper considers the construction of the high-speed maglev system on the existing infrastructure of the high-speed railway system, such as bridges, tunnels and subgrades etc. In this way, not only the goal of upgrading railway system can be achieved, but also the existing railway Infrastructure and equipment can be sufficiently utilized to reduce construction costs and land resource consumption. This paper analyzes the possibility of this upgrading method in the following four aspects: system structure, vehicle system, power supply system and operation control system. The technical measures and costs of upgrading process are also analyzed in this paper.

Based on the above analysis, the upgrade of high-speed maglev on the existing high-speed railway infrastructure has significant advantages in operation speed and system cost. Therefore, high-speed maglev still has wide development prospects even in the country which has already constructed a large-scale high-speed railway network.

Keywords

High-speed maglev, High-speed railway, Development prospects, Upgrading method, Speed and cost

1 High-Speed Maglev, Presentation

Comparison of HSM and HSR – Chinese Scene

Liu Wanming
Co-Authors: Caoshuai An

Short Description / Abstract

Introduction: Large population and vast territory decides that China needs a large scale high speed mass transport passenger system. China had imported Germany high-speed Maglev technology to build the first high-speed maglev (HSM) demonstration line in the world. Meanwhile China also imported high-speed railway (HSR) train from Germany, Japan, France and Canada. It is important to know which area is suitable to build a HSR or HSM line. So a comprehensive comparison of HSR and HSM from technological and economic aspects is necessary.

Cost of infrastructure: The analysis was started from the running mechanism of HSM and HSR. The operating loads and the precision requirements for track irregularities are used as basic data for calculating the cost of normal track. The requirements for alignment were used for analyzing the cost of civil-works in different topography. The results showed that the cost of infrastructure of HSM would be 20% more than HSR in plain area, while as 20% less than HSR in mountain area because the alignment of HSM could be more flexible.

Cost of vehicles: Through the comparative analysis of the technical parameters and prices of nine kinds of high-speed rail vehicles abroad and the German maglev vehicles, the results show that the average price of high-speed maglev vehicles is 48% higher than that of high-speed rail vehicles. Considering the factors of the running speed of the train, the difference of vehicle cost for the same passenger turnover would be much less. The acquisition cost of maglev vehicle per seat-kilometer would be almost the same as the HSR.

Cost of operation: Through the qualitative and quantitative analysis of the configuration of technical equipment, driving consumption, replacement parts and wear parts of the two systems, combined with the references of theoretic and experimental international research, the comparison of the operating expenditures of the two systems was studied. The result shows that, in the plain areas, the difference in operating expenditures between the two transport modes is small. Due to less original value of fixed assets of HSM than HSR, the operation cost of HSM would be some less than HSR in mountain area.

Market adaptabilities: As an important part of the comparison of two transport systems, the market adaptability of HSM and HSR was studied. This research is based on the study of the behavior of passenger while they choosing transport model for their travel. The train speed, the ticket fare level, the safety aspect, the comfort aspect, the reliability and the convenience aspects were taken into account as the factors satisfying the demand of passengers. A multi-objectives model was established to simulate the behaviors of passenger while they choose transport model. The results show that the economic development level, which could be described as the value of time(VOT), will play a decisive role for a traffic corridor to choose HSM or HSR as the high speed passenger transport system. The average VOT of 7.5-7.9 RMB yuan per hour may be the threshold to build a HRM line.

Conclusions: Basing on theoretical analysis, experimental alignment, experimental design and case study, two typical high-speed passenger transport systems, i.e. the high-speed maglev(HSM) and high-speed railway(HSR), were compared. The comparison was implemented from the point of view of project investment, operation costs, passenger transport demand and market adaptability, and so on. Research results can be used as reference for China to make investment decision in constructing high-speed ground passenger transport system in different regions.

Keywords

High-speed maglev, High-speed rail, Passenger transportation, Transportation planning, Comparison

1 High-Speed Maglev, Presentation

Service Experiences Maglev Vehicles Shanghai

Reinhard Rampelmann
Co-Authors: Reiner Köhler

Short Description / Abstract

In the late 1990s Thyssenkrupp Transrapid GmbH successfully qualified the Maglev Vehicle TR08 and obtained the type approval certificate. Based on that design, in 2001-2003 three five-car vehicles for the first commercial high speed Maglev Line in Shanghai were manufactured and set into operation. The VIP-Run took place over 15 years ago and the commercial operation has been running for almost 15 years at great availability.

The Transrapid system concept of small autonomous redundant electronics based modules facilitates significantly smooth maintenance - diagnosis, testing and system inspection.

Thanks to intelligent diagnostics, the use of easily interchangeable plug-in units, the dimensioning of the spare parts inventory according to the expected failure rates and the replenishment lead time, the maintenance efforts are still within the forecast range at the beginning of the project. Furthermore, the maintenance concept is essentially unchanged since the beginning.

There are no special materials that are subject to a potential shortage or price leap, but all according to normal industrial base.

Thanks to the low level of stress to components on board, most electrical and electronic units are still on-board as original equipment, which are 15 years old and at no end of life is visible.

But in case of repair or replacement, the challenge is the adaptation to the volatile market of electronic components. This includes the necessary lead-time for adaptive development and qualification, which has to be considered.

On the side of the vehicle supplier, a small smart team of electronics experts is managing obsolescence and compensates discontinuation.

The paper tells how it works and appreciates trustful cooperation of the supplier in Europe with the operator in China.

Keywords

Maglev vehicle, Service, Spare parts strategy, Maintenance, Electronic components

1 High-Speed Maglev, Presentation

Permanent-Magnet-Based Maglev Using Low-Frequency Null-Flux Stabilization

John Van Rosendale

Short Description / Abstract

This paper presents a new maglev design, known as "MagFlite." Levitation in MagFlite is based on attraction between permanent magnets on the vehicle and steel plates in the guideway. The result is continuous, almost lossless, vertically stable levitation, though by Earnshaw's theorem the system must be unstable horizontally. To stabilize the system horizontally at low speed we use small rollers like those on steel roller-coasters. To stabilize the system at high speed we use a permanent-magnet-based null-flux stabilization system.

Permanent-magnet-based levitation is inherently simple and provides fail-safe operation not dependent on high-speed electronics or cryogenic magnets. Its main advantage, however, is that the required stabilization forces are typically much smaller than levitation forces. Our system is loosely similar to Lawrence Livermore's "Inductrack III" system. Unlike Inductrack III, however, in which the stabilization magnets are 1D Halbach arrays, MagFlite uses stabilization magnets with a 2D pole pattern. We choose the vertical pole spacing to maximize horizontal stiffness. We can then independently choose the longitudinal pole spacing to optimize the operating frequency of the stabilization system. In particular, by choosing a relatively low frequency we can use reaction coils made of low-cost aluminum wire.

This paper presents numerical modeling of the electromagnetic forces, system stability, and the various losses. We also describe a way to incorporate a reluctance synchronous linear motor for propulsion and braking that requires no additional guideway components.

Keywords

Permanent-magnet levitation, Null-flux stabilization, Low-frequency, Aluminum wire, Inductrack III

1 High-Speed Maglev, Presentation

Magnetic Levitation Train

Mir Nazmul Haque
Co-Authors: Md Momin Molla

Short Description / Abstract

The report titled 'MAGLEVTRAIN' accomplishes a research on the developing discipline of magnetic levitation and its application to transport through trains and has been experimented with intensity over the past couple decades. It provides detailed information about the evaluation of maglev science, its progression and improvisation till date, but it wasn't until the last ten years when scientists began to develop systems that transportation. As well as the technology implemented using the levitation. High speed magnetically levitated ground transportation (maglev) is a new surface mode of transportation, in which vehicles glide above their guideway. Suspended, guided and propelled by magnetic forces. This report tries to explain the complexities involved in this technology in a simple but precise manner, and tries to compare the conventional modes of transport with maglev trains in various aspects such as safety, durability, comfort and so on. Thus providing advantages and disadvantages of this train. Consecutively it deals with the accidents that have occurred at places where maglev trains have been implemented and the reasons that triggered them. This data has been included so that such type of incidents maybe avoided in the future and in order that certain necessary modifications are made to improve the safety measures of these trains capable of traveling at speed of 250 to 300 mph or higher. So the implementation of large-scale transportation system using magnetic-levitation has huge social as well as economical effects. These aspects are looked at a number of situation to see if the effort in producing a system using magnets is worth the time and efficiency and it's assures that maglev trains are no longer a science fiction, and are in fact the future of world transportation.

Keywords

Maglev, Levitation, Train, Transportation, Safety

1 High-Speed Maglev, Presentation

Integrated Transit Transport System (ITTS) of Russia Based on Vacuum Magnetic Levitation Transport (VMLT)

Yuri Terentyev
Co-Authors: V.V. Filimonov, G.G. Malinetsky, V.A. Smolin, V.G. Shavrov, V.V. Koledov, D.A. Suslov, D.A. Karpukhin, A.V. Mashirov, S.V. Fongratovsky, K.L. Kovalev, R.I. Ilyasov, V.N. Poltavets, B.A. Lyovin, A.M. Davydov, P.V. Kurenkov, I.V. Karapetyants, P.V. Kryukov, B.V. Drozdov, V.S. Kroposhin, M.Y. Semenov, N.A. Nizhelsky, V.A. Solomin, V.A. Bogachev, V.M. Fomin, D.G. Nalivaichenko, T.V. Bogachev

Short Description / Abstract

The Russian Federation is located at the crossroads of the shortest trade routes between the states of Western and Northern Europe, Middle East and Central Asia, Asian part of the Pacific Region, where a significant amount of international transport trade flow is formed. The territory of Russia may become an optimal communication bridge between these poles of economic and technical development, since it possesses an immense transit transport potential, the economic and geopolitical realisation results of which are comparable with our today's benefits from traditional export of natural resources, hydrocarbon and other raw resources, as well as weaponry. The transition of the society to another technological pattern explains the emergences of the corresponding system of economic relationships, at which the category of time serves as one of the major criteria for efficiency not only in assessment of the information flows, but also in the traditional market of goods and services. Essentially, at present the high-speed economics is forming. The acceleration of scientific and technical progress and the globalisation at the beginning of XXI century conflict the insufficient and largely limited tempo of development and modernisation opportunities of the existing traditional transport systems. There emerged a necessity to find efficient solutions to this problem, which will combine cardinal increase of speed and capacity of transport system with an affordable cost and low consumption of energy for transportation of passengers and freight.

The paper deals with a large-scale infrastructure project of construction of this ITTS on the basis of the VMLT, which combines energy efficiency, unachievable in other approaches, environmental friendliness, speed (hypersonic) of transportation (resulting in capacity as well) with an affordable cost of freight and passenger transportation. The results of the preliminary experiments on (laboratory size) a test track with the full realisation of the magnetic levitation, which enables further modelling of the full-size VMLT, were obtained.

The research was conducted with the support of the Russian Foundation for Basic Research (RFBR), grant number 17-20-04236.

Keywords

High-speed ground transport corridors, Vacuum magnetic levitation transport, Specific energy inputs, Transit transport resource

1 High-Speed Maglev, Presentation

State Monitoring and Fault Detection for PEMS High Speed Maglev Train Levitation System Based On I/O Data

Wang Zhiqiang
Co-Authors: Po Zhiqiang Long, Xiaolong Li

Short Description / Abstract

To reduce levitation energy consumption and prevent the electromagnets from overheating, a PEMS (Permanent Magnet Electro-Magnetic Suspension) type high speed maglev train has been proposed. Considering the permanent magnet may be harmful to levitation system if there a fault takes place, state monitoring and fault diagnosis are of great importance for safety of PEMS high speed maglev train. In this paper a data driven state monitoring and fault diagnosis method is applied instead of the model-based approach which is dependent on precise system model. First, a method to generate observer based on system I/O data is proposed, no system model is needed in this process.

Then an adaptive way for residual generation is presented in detail. At last simulation results are given which verify that the state changes and system faults can be effectively detected with the proposed data driven methods.

Keywords

High speed maglev train, PEMS, State monitoring, Adaptive residual generator, Data driven

1 High-Speed Maglev, Presentation

Study on Signal Processing and Fault Diagnosis of Absolute Positioning Sensor for High Speed Maglev Train

Wang Xinwei
Co-Authors: Dai Chunhui, Long Zhiqiang

Short Description / Abstract

The absolute positioning sensor is an important part for the high speed maglev train to realize its synchronous traction, which can provide location, speed and direction information for the maglev train to accomplish safe and reliable operation of the train. This paper analyzed the signal processing of the absolute positioning sensor for High-Speed Maglev Train, and proposed a fault diagnosis method for the key signal in signal processing. Based on the working principle of the absolute positioning sensor, we analyzed the transmitter circuit, signal processing circuit and digital decoding circuit, besides we also studied the process of signal generation and code reading part.

What's more, considering the temperature, electromagnetic interference and other factors on the signal processing, we put forward the improvement scheme for the absolute positioning sensor. Finally, we analyzed the key signal inside the absolute positioning sensor, and designed a state detection circuit to realize fault diagnosis for the absolute positioning sensor.

Keywords

High-speed maglev train, Absolute positioning sensor, Signal processing, Fault diagnosis, State detection circuit

1 High-Speed Maglev, Presentation

Curving Performance of Medium-Low Speed Maglev Vehicle Considering Nonlinear Characteristics of Air Spring Suspension

Zhao Chunfa
Co-Authors: Feng Yang, Ren Xiaobo, Li Yan

Short Description / Abstract

Considering the controlled nonlinear air spring and the levitation control system, a dynamic model is built to simulate curving behavior of medium-low speed maglev vehicle with five type of air spring suspension topology. The influence of air spring suspension topology on curve negotiation performance of maglev vehicle is analyzed. The numerical results show that air spring suspension topology affect obviously the vertical displacement of the vehicle body after the vehicle passed the curve segment, and has considerable effect on air spring force, bogie frame, levitation airgap and electromagnetic forces.

When the air spring system of maglev vehicle use six-point suspension topologies, curve negotiation performance of the vehicle is better than the other suspension topologies, the following is the four-point suspension topologies characterized by the front three bogie unit and the rear two bogie unit. The four-point suspension topologies characterized by the front five air springs and the rear five air springs bring the worse curve negotiation performance for the medium-low speed maglev vehicle.

Keywords

Maglev vehicle, Air spring, Curve negotiation, Dynamics, Numerical simulation

1 High-Speed Maglev, Presentation

Dynamic Mechanical Behaviors of Secondary Air Spring Suspension of High-Speed Maglev Vehicles Running over the Curve Track

Zhao Chunfa
Co-Authors: Yang Feng, Degang Liu, Xiaobo Ren

Short Description / Abstract

In order to develop a new-type levitation frame for the 600km/h high-speed maglev vehicles, the technical requirements of secondary air spring suspension system are investigated from the perspective of curve negotiating status and dynamic characteristics of maglev vehicles. Firstly, a detailed dynamic model of high-speed maglev vehicles is built using the MATLAB/Simulink and SIMPACK software, which contains a non-linear air-spring model considering the physical structure and thermodynamics property, and the electromagnet levitation/guide controller based on an airgap state observer.

Then, dynamic responses of high-speed maglev vehicles running over various curve tracks are simulated, and mechanical behaviors of secondary air spring suspension are analyzed. Simulated results show that the lateral displacement of the vehicle body increases with the decrease of curve radius, the maximum lateral displacement is about 90 mm when the curve radius is 5500 m. The lateral acceleration of the vehicle body increases appreciably with decrease of curve radius, but it increases remarkably with decrease of transition curve length. The lateral airgap, coil current and electromagnetic force of the guide electromagnet increase with decrease of curve radius and transition curve length, which means the increase of energy consumption.

Finally, the relationship curves between dynamic response of secondary air spring suspension and the radius, the transition length and the torsion angle of the curve track are presented, which give valuable guidelines to design a new-type levitation frame.

Keywords

Maglev vehicle, Air spring, Curve negotiation, Dynamics, Numerical simulation

1 High-Speed Maglev, Poster Session

Hardware-in-the-Loop Simulation of High-Speed Maglev Transportation Five–Segment Propulsion System Based on dSPACE

Qin Feng
Co-Authors: Ying Lin, Diqiang Lu

Short Description / Abstract

For exploring and testing the key technology of high-speed maglev transportation propulsion control system, this paper designs and establishes a hardware-in-the-loop (HIL) real-time simulation system of the high-speed maglev transportation five-segment propulsion system. According to the route conditions and propulsion segment division of Shanghai maglev demonstration and operation line, the real-time simulation platform based on dSPACE multiprocessor systems is implemented.

The simulation system can achieve the functional simulation of all the high-power related equipment in the 5-segment area, including 8 sets of high-power converter units, 2 sets of medium-power converter units, 2 sets of low-power converter units, five-segment trackside switch stations and long-stator linear synchronous motors. The mathematical models of linear motors and converters are built in MATLAB/Simulink and System Generator, after compiling, they can be downloaded and executed in Field Programmable Logic Array (FPGA). All the interfaces connecting the simulation system to the propulsion control system physical equipment use real physical components as in the field, such as analog I/O, digital I/O, optical signals and Profibus.

By using CPU+FPGA hardware configuration, the simulation steps are greatly shortened and the response speed and accuracy of real-time simulation system are improved. The HIL system can simulate multiple operating modes such as multi-segment, multi-vehicle, double-track, double-feeding, step-by-step stator section changeover, and so on. The experimental results show that the maximum speed of the HIL system can reach 500 km/h, which has important research significance for real-time on-line test and verification of high speed maglev propulsion control system.

Keywords

Hardware-in-the-loop, Real-time simulation, High-speed maglev transportation, Five-segment propulsion system, dSPACE

1 High-Speed Maglev, Poster Session

Sensorless Control High-Speed Maglev Transportation System

Jin Yu
Co-Author: Fang Hua

Short Description / Abstract

Sensorless control is a hot research topic in the field of motor control nowadays. High-speed maglev transportation system is essentially a linear motor system (with long Primary and Short Secondary). Because of the high speed, only sensorless control can meet the real-time control requirements. Lots of work to estimate the rotor's speed and position has been done especially in the field of rotating electrical machines, while relative little for linear motors.

In this paper, the actual inverter output voltage and current data are used to estimate the speed and position of the vehicle. Two commonly used methods in the field of rotating electrical machines are used: Back-EMF direct calculation and MRAS (Model Reference Adaptive System). The results show that the accuracy of the parameters, proper signal processing and a reasonable model are very important.

Keywords

High-speed maglev, Sensorless control, Speed and position estimation

1 High-Speed Maglev, Poster Session

Improving Transportation Systems with the Use of Innovative Modes of Transport

Natalia Korytko
Co-Authors: Aleksey Laptsevich, Anton Koshcheev,
Rimma Pisareva, Natalya Kascheeva

Short Description / Abstract

In modern conditions, passengers as consumers of services, put forward exclusive standards for transport. Transport should provide speed of transportation, accessibility, safety, comfort, saving its travellers efforts and time. The main step in this direction is the introduction of innovative modes of transport.

The article considers the possibility of introducing innovative modes of transport in urban transport systems. Moreover, we propose an option of using innovative modes of transport to develop the long-distance passenger transportation. To solve the problems of the urban transport system in Yekaterinburg, it is necessary to introduce the innovative modes of transport that provide high speed, independent from the traffic situation, environmentally friendly and energy efficient. Using the method of expert assessments, it has been determined that the use of vacuum levitation transport (VLT) and magnetic levitation transport (MLT) in the urban transport system is irrational because they cannot develop high speed due to frequent stops. It is more efficient to use these modes of transport in long-distance passenger transportation. That is why the expediency of introducing these modes of transport for the organization of long-distance communication in the northern direction of the Ural region was considered in the paper.

The most promising area of the Ural region is Tyumen-Novy Urengoy direction, as it is the main route for the delivery of large volumes of oil products and hydrocarbons from fields located in the regions of the Far North. The main problem of the direction consists in the limited throughput and its proximity to the maximum limitation. With the projected growth in mineral production, rail transport will not be able to meet the demand for their transportation.

The research proposes to organize long-distance passenger traffic using innovative modes of transport, the most efficient mode of transport under these conditions - VLT, the route of the Tyumen-Novy Urengoy VLT line is designed. This line must be constructed on the flyover due to the numerous intersections of oil, gas and product pipelines, and also due to difficult local conditions (a large number of water barriers, permafrost areas). The net discounted income is calculated to justify the economic efficiency of these measures.

Keywords

Innovative modes of transport, Vacuum levitation transport, Magnetic Levitation transport

1 High-Speed Maglev, Poster Session

A Study of Non-Symmetric Double-Sided Linear Induction Motor for Hyperloop All-in-One System (Propulsion, Levitation, Guidance)

Lee Hyung-Woo
Co-Authors: WooYoung Ji, GeoChul Jeong, IkHyun Jo, HyeongSeok Oh

Short Description / Abstract

This paper proposes All-in-one system for Hyperloop that conducts propulsion, levitation and guidance. Currently demand in environment-friendly ultrahigh speed long distance transportation is increasing, so that Hyperloop is getting attention and is studied hard globally. Hyperloop is a new innovative transportation that a levitated subsonic speed train travels through vacuum cylindrical tube. Hyperloop needs functions of propulsion, levitation and guidance for its service and also many devices are necessary for those functions. In high speed maglev train, generally, linear synchronous motor is applied for propulsion and permanent magnet or superconducting electromagnet is used for passive levitation, and electromagnet or permanent magnet is used for guidance. In tube, constrained space, many devices make entire system complicated and size of vehicle and tube is increased. Therefore, costs of maintenance, manufacture, construction are increased and control of each devices is very difficult. But a Non-symmetric Double-sided Linear Induction Motor (NSDLIM), subject of this study, is All-in-One system that could conduct all functions. This system uses the 3 features of single-sided linear induction motor for propulsion, levitation and guidance.

Thrust force by the propulsion principle of a conventional linear induction motor, levitation force by transverse end effect, guide force by normal force are generated in NSDLIM. In this paper, requirements of NSDLIM was investigated considering special structure and operating environment such as vacuum tube, very high speed and acceleration. And by using finite element method, NSDLIM was designed and analyzed.

The effects of parameters on force of propulsion, levitation and guide was investigated. By analyzing 3 forces, possibility was confirmed and All-in-One system for Hyperloop was proposed.

Keywords

Hyperloop, Maglev train, Sub-sonic speed, All-in-one system, Linear induction motor

1 High-Speed Maglev, Poster Session

Analysis of Impact of Energy-Saving Circuit Design on Energy Consumption of High Speed Maglev Transportation

Li Huibai
Co-Authors: Jingyu Huang, Yang Gao, Dongshuai Li

Short Description / Abstract

Based on the Shanghai Maglev Train, and combined with the technical characteristics of the high-speed maglev train and its vehicle characteristics, the running resistance and traction characteristics of the train were analyzed and studied in this paper. And the relationship of the maglev train speed was analyzed with its operating characteristic and traction efficiency respectively.

Through data investigation and traction calculation simulation, the paper analyzed the impact of circuit design factors such as flat curve radius, longitudinal gradient and slope length and energy-saving slope combination on train traction energy consumption and running time, and accordingly proposed the general principles of energy-saving circuit design, and drew some up-hill traction strategies which were instructive for high-speed maglev train energy-saving driving.

Keywords

High speed maglev transportation, Uphill traction, Operation energy consumption, Energy-saving, Circuit design

1 High-Speed Maglev, Poster Session

Onboard Diagnosis and Control System of High Speed Maglev Train

Liao Zhiming
Co-Authors: Jiguang Yue, Huahua Zhao, Guobin Lin

Short Description / Abstract

The Shanghai high speed maglev demonstration line has been running for more than fourteen years. Its punctuality rate arrives at 99.95%, which shows the high reliability of the high speed maglev train. The onboard diagnosis and control system acts a very important role for the safety running of the train.

This paper introduces one kind of onboard diagnosis and control system used on high speed maglev train. This system is composed with two subsystems. One is diagnosis subsystem, and another is control subsystem. The diagnosis subsystem includes CAN bus and Ethernet. The CAN bus acts as vehicle bus, and Ethernet acts as train bus. The state signals of all units can be transmitted to the diagnosis system and displayed on the computer in the driver cab. The safety independent control signals are also transmitted to the controlled devices through the diagnosis system. The control subsystem includes redundancy signal processing units and transmission units. All safety related control signals and state signals are transmitted through the control system via redundancy hard wires. The structure and communication protocol of the diagnosis and control system are also introduced in this paper.

Keywords

High speed maglev train, Diagnosis and control system, CAN bus, Redundancy, Safety

1 High-Speed Maglev, Poster Session

A Special Excitation System for Analysis of Coupling Characteristics of Thrust and Levitation Force of Maglev Train

Rao Jian
Co-Authors: Ke Wang, Qiongxuan Ge, Liming Shi, Yaohua Li

Short Description / Abstract

In the maglev system utilizing long stator linear synchronous motor (LSLSM), the characteristic of propulsion control system is one of important points to evaluate the performance of the Maglev train. However, coupling characteristics are very complex between thrust and levitation force. The wide range of field excitation fluctuation caused by severe or continuous external interference can make the performance of the propulsion bad. Therefore, the interference from the levitation system must be considered when the propulsion system is designed.

It is a convenient and feasible scheme to verify the propulsion control strategy of maglev train on Rotating synchronous motor. Considering the influence of field excitation fluctuation on propulsion control, a special excitation system of the Rotating synchronous motor is introduced in this paper.

The electromagnetic force that makes the train suspend upon the track is produced by the excitation current. The suspension system of high speed maglev train must adjust the exciting current to sustain the given air gap in actual operation. Therefore, no matter the fluctuating air gap or the change of levitation force can be reflected by the fluctuation of the excitation current. The excitation system is designed to generate the direct current for the field excitation, it also can generate the alternating current at different frequencies to imitate the fluctuation of the exciting current during the actual operation. By this way, the complex coupling relationship between thrust and levitation force can be simplified.

Keywords

Maglev train, Coupling characteristics, Levitation force, Thrust force

1 High-Speed Maglev, Poster Session

Research on Speed Sensorless Control of Maglev Train with Double-End Power Supply

Sun Pengkun
Co-Authors: Qiongxuan Ge, Xiaoxin Wang, Bo Zhang

Short Description / Abstract

The core technology of stable operation of the maglev train is how to accurately obtain the train speed, position and linear motor angle information. In the double-end power supply mode of maglev train, the principle of the extended electromotive force (EEMF) of the AC motor is extended to the control of the long stator permanent magnet synchronous linear motor. The mathematic model of long stator permanent magnet synchronous linear motor and converter is constructed; Suitable EEMF observer is designed based on the mathematic model.

The speed of the maglev train and the rotor angle are obtained by the method of phase locked loop (PLL). Through the semi-physical simulation experiment, the speed sensorless control method is force (EEMF); double-end power supply.

Keywords

Maglev train, Long stator permanent magnet synchronous linear motor, Speed sensorless control, Extended electromotive force (EEMF), Double-end power supply

1 High-Speed Maglev, Poster Session

Design and Implementation of a New Kind of Hybrid Permanent Magnet and Electromagnetic High Speed Maglev Train Levitation System

Wang Zhiqiang
Co-Author: Zhiqiang Long

Short Description / Abstract

Hybrid permanent magnet and electromagnetic high speed maglev train is innovative compared with normal electromagnetic type maglev train in that there is an existing permanent magnet added inside the yoke of the electromagnet, which will reduce the levitation energy consumption and alleviate the adverse effects caused by the over-heating of the electromagnet.

To make this hybrid maglev system work, new system architectures and safety protection strategies are to be proposed. This article is focused on the design and implementation of hybrid high speed maglev train levitation system, firstly the design and manufacturing of hybrid electromagnets are introduced, then the modification of the driving chopper module together with its control strategy and the design of an absorption-prevention module are presented in detail, at the end a complete two-carriage maglev train is upgraded with the modified hybrid electromagnets, choppers and absorption modules, and an experiment is made on a 1.5-km high speed maglev test line.

Keywords

High speed maglev train, Levitation system, Hybrid permanent magnet and electromagnetic, Chopper, Absorption prevention

1 High-Speed Maglev, Poster Session

Ultra High Cycle Fatigue of the High-Speed Maglev Train Levitation Frame Arm Based on Damage Tolerance

Yin Long
Co-Authors: Guoxin Sun, Chunjiang Guo, Jie Hu

Short Description / Abstract

This paper aims to study the safety of levitation frame arm on ultra-high cycle fatigue.

Levitation frame arm is the main part in the levitation frame and plays a very important role in the safe operation of high-speed maglev system.

Because the frequency of alternating load on levitation frame arm is so high, and the materials have a great possibility of destruction under the ultra-high cycle fatigue cycle, that the paper study the influence of the defect on the part.

In the high stress area of the levitation frame arm, the initial defect simulation, such as material defects, structural damage that is added according to the NASA standards. At the same time, the actual appearance defects of existing parts are also added to the part, in order to calculate the crack initiation stress intensity factor for residual strength curve under the condition of linear elastic fracture mechanics.

Through the simulation and calculation, the time that the standard defect in high stress zone extend to allowable crack length is to be calculated. When the dispersion coefficient is given, the safe maintenance period in which the defect extend to the maximum allowable crack is also calculated, which provides the maintenance reference of the Shanghai maglev demonstration line.

Keywords

High-speed maglev train, Ultra-high cycle fatigue, Damage tolerance

1 High-Speed Maglev, Poster Session

Fault Diagnosis of High Speed Maglev Train

Yuan Jianjun
Co-Authors: Yu yi, Cui Weiqi

Short Description / Abstract

Fault diagnosis plays an important role for guaranteeing the efficient and safe operation of high speed maglev train.

This paper studies the fault trees and fault detection technology of maglev train, analyses the fault types and the effect on system operation, and then studies the fault location technology to the minimal replaceable unit.

The fault information management system and fault recovery are discussed at the end.

Keywords

Fault diagnosis, High speed maglev train, Fault detection, Fault location, Fault recovery

1 High-Speed Maglev, Poster Session

Study on Energy Saving Optimization of High Speed Maglev Train

Yun Lanying
Co-Authors: Xiaochun Zhang, Siyuan Mu, Jinsong Kang

Short Description / Abstract

Maglev train is a new kind of urban rail transit, which runs smoothly, is safe and comfortable, and has excellent climbing ability. However, the running energy consumption is an important aspect that restricts the large-scale application of maglev.

Therefore, from the perspective of the dynamics, this paper analyzes the operating energy consumption of the vehicle by designing the traction calculation algorithm suitable for high-speed maglev train. Firstly, the traction calculation model of the maglev train is established, then a hybrid optimization strategy is proposed, in order to achieve optimal energy-saving operation of the train, the paper applies the intelligent algorithm to the strategy for optimization, which will improve the selection of the point of operating mode transition.

Finally, the simulation software is developed and by it we calculate the operating energy consumption of the Shanghai maglev train. The result shows that the algorithm can reduce the operating energy consumption and provide a reference for the actual energy-saving operation of the maglev train.

Keywords

High-speed maglev train, Energy-saving optimization, Intelligent algorithm

1 High-Speed Maglev, Poster Session

Research on Suppression Strategy of Short Wave Irregularity in High Speed Maglev Train

Zhai Mingda
Co-Authors: Mingda Zhai, Zhiqiang Long, Xiaolong Li

Short Description / Abstract

The high speed maglev train is through the electromagnetic force to levitate the vehicle upon the track contactless at a certain height and run the train by the linear motor. Compared with the airplane, it is generally believed that it must have a solid support and guidance system, that is, track system.

However, due to the existence of steps between the track beams and the irregularity of the track, the geometric factors of the track will inevitably affect the suspension of the high speed maglev train. This paper focuses on the analysis of the influence of the track steps on the suspension control system of the high speed maglev train.

Moreover, the suspension control algorithm is improved to restrain the vibration induced by the orbital step, so that the high speed maglev train passes through the above sections more smoothly.

Keywords

High speed maglev, Track, Irregularity, Vibration

2 Urban Maglev, Presentation

Innovations and Performance of Italian UAQ4 Superconducting Magnetic Levitated System

Gino D'Ovidio
Co-Author: Giovanni Lanzara

Short Description / Abstract

This article illustrates the technological innovations of the UAQ4 (University of L'Aquila model 4) maglev train project that aims to greatly reduce energy consumption.

The project is the outcome of the Italian research activities, started in 1976, on the field of non-conventional high-speed transportation systems.

The technological feasibility of the UAQ4 suspension and propulsion devices has been patented and successfully laboratory tested.

The train architecture and the work principles of suspension and propulsion devices are all innovative, with concepts very close to the aeronautical standard.

Compared to Electro Magnetic and Electro-Dynamic maglev systems (mostly already mature to be operative), the experimental UAQ4 system allows to:

- Eliminate any ordinary resistance to motion (magnetic drag included), except the aerodynamic drag;

- Avoid electric power consumption for levitation, except the negligible amount needed for cooling the superconductors.

The suspension device uses superconducting magnetic levitating method based on passive, self-balancing interaction between on board superconducting skater devices (consist of "V" shaped assembled close arrays of melt textured YBa2Cu3OX bulks kept at LH2 temperature in a suitable cryogenic vessel) and Nd2Fe14B permanent magnets distributed along the track.

As consequence the train stably floats with a large air gap in all phases of motion, zero speed included, without control devices.

Propulsion and braking are provided by an innovative direct current linear stepper motor, safely operating along the whole speed range.

Even if the work criteria are valid for both low-speed and high-speed transportation applications, the UAQ4 system is particularly suitable for urban environment that involves short distances between stops, the ability to overcome longitudinal gradients, large accelerations, and low operating speed. In this context, the UAQ4 operates with negligible power consumption since the ordinary resistance to the motion is almost zero.

In the international scenario of maglev technologies, the UAQ4 system introduces the following significant innovations: i) self-balancing three axes suspension, ii) a high-efficiency DC linear motor with a large air gap iii) near-zero energy consumption at low and constant speed iv) light-weight vehicle architecture very close to aeronautical standard (light materials, big size, and high comfort level).

The system innovations, technologies, performance and applications are illustrated in detail and discussed in the full version of the paper.

Keywords

Urban maglev system, Superconducting magnetic levitation, Free magnetic resistance maglev system

2 Urban Maglev, Presentation

Research on Dynamic Characteristic of Multi-Span Continuous Steel Turnout Beam in Medium Maglev Transportation System

Gao Shangkang
Co-Authors: Liang Xiao, Wang Wuliang

Short Description / Abstract

Medium speed maglev transportation has proposed new requirements on maglev turnout, the maglev turnout used in the medium/low speed maglev express cannot meet the demand. For the study on dynamic characteristics of multi-span continuous steel turnout beam in medium maglev transportation system, the dynamic simulation model of the continuous steel structure was established, and the dynamic characteristics of the turnout were analyzed numerically.

In view of the speed and dynamic performance requirements of a medium-speed maglev vehicle, the dynamic response of the lateral position is calculated at the speed of 40km/h and 60km/h, and the direct position at the speed of 160km/h.

The calculation results can be used as reference for the adaptive research of the multi-span steel structure continuous beam in the medium-speed maglev turnout.

Keywords

Medium speed maglev, Continuous steel structure, Turnout beam, Dynamic characteristics

2 Urban Maglev, Presentation

Latest Advancements in the Urban Maglev ECOBEE

Han Hyung-Suk
Co-Authors: Chyung-Hyn Kim, Jaewon Lim, Chang-Wan Ha

Short Description / Abstract

This paper introduces recent advancements in the Urban Maglev ECOBEE to improve the reliability and lower O & M costs.

The first is the redundancy of the controller to increase the reliability of magnetic levitation. The second is improvement of motor control algorithm to reduce propulsion energy consumption. The third is the improvement of the braking control algorithm to minimize the mechanical braking operation.

Keywords
ECOBEE, O&M costs, Energy consumption, Reliability

2 Urban Maglev, Presentation

Multifunctional Maglev Transport System "ELTRO"

Vladimir Komarov
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Short Description / Abstract

Evaluation of current transport technology to create reliable and effective innovative system of the integrated communications for transport, power engineering and information maintenance of any city infrastructure was performed. This analysis has shown the essential discontinuity in transport infrastructure and information technologies interfering with new post-industrial technological pattern of municipal economy. Following this evaluation, the strategy of integrated communications that forms the kernel of new technological wave was founded. Practical base of this strategy is the current technology of electric transport and the determined vehicle traffic that is seamlessly associated with modern information and power engineering technologies and maglev technologies.

Based on simulated computer-aided engineering prototypes of key technical solutions of the innovative transport system, the preliminary engineering development was performed that allows to estimate practical feasibility of the system.

The current phase of the system creation is the tests and researches of experimental prototypes of key technical solutions.

The tasks completed by the ELTRO system were:

- the availability and multifunctionality which are specific for the motor transport, providing the required high traffic capacity and lack of environmental damage;
- safety of people's lives;
- minimization of necessary land allocation for system communications;
- independence from environmental conditions;
- minimization of power engineering and operational costs;
- power supply of adjacent territories;
- highly reliable and uninterrupted information support of adjacent territories with the expanded range of services, such as remote equipment control (IoT), the automatic systems of remote logistics (IoL) and parking (IoP), distance selling and delivery (IoM), safe management of finance and transactions (IoF), remote control of business processes, or Internet Business (IoB).

Keywords

ELTRO, Maglev, Transport system, IT technology, Integrated communication

2 Urban Maglev, Presentation

Characteristic Research for Collector-Contact Line Relation of Lateral Current Collection for the Medium Speed Maglev Train

Li Ye
Co-Authors: Liang Xiao, Wang Wu-Liang, Gao Shang-Kang

Short Description / Abstract

The collector-contact line relation of lateral current collection mode for maglev train is always the emphasis research content in the field of power supply system of the medium-low speed maglev train. Typical conditions in low speed are integrated in the paper, large-scale finite element universal software ANSYS was used to establish models of current collector and the third rail coupling and dynamic responses computation methods, dynamic responses computation of coupling process was launched and verified the simulation methods by experimental data of real train test.

And on that basis dynamic responses computation methods of the medium speed maglev train coupling process was emerged and characteristic research for collector-contact line relation were summarized in the paper, which provided references for the reliability of lateral current collection mode of the medium speed maglev train.

Keywords

Medium-low speed maglev train, Collector-contact line relation, Lateral current collection mode, Dynamic responses

2 Urban Maglev, Presentation

Construction and Equipment Configuration of Beijing Urban Maglev Commercial Line (S1 line)

Li Jie
Co-Authors: P. Wang, Y.G. Wang, G.B. Zeng, P. Cui, D.F. Zhou, P.C. Yu

Short Description / Abstract

Beijing urban maglev commercial line (Beijing S1 line) connects Pingguoyuan Subway Station and Shichang Station of the Mentougou district, it is the world's first medium and low speed maglev line equipped with the type A vehicles and has a large transportation quantity.

This paper introduces the whole project construction situations, the development history of the key technologies, the configuration and main parameters of vehicles, track, power supply, velocity measurement and positioning etc.

At last some new technologies and further applications of maglev system in China is prospected.

Keywords

Urban maglev, Beijing S1 line, Construction situation, System configuration

2 Urban Maglev, Presentation

Suspension Gap Fluctuation Suppression Method of Low Speed Maglev Train Considering Sensor Layout

Li Ya Jian
Co-Authors: Peng Cui, Dan Feng Zhou, Pei Chang Yu, Jie Li

Short Description / Abstract

Magnetically levitated (maglev) train achieves non-contact operation by maintaining a constant suspension gap between the electromagnet and the track. The gap is generally 8-10mm. Such a small suspension gap makes a limited range of the suspension gap, which affects the riding comfort and stability of the vehicle. At present, the suspension gap sensors of the low-speed maglev train are installed at both ends of the electromagnet respectively, which leads to differences in suspension gap responses between the two suspension points in one module.

It is found that the rear suspension point has greater gap fluctuation than that of the front suspension point. In order to find out the relationship between the sensor layout and the suspension gap responses, a coupled model of rigid rail and suspension module is proposed in this paper.

According to the analysis of the gap responses of coupled system with different sensor layout under the conditions of track steps, periodic irregularity and random irregularity, it is found that placing the gap sensors to the center of the outer wire package can reduce the difference of gap responses between two suspension points and the amplitude of gap fluctuation.

Keywords

Maglev train, Coupled system, Track irregularity

2 Urban Maglev, Presentation

Operating Cost of Incheon Airport Maglev Line

Park Doh
Co-Authors: B.C. Shin, K.B. Lee, S.K. Ma

Short Description / Abstract

In December 2006, the Ministry of Land, Infrastructure and Transport initiated Urban Maglev Program to finalize the previous maglev R&D projects and to prove that the developed system is ready for revenue service. The Center for Urban Maglev Program was set up to lead the program.

In the first stage of Urban Maglev Program, R&D activities to improve performance of maglev train were successfully completed. In December 2009, the prototype maglev vehicles were built and transferred to 1.3 km test track in KIMM, Daejon, Korea. Various tests were performed until May 2013 including long-term reliability test. Also various guideway related technologies were developed, including the articulated type turnout switches. In the second stage of Urban Maglev Program, the focus has been shifted to the construction of Demonstration Line at Incheon International Airport and various test and commissioning required by the regulations for urban railway.

The commercial service of Incheon Airport Maglev Line started from February 3, 2016 after all system interface tests required by the regulations. Commercial service of Incheon Airport Maglev Line started with four trainsets of permanently coupled two Urban Maglev vehicles. The vehicle, which is called EcoBee, specifications are listed in Table 1. Figure 1 shows the Incheon International Airport Maglev Line with six stations and a depot. The construction cost was 37.4 million US Dollars (1 USD = 1,150 KRW).

Incheon Airport Maglev Line provided 71 trips per day from 9 am to 6 pm with a headway of 15 minutes from Feb. 4, 2016 until Oct. 19, 2016. The number of trips per day increased to 79 from Oct. 20, 2016 until Apr. 19, 2017 with the operating hours from 09:00 to 19:00. Since Apr. 20, 2017 the passengers can enjoy 103 trips per day from 07:30 to 20:30 every day.

In this paper, the operating cost of Incheon Airport Maglev Line including maintenance cost for the period of one year is analyzed. Also the comparison of operating cost per km with three metro lines and one light rail line in Korea. The analyzed operating cost of Incheon Airport Maglev Line consists of four major components: labour cost, operation and maintenance cost, electrical power cost and general overhead cost. The analysis shows that the operating cost of Incheon Airport Maglev Line is 64.78% of that of a monorail type light rail transit system per year per km basis.

The successful commercial operation of Incheon Airport Maglev Line will prove that an urban maglev system based on EMS technology is a new eco-friendly alternative with superior ride quality and low Life-cycle-cost for the worldwide light rail system applications.

Keywords

Urban maglev, EcoBee, Passenger Service, Operating Cost

2 Urban Maglev, Presentation

Speed Increasing Scheme by Using 3000V DC Power Supply for Low-Speed Maglev

Wang Xiaohua
Co-Authors: Jin Yu, Lin Ying, Lu Diqiang, Qin Feng

Short Description / Abstract

Low-speed Maglev is usually designed to run at a maximum speed of about 100~110km/h., it does not get any advantage to the traditional urban railway transportation system nowadays at the aspect of running speed. This paper presents a scheme using 3000V DC power supply instead of original 1500V DC.

So the max output voltage of propulsion inverter could be doubled. For reason that the insulation of linear induction motor has enough margin and enhancing potential, only small adjustment of motor is needed to adapt the doubled voltage, a model of short primary linear induction motor is built to calculate the performance of new running mode, and the result shows that the max running speed could be increased at least to 160km/h, so it's an easy and economical approach to enhance competitiveness of low-speed maglev, and will further promote the popularization of low-speed maglev.

Keywords

3000V DC, Power supply, Low speed maglev, Speed increasing

2 Urban Maglev, Presentation

Measurement of the Residual Stress for the Bogie Frame of Maglev Vehicle Based on Barkhausen Effect

Zeng Jiewei
Co-Authors: Long Zhiqiang, Liang Xiao

Short Description / Abstract

The effect of residual stress resulted from the manufacturing process on the performance of bogie frame has been attracting more and more attention with the increasing of running speed of maglev vehicle, which could develop cracks on the frame and compromise the operational safety. It is necessary to determine and understand the distribution rules of residual stress on the bogie frames.

Barkhausen effect is one of the effective methods used to measure residual stress. This paper presents a confirmatory experiment system that is designed for residual stress detection and the measuring principles with Barkhausen effect. Finite element simulation analysis on magnetization device is carried out using Ansoft, and the effect of magnetization under different excitation conditions is analyzed.

The confirmatory experiment system is designed for residual stress detection bogie frame, and an excitation module and fast signal processing system of dynamic online detection based on the principle of inverse magnetostriction are developed in this paper. Moreover, the test system of new methods for detecting strip shape is constructed in the laboratory.

The feasibility of the online magnetic detection method of internal stresses in strip is verified through the experiment, which would be provided the basis for bogie frames internal stresses detection.

Keywords

Bogie frames, Maglev vehicle, Barkhausen effect, Residual stress, Nondestructive examination

2 Urban Maglev, Presentation

Application of Low-Dynamic-Interaction Levitation Frame to Medium-Low Speed Maglev Vehicle

Zhang Min
Co-Authors: Ma Weihua, Gao Chang, Luo Shihui

Short Description / Abstract

For the low-dynamic-interaction levitation frame, the interaction force between this levitation frame and guideway is lower than that of HSST-type levitation frame. In this paper, the structure and the advantages of low-dynamic-interaction levitation frame were introduced. Similarities and differences of the structure of the two types of levitation frames were analysed. Specifically, the installation method, the levitation adjustment mode and the operation mode of the two frames were compared. One levitation frame consists of two modules. By vertical coupling motion equation of one levitation module, the vertical degree of coupling of the two frames and the release condition of degree of freedom at the end of module were analysed. In order to explain the effect of decoupling at the end of frame on levitation performance, a multi-body dynamics vehicle model was developed. Vibration accelerations of the two types were compared. By energy method, the mechanism of low-dynamic-interaction levitation frame was analysed; the work in each adjustment process was theoretically calculated; the energy consumptions were calculated and compared based on the adjustment process in the dynamics analysis. Tests about vehicle-guideway coupling vibration were carried out to verify the levitation capacity of low-dynamic-interaction levitation frame. Running tests were carried out to test the levitation stability at the maximum running speed. The result indicates that: because of the mid-set mode of air springs, the vertical degree of decoupling of the levitation module is higher, which makes it easier to adapt the changes of guideway. The energy method indicates that in all levitation adjustment process, the energy consumption of levitation system of the low-dynamic-interaction levitation frame is lower than that of HSST-type levitation frame. The above tests verify that the low-dynamic-interaction levitation frame has larger carrying capacity and better guideway adaptability, which further confirms the validity of its low dynamic.

Keywords

Medium-low speed maglev, Low dynamic interaction, Energy method, Coupled vibration, Levitation performance

2 Urban Maglev, Presentation

Modeling and Simulation of Coupling Vibration between Medium-Low Speed Maglev Vehicle and Switch Beam

Zhao Chunfa
Co-Authors: Zhao Chunfa, Feng Yang, Ren Xiaobo, Luo Yingkun

Short Description / Abstract

A railroad switch (turnout) is an important infrastructure enabling trains to be guided from one track to another. For the medium-low speed EMS maglev trains, because the on-board levitation bogies wrap around the track, the switch is make up of multi-span moveable beam, and whose stiffness is weaker than the standard concrete girder. So, excessive vibration and deformation often occurs when maglev trains levitate over or pass through the switch. In engineering practice, TLMD (tuned liquid mass damper) technology is adopted to reduce vibration response of the switch beam, but the TLMD damper is to be specific to a certain resonance frequency.

If the actual resonant frequency is remarkably less or greater than the predicted resonant frequency, TLMD could not achieve good vibration damping effect. In fact, the switch beam on the Changsha Maglev Express Line once appeared excessive vibration in trial operation period, which seriously affected running safety of maglev trains. In order to understand vibration characteristics of maglev switch beam and develop effective measures of vibration reduction, a finite element model of the switch beam used on Changsha Maglev Express Line is built, and its vibration modes and natural frequencies are analyzed.

Furthermore, dynamic interaction model between maglev vehicle and switch beam is built to calculate vibration responses of maglev train-switch beam system, which considers the completed PD active electromagnetic levitation controllers. The numerical simulation program for maglev vehicle-switch beam dynamic interaction is developed by using the APDL language in ANSYS. Numerical results show that the vertical resonance frequency of switch beam is about 16.5 Hz.

The simulation results of maglev vehicle-switch beam system can meet well with the measured results, which indicate the coupling vibration model is reasonable. The acceleration and displacement response of the flange are larger than that of the bottom of the main beam, it shows that the flange have violent local vibration especially when the maglev vehicle passes through the switch beam with a low speed.

Keywords

Maglev vehicle, Switch beam, Dynamic interaction, Vibration attenuation, Feedback control, Mode analysis, Numerical simulation

2 Urban Maglev, Presentation

Adaptive Vibration Control of the Electromagnet-Track Coupled High Frequency Resonance for an Urban Maglev System

Zhou Danfeng
Co-Authors: Peichang Yu, Jie Li, Peng Cui, Mengxiao Song

Short Description / Abstract

The commercial operations of the Beijing S1 urban maglev line and the Changsha maglev express symbol that the urban maglev technology is well developed in China. However, during the operation, it was found that high frequency resonances between the electromagnet and the steel track would be encountered in some spots along the track, especially at those locations where the F-rail was not well supported.

In this paper, the model of the electromagnet-track coupled system is firstly established, in which some special cases, which correspond to the situations when the screws that fasten the F-rail to the sleepers are fatigue, or the stiffness of the rubber plates beneath the sleepers weaken for temperature reasons, are studied; and the reason that leads to the coupled resonance are explained as well. Secondly, an adaptive vibration control algorithm, which consists of a vibration observer and a tunable adaptive filter, is designed to suppress the high frequency electromagnet-track coupled resonance. Using this algorithm, when the train arrives at the spots where the coupled resonance may occur, the vibration observer will detect the occurring of the vibration and estimates its frequency, and then activate the adaptive filter and tune it to absorb the vibration.

The test indicates that this algorithm is practical for use, and it is simple and can be easily integrated into the levitation control code in a digital levitation control system.

Keywords

Vibration, Resonance, Track, Control, Adaptive, Urban maglev

2 Urban Maglev, Poster Session

A New Concept of Modular Magnetic Levitation Train for Urban Transport

Vincenzo Delle Site
Co-Author: Maurizio Cavagnaro

Short Description / Abstract

Maglev systems have some features that make them still very interesting, especially for urban transport: the lack of contact between the vehicle and the track reduces maintenance costs; the reduction of noise generated by running trains in urban areas is also very important. Therefore, the development of Maglev systems cannot be abandoned, but we need to focus on a new generation, custom-made solution for urban transport, characterized by simple construction, lightweight, low energy consumption, small cross-section, full automation, low cost of construction and operation. Taking advantage of the important evolution in performance of the permanent magnets and on the basis of studies conducted over the past few years on the optimization of the technology of magnets operating in opposition (among them those conducted by the National Research Council of Italy), an original solution of an urban suspended Maglev system (where the vehicle is suspended from a fixed track) was developed in recent years in order to meet these requirements of simplicity and low cost. The first version of this system, already presented at the Maglev 2016 Conference in Berlin, adopted original vehicle levitation and guidance systems based on repulsive forces between permanent magnets of particular shape and dimensions.

In this paper we now present an updated version of this system, which uses superconductors installed on a frame joined to the vehicle that interact with permanent magnets placed on the suspended track. Propulsion and operating braking are assured by a linear synchronous motor, whose armature is placed on the ground along the whole track, while the permanent magnet inductor is joined to the vehicle. In this paper the proposed maglev system and its components are fully described, also focusing on the advantages of this solution for urban use (modular design of the train consisting of very short modules, infrastructure, optimal design of the components, etc.), and emphasizing the versatility of the system, which allows innovative links in future metropolitan areas.

Keywords

Maglev, Urban transport, Suspended system, Modular construction, Cost saving

2 Urban Maglev, Poster Session

The Battery Management System of Urban Maglev Train

Ji Wen
Co-Authors: Xu Junqi, Rong Lijun

Short Description / Abstract

It is well-known that the battery plays a significant role in the urban maglev system, so how to charge or discharge battery is especially important to urban maglev train. This paper aims to design a charge and discharge management system for battery of urban maglev train. This system employs raspberry Pi as the principal computer. Raspberry Pi has many general purpose inputs/outputs (GPIO) which is easy to control the charge circuit. Then raspberry pi records the changes of current and voltage in the process of charging and discharging, calculates the SOC of the battery, detects temperature, and shows the battery state on the screen in the driving cab.

The battery management system mentioned in this paper has been applied in our experiment. It proved to be beneficial for improving the maintenance efficiency of battery of urban maglev trains.

Keywords

Battery management system, Raspberry Pi, Urban maglev system

2 Urban Maglev, Poster Session

Research on Key Technologies of Medium Speed Maglev Transportation System

Liang Xiao
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Short Description / Abstract

Maglev transportation systems are put into commercial operation at medium-low speed (100km/h) or high speed. There is no record showing that medium speed (160 km/h) maglev transportation system has been applied in any engineering project yet. From the year 2016, Maglev Technology Research Center of Hunan Province in China has been conducting the research and development of medium speed maglev transportation system aimed at 160km/h.

The structure of traction system is adopted from the operating medium-low speed maglev transportation systems, which is the short-stator liner induction motor. But the liner motor, power supply rail, current collector, light weighted car body and some other sub-systems/parts are optimized for speed increase. Also, solving schemes are proposed to improve traction performance and power supply efficiency. Furthermore, the pilot production of medium speed maglev train is completed by now.

The success of researching and developing medium speed maglev transportation system has great significance to strengthen the vitality of maglev transportation systems.

Now, Maglev Technology Research Center of Hunan Province has the ability to put the medium speed maglev transportation system into engineering application.

Keywords

Medium speed maglev transportation, Key technologies, Engineering application

2 Urban Maglev, Poster Session

The Simulation and Analysis for a New Concept of the Stator Power Supply Mode of a Medium Speed Maglev System

Lin Ying

Short Description / Abstract

This paper introduces a new concept of the stator power supply mode which is proposed in a medium speed project supported by Ministry of Science and Technology of China in "The 13th Five-year plan". Basically, the structure of the propulsion system is a long stator synchronized linear motor, which is the same as that of Transrapid Maglev system.

The difference is that each stator section of the long stator motor is divided into sub-sections according to the length of two carriages. Several such sub-section stators are serially connected in interval to form a group and is excited by a trackside converter. As a result, each stator section consists of several groups of sub-sections, and the number of the groups equals to half of the number of the train carriages. The trackside converter requires no feeder line cables, and thus no voltage loss occurred on the cables. The medium speed, for example 200km/h, of the project means relatively low voltage requirement for the motor.

Both of these two features make the application of medium power converters, for example 4.5MVA, possible. In this paper the simulation results of the new power supply mode based on the same motor parameters as Shanghai Maglev Project are presented. Then the advantage and disadvantage is analyzed, and some conclusions are drawn at the end of the paper.

Keywords

Medium speed transport, Power supply mode, Medium power converter, Simulation, Long stator synchronized linear motor

2 Urban Maglev, Poster Session

Study on Bogies Anti-rolling and Decoupling Characteristics of 160km/h Medium-speed Maglev Train

Xiang Xianglin
Co-Authors: Long Zhiqiang, Liang Xiao, Wang Wu-Liang

Short Description / Abstract

Anti-rolling and decoupling performance are basic requirements for the kinematics performance of maglev vehicles. In order to analyze bogies anti-rolling and decoupling characteristics of 160km/h medium-speed maglev train, a single suspension dynamic simulation model of a medium-speed maglev train was established based on the virtual prototype technology.

Meanwhile, anti-rolling stiffness and decoupling stiffness are proposed as evaluation indexes. With existing low-speed maglev train anti-rolling and decoupling ability as a reference, the paper has analyzed the medium-speed maglev bogies anti-rolling and decoupling performance, and provided references for parameters optimization of the medium-speed maglev bogies.

Keywords

Anti-rolling stiffness, Decoupling stiffness, Medium-speed maglev train, Maglev bogies

2 Urban Maglev, Poster Session

Analysis and Solution of Eddy Current Induced in Rail for Medium and Low Speed Maglev Transportation System

Zhang Wenyue
Co-Authors: Ying Yang, Wenyue Zhang, Laisheng Tong, Qibiao Peng, Huajun Luo, Xiaochun Li, Jianguo Suo

Short Description / Abstract

For Medium and low speed maglev transportation system, the eddy current will be induced in rail, which is made of solid steel, while the train is running. The levitation force of electromagnets of the train will be weakened by the magnetic field generated by eddy current in the rail, especially at the position of the forefront electromagnets. Experiment results show that the current of a forefront electromagnet of the train is more than 1.3 times of the average value of others, when the train speed is up to 90km/h, which means that the forefront electromagnet will be heated seriously.

In order to solve the above-mentioned problem, two solutions are proposed here. One is using two smaller air springs above the forefront electromagnets, so that the loads applied on the forefront electromagnets can be decreased with the pressure of air springs being constant. The other method is to lengthen the forefront electromagnets, and increase the number of windings, as a result the levitation ability of the forefront electromagnets will be enhanced, and the needed current of windings can be reduced with same load.

The analysis, calculation process and the experiments of above solutions will be presented in this paper.

Keywords

Medium and low speed maglev, Eddy current, Electromagnet, Air spring

3 Cargo Maglev, Presentation

Prospects of Establishment of East-West Transport Transit Corridor with Application of Magnetic Levitation Technology

Anatoly A. Zaitsev
Co-Author: Iana V. Sokolova

Short Description / Abstract

According to the Economist Klaus Schwab, the society of today is on the threshold of the Fourth Industrial Revolution. It will especially influence the transport branch, where the cardinal changes of the assessment of the place and the role of transport in the world progress, as well as the requirements to its characteristics are being observed. At the national level the tasks have been determined, which are connected with the necessity of realising big transport projects in order to strengthen positions of Russia in the world transportation market, including the container transportation, to increase the transit potential of Russia, to develop the speed and improve the quality, service of passengers and freight.

The options of solving the tasks, based on the implementation of cutting-edge maglev technology for transport while establishing the East-West Transport Transit Corridor, are suggested by the authors. The magnetic levitation technology is competitive with the existing transport modes in terms of speed, sustainability, energy efficiency, and safety.

The main purpose of the establishment of the transit corridor is to provide a new transport service with a unique set of properties. At that, the transport and technology tasks are solved, which are connected with the construction and modernisation of means of communication, terminals and hubs, information systems, etc. The project of establishment of the East-West Transit Transport Corridor deploying magnetic maglev technology is suggested to perform in three stages. The assessment of the Russian container transportation market and the comparable analysis of properties of maglev and railway transport prove efficiency of the project. To commence the realisation of the project, the decision at the state level is required.

Keywords

Transit transport corridor, Magnetic levitation, Industrial revolution, Innovations

3 Cargo Maglev, Presentation

High-Speed Container Transport System

Alexander Kireev
Co-Authors: Nikolay Kozhemyaka, Gennadiy Kononov

Short Description / Abstract

The new scope of application for vehicles equipped with magnetic suspension is the fright container transportation. In order to realize the transit potential of the country, the increase in mean speed of the container trains is required.

Purpose. The present work aims to explore the possibilities to develop the high-speed transport system equipped with magnetic suspension for container transportation along Euro-Asian land bridge.

Methodology. As the research tools used methods of situational analysis, computer modeling, transport geography, technical and economic analysis.

Results. The market analysis results of the transit container transportation have shown that the major challenge for Russian transit development is the constrained traffic capacity of the existing transport corridors. The drastic solution to the problem can be the construction of a new high-speed transport system. The following factors determining the conditions for the creation of the new transport system have been identified: use of transport possibilities of the Azov-Black Sea basin; ensuring accessibility of the northern territories; development of technical solutions for the creation of a transport system with low-cost infrastructure. The combined traction levitation system has been developed based on the extremely simple design of the linear switched reluctance motor. The experimental researches of the full-functional physical model of the transport platform have been performed. The assessment of investment project efficiency has shown that despite the large start-up investment in the track infrastructure, the project has positive economic effect.

Practical importance. The computer model of the combined traction levitation system based on the linear switched reluctance motor has been designed. The concept of constructing a new transport system is proposed, taking into account the characteristics of the proposed operational region in poorly developed territories. The high-speed route has been proposed connecting the Azov-Black sea basin with the Pacific coastline and completely passing through the territories of Russia including some northern regions. The transit potential assessment has shown that due to the transit time reduction it is possible to attract the container freights with traffic volume of 1.52 million in twenty-foot equivalent unit.

The work has been carried out with the financial support of Russia's Ministry of Education and Science. The unique identification code of studies RFMEFI57916X0132.

Keywords

Container traffic, Conveyor container transport, Maglev freight train, Transport corridors, Linear switched reluctance motor

3 Cargo Maglev, Presentation

Maglev Freight - One Possible Path Forward in the U.S.A.

Arthur Wolek

Short Description / Abstract

As high-speed rail and other transportation technologies are moving forward and gaining funding in the United States, the push for MAGLEV is not receiving the necessary support that would make it viable for the near future. Major changes in the approach could make a better case for MAGLEV, specifically for carrying freight. One alternative that has been considered in the past is the modification of existing freight rail lines to support MAGLEV. For this to be economically feasible and practical, such a solution had to be able to support both conventional freight trains and MAGLEV freight.

The dual use of rail lines has substantial cost advantages when compared to building new dedicated MAGLEV freight corridors. However, there are many limitations and uncertainties that would cause policy makers to reject such proposals. Essential rail installations such as switches are difficult to modify in a way that would ensure reliable functionality for both MAGLEV and conventional freight trains, and grade crossings pose serious safety concerns. It is difficult to envision the tremendous leap forward of merging MAGLEV with existing freight rail lines when much more basic technologies such as positive train control are not even fully implemented. Consequently, it is a challenge to advance MAGLEV in the United States where new dedicated freight corridors are too cost-prohibitive and dual use rail lines pose risks and uncertainties that rail companies simply do not want to take. However, there is one more solution which is a partially levitated freight train.

Modifying existing freight rail with magnetic quasi-lift technology is a much lower cost alternative that will provide very important benefits and could even enhance safety in the rail industry. The proposed system will levitate a significant portion of the weight of the train but still utilize the existing steel rails for traction and guidance. The most evident advantages include reduced wear on rail and other supporting elements, and a significant reduction in friction and energy use. Locomotives and all other mechanical components may be made lighter and travel speeds could increase due to less impact. Most importantly, the acceptance and success of this partially levitated system will lead to the future implementation of fully levitated freight transport technology. Sometimes it is necessary to take smaller steps to achieve the desired future.

Keywords

MAGLEV Cargo, Partially levitated freight

3 Cargo Maglev, Poster Session

Design and Analysis of PMLSM Based on Halbach Array for Freight Maglev

Lin Guobin
Co-Author: Yan Sun

Short Description / Abstract

This paper presents a design of permanent magnet linear synchronous motor (PMLSM) for freight linear driving with rail-wheel system, especially for container transportation. The parameters of the motor have been defined in accordance with the specifications of the standard containers. Halbach array of permanent magnet installed on the vehicle is used for magnetic field excitation. The concentrated and distributed forms of three-phase armature winding are compared and discussed. 2D finite element method is used for modeling and simulation of PMLSM.

Keywords
PMLSM, Halbach array, Freight maglev, Finite element method

4 Magnetic Levitation and Guidance in Transport, Presentation

Influence of Electromagnet Eddy Current on Electromagnetic Force Characteristics of EMS Medium Speed Maglev Systems

Dang Ning
Co-Authors: Zhiqiang Long, Xiao Liang, Wuliang Wang

Short Description / Abstract

The electromagnet in the EMS system is the executive part of the train suspension, to analyze the characteristics of the eddy current produced by the end electromagnets, the article takes a single car and a single train as the research object, established the corresponding electromagnet model. Through comparing and analyzing the data from the magnetic field simulation and the experimental data of the Changsha maglev train, we can gain the characteristics of the eddy current at the speed of 160km/h and put forward the corresponding solutions.

Keywords
Electromagnet, Eddy current, EMS, Medium speed, Maglev

4 Magnetic Levitation and Guidance in Transport, Presentation

Characterization of Levitation Force for a Superconducting Magnetic Levitation Vehicle

Dos Santos Costa Felipe
Co-Authors: Rubens de Andrade, Richard M. Stephan

Short Description / Abstract

In Superconducting Magnetic Levitation (SML) transportation systems, such as the MagLev-Cobra prototype, the levitation force plays an important role, both for efficiency and safety reasons. To determine how much load the magnetic suspension system supports, numerical simulations, based on computational models, and laboratory experimental tests are normally used.

The most common way for characterization of a SML bearing is the measurement of the levitation force as a function of distance between a Superconductor and a Permanent Magnet Guideway (PMG). The measurement of levitation as a function of distance, the banana curve, has a hysteretic behavior with the results depending of the history of measurement: whether the distance between the superconductor and the PMG is decreasing the force is higher than when the distance is increasing, the force is higher with faster movements and so on. A new approach of levitation force test will be proposed as an alternative to the banana curve. This method, applied to characterize the levitation dynamics of the Maglev-Cobra vehicle, provided more reliable and consistent data with the levitation dynamics observed during the operation of the real scale prototype in the transportation of passengers.

The bench-top levitation test emulates the behavior of the vehicle along its operation, regardless of the position history between the magnets and the superconductor materials. The test consists in placing the superconductor, refrigerated inside cryostats, in a predetermined Field Cooling (FC) position, and slowly move the cryostat above the PMG to a lower high, for example 15mm, and wait 10 minutes. After that, the high is decreased 1 mm and again hold there for 10 minutes. The procedure is repeated until a high of 10mm is reached. The hole process is repeated at least 5 times. This routine replicates the load condition during the vehicle operation when passengers board the train and the load stay constant until the end of the journey. After that, another group of passengers takes place inside the vehicle and is carried to the next station.

This kind of test shows the creep of the levitation force over time with slow dynamics and gives the average load over height of levitation along the given time of operation, helping engineers to predict the load capacity of the vehicle and design a more reliable layout.

Three FC positions were investigated. The position currently used by the MagLev-Cobra (35mm) and other 2 positions (45mm and 55mm) of initial height between the superconductor and the permanent magnet guideway.

The results of these dynamic tests will be compared with the quasi static levitation force measurements and the different outcomes will be pointed out.

Keywords

Maglev Cobra, Quasi static levitation force measurements, Magnetic suspension, Superconductivity, Bench-top levitation test.

4 Magnetic Levitation and Guidance in Transport, Presentation

Experimental Confirmation of Thrust and Attractive Force of Linear Induction Motor

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Short Description / Abstract

In this paper, a maglev transportation system with a Linear Induction Motor (LIM) is introduced. Linear motors and Electro Magnetic Suspension (EMS) are used in the maglev system. Linear Induction motors (LIMs) have simple structure, flexible mechanism, and direct drive. LIMs are used to control the traction in transportation and carrier systems. High Speed Surface Transport (HSST) is one of the maglev carrier system using LIMs and EMS. In this system, the traction is controlled by LIMs, and the levitation is controlled by EMS. In this system, however, the attractive force generated by LIMs interferes to levitation. Therefore, we have proposed the maglev system using only LIMs. In this system, LIMs generates not only the thrust force but also the attractive force. The proposed system is expected to have a low cost, a compact structure and easy maintenance since levitation magnets are unnecessary.

It is proposed that two different frequency components are used to achieve the simultaneous and independent control of the thrust and attractive force of LIM. One of the frequency components is synchronous with the motor speed (fm). The other frequency is drive frequency (fd) that generates the thrust and attractive force. This proposed control method simplifies the design of the controller more easily, because the fm frequency component generates only an attractive force. Therefore, the controllers for thrust and attractive force can be separated and independent. In addition, this system has other merits. In the typical levitation system, the DC current is used in the levitation magnets for the levitation control. However, these levitation magnets generate the eddy-current brake, since the dc component has a minus slip. On the other hand, in the proposed control system, the frequency component synchronous with motor speed fm doesn't generate the brake force at all. The thrust force of LIM can be effectively used for propulsion.

We use a LIM with a disk-shaped secondary side to verify the dynamic characteristics. It is possible to measure characteristics of the LIM over a longer span of time by using a disk-shaped secondary side. We provide the torque to the secondary side via the timing belt with an additional rotary assist induction motor. It can control the rotational speed of the secondary side to a synchronous speed for the no-load test to identify the LIM parameters. In addition, it is possible to control the load torque with the secondary side in order to measure the power running and regenerative characteristics of the LIM. The load cells are implemented on the primary side and measure the thrust and attractive forces directly.

The LIM experimental equipment using a disc-shaped secondary side was used to verify the control performance. As result, it is confirmed that LIM speed control can be achieved and the thrust force and the attractive force of LIM are also able to be controlled simultaneously and independently by the proposed control method. In this paper, we control only the attractive force. It means that the primary side is not levitated because it is difficult to measure the attractive force of the levitated primary side.

In future experiments, we will control the speed and levitation of the LIM. First, we will control levitation at stop. Second, we will control speed and levitation.

Keywords

Linear drive, Linear induction motor, Motor drive, Maglev system, Motion control

4 Magnetic Levitation and Guidance in Transport, Presentation

Passively Stable Energy Efficient MAGLEV System Based on Quantum Levitation: The SupraTrans

Schultz Ludwig
Co-Authors: Oliver de Haas, Bernhard Holzapfel, Dietmar Berger, Guenter Fuchs

Short Description / Abstract

Superconducting magnetic levitation is passively stable without any electronic control, but with attracting and repelling forces to suspend a vehicle hanging or standing upright. Due to this intrinsic stability, the levitation itself does not consume any energy. These are perfect conditions for a rail-bound mass transport system like Hyperloop or for an individual transport with cabins for 4 to 5 passengers, requested call by call. The vehicles will levitate without noise over a track made of rare-earth permanent magnets. We made a big step forward in this vision by setting up the world largest research and test facility for transport systems using bulk high-temperature superconducting material in the levitation and guidance system in combination with a permanent magnet track. A vehicle for 2 passengers, equipped with linear drive propulsion, non-contact energy supply, second braking system and various test and measurement features is running on an 80 m long oval driveway. In the presentation, the principle of passively stable superconducting levitation by flux pinning in bulk high-temperature superconductors will be described. Based on this, an overview of the SupraTrans II research facility and future directions of superconductivity-based magnetic levitation and bearing for automation technology, transportation, and medical treatment under enhanced gravity will be given. Also the physics behind the “Back to the Future II” superconducting hoverboard, presented by Lexus in 2015, will be described.

Keywords

Passively stable levitation, Hyperloop, Urban transportation, SupraTrans, Superconducting levitation

Nonlinear Suspension Controller Design for EMS Maglev Train Considering Track Periodical Irregularity

Ni Fei
Co-Authors: Junqi Xu, Wen Ji, Guobin Lin

Short Description / Abstract

The design of suspension controller is one of the key technologies of EMS maglev train. Considering periodical irregularities of the rail track, a new nonlinear controller was proposed in this paper. Firstly, the nonlinear mathematical model of a single magnetic levitation system was derived. Secondly, a pseudo linear system of this nonlinear model was obtained by the exact linearization approach. Then, the sources of rail track irregularity are discussed, and the irregularity models are presented. Finally, based on the pseudo linear model, a nonlinear suspension controller which can track the predefined suspension gap, was designed using state feedback. The effectiveness of the control rule is evaluated by numerical simulations.

Keywords

Maglev train, Suspension control, Nonlinear feedback, Rail track, Periodical irregularity

A New Type of Levitation Chopper for Middle-Low Speed Maglev Train

Xu Junqi
Co-Authors: Guo Yuhua, Lin Guobin, Ji Wen, Ren Linjie

Short Description / Abstract

At present, Changsha maglev express line and Beijing S1 line middle-low speed maglev train which have been put into operation are all constructed by H-bridge type levitation chopper consisting of IGBT power module. This type of levitation chopper has the advantages of simple control, stability and reliability, but there are many problems such as large volume and weight, large switching loss, low conversion efficiency, poor electromagnetic compatibility, severe heat and the need of additional heat dissipation fans.

Having adopted new technologies and devices and aiming at reducing the weight and volume, reducing the noise and improving the electromagnetic compatibility, a systematic optimization scheme is put forward. To increase fast discharge circuit, reduce switching loss and reduce the volume, the high-power MODFET and SIC which substitute IGBT are used in the main circuit, and four small capacity parallel capacitors are used as the supporting capacitor. Besides, the electronic switch substitutes the charge contactor to increase the output common mode suppression circuit. In this paper, the performance test of single suspension rack and suspension operation test of a single car are carried out by using a prototype. The maximum running speed of maglev train reaches 100km/h, and the suspension performance is stable and reliable.

The final test results show that the weight, volume and loss of the developed prototype are 25%,35% and 25% of the original and there is no need of the heat dissipation fan, so that the mute operation is realized.

Keywords

Middle-low speed maglev train, Levitation, Chopper, MOSFET, SIC, IGBT

6 Linear Motors, Presentation

An Approach to Research the Fringing Flux in Transverse Flux Linear Induction Motors

Rolando Caicedo
Co-Authors: Ernesto Ruppert Filho, Carlos A. Baldan

Short Description / Abstract

This work shows a study of the magnetic fringing flux which is present in the air-gap of an E-shape transverse flux linear-induction motor. The distribution of the fringing flux was modeled assuming exponential functions in the transverse and longitudinal directions. An analytical method was developed to evaluate the influence of the fringing flux in the linear force produced by the transverse flux linear induction motor. The results obtained from the analytical method are compared with a model developed with the finite element method. Comparison results show that the fringing flux has an important role in the total force developed by the transverse flux linear induction motor, thus it cannot be neglected.

Keywords

Linear induction motor, Fringing flux, Finite element method, Transverse flux, Linear force

6 Linear Motors, Presentation

Concentrated Winding Linear Synchronous Machines for Transport

Stephen Colyer
Co-Authors: J.F. Eastham, A. Foster

Short Description / Abstract

Concentrated winding Linear Synchronous Machines for Transport

The paper is concerned with the winding configurations for an air-gap wound linear synchronous machine for transport applications. The machine uses a long track winding in the form of a coreless vertical fin. This cooperates with a vehicle mounted excitation system using double-sided permanent magnets with backing core. This configuration has useful attributes:

• There are no current pick-up problems.

• There is a relatively small lateral force on the vehicle even when the fin is not centrally disposed.

• The inductance of the winding outside the vehicle is low which minimises the supply volt amp requirements.

The most compact form of winding for the machine uses a set of 3 non-overlapping planar race track coils connected in sequence to a 3-phase supply. This 3-coil set principally produces 2 and 4 pole harmonic fields. Either of these fields may be used for force production by using a matching magnet array. The other field then drives airgap flux, but no force is produced. The disadvantages of the unused field are:

• In the vehicle permanent magnet region, it increases the synchronous reactance and therefore reduces the power factor. It also induces permanent magnet eddy current losses.

• More importantly it increases the reactance of the winding outside the excited region and can produce a considerable increase in the power supply volt amps.

The unwanted field can be cancelled by dividing the airgap winding into two longitudinal sections and offsetting one of them in the direction of motion. This principle has been used for linear induction machines and other applications. (1)(2).

The offsetting principle can also be applied to the other common forms of concentrated winding connection, namely the 9-coil set to produce 8 and 10 pole harmonic fields, and the 12-coil set to produce 10 and 14 pole harmonic fields.

A new comprehensive harmonic winding analysis is used to compare and contrast the different possibilities with the 3 coil/4 pole and 12 coil/14 pole arrangements down selected for further attention. Designs analysed by both algebraic layer theory (3) and 3D finite element models, are compared with results from a test rig.

The results obtained confirmed that the offset windings produce benefits in ripple force, force density, and VA/N. However, the outstanding benefit is shown in the inactive region of the machine where the supply voltage required is of the order of 60 % of the single layer case. This is of great system benefit.

Keywords

Linear, Synchronous, Windings, Permanent magnet, Concentrated

6 Linear Motors, Presentation

Linear Motors for High Precision Applications

Chris Cook
Co-Author: Philip Commins

Short Description / Abstract

The consistent need for increased accuracy and speed of machine tool linear axes has lead industry and researchers to look for alternatives to the common ball screw mechanism. Direct drive linear motors can exhibit less position dependent force variations and smoother velocity control at low speed compared to ball screws due to reduced friction and zero backlash. This paper presents three different types of linear motor technologies, namely a permanent magnet tubular motor, a synchronous reluctance tubular motor and a double-sided flat induction motor. Each motor has been designed and simulated with Finite Element methods to minimise cogging forces while maximising thrust. The motors were built and experimentally tested to validate the simulated results.

The manufacturability of these motors has been investigated and novel techniques to construct the motors will be presented. Given the nature of the tubular design, the synchronous reluctance motor presents a unique topology of structuring the layers of permeable material in the stator. Optimal geometry of the permanent magnet motor results in minimising cogging forces and a novel technique of winding is presented. The cogging forces of a double sided linear induction motor with a ladder array in the stator is analysed. Algorithms for increased precision motion control are discussed for the linear motors, taking into account compensation for cogging forces.

The three linear motors are experimentally tested and compared to simulated results with good comparisons.

Keywords
High precision linear motors

6 Linear Motors, Presentation

Design of a SLIM for HTS Magnetic Levitation and Propulsion System

Guo Youguang
Co-Authors: Jianxun Jin, Jianguo Zhu, Gang Lei

Short Description / Abstract

The single-sided linear induction motor (SLIM) may be classified into two categories based on the relative length of the primary and the secondary, short-primary (long-secondary) SLIM and long-primary (short-secondary) SLIM. Currently, the short-primary SLIM is widely applied to industrial equipment and transportation systems, especially in intermediate speed range for its lower manufacturing and operating cost. However, in certain applications where higher force density or acceleration is required to be provided in short operating time, the latter would be the preferred type due to its lightweight secondary conductive sheet. These applications include electromagnetic aircraft launching and car-crash testing systems. In order to keep stable and unchangeable air gap, slide rails are commonly used on both-sides of SLIM, which will cause sliding friction force to degrade performance of motor. Because stable levitation force can be generated between NdFeB permanents magnets (PMs) and high temperature superconducting (HTS) bulks, HTS-PM repulsion levitation system composed of PM-guideway and HTS bulks can be integrated into the SLIM to replace the slide rails. The main advantage of HTS levitation propulsion system is the strong levitating force with passive and self-stabilizing feature, leading to the removal of the sophisticated control system for regulating the air gap between guideway and levitated moving secondary, which is necessary for other types of levitation transportation systems.

In this work, an HTS magnetic levitation and propulsion system having a long-primary SLIM and an HTS bulks-PM guideway repulsion levitation sub-system is developed. The performance and characteristics of the SLIM are studied using analytical method and numerical method like finite element analysis (FEA). The performance includes the start-up characteristic and load capacity, taking into account the influence of exciting frequency and length of air-gap. Based on the analysis, and other correlation techniques previously developed, an optimal design for the SLIM secondary is carried out, and the influences on the SLIM performance from its structure, material and dimensions of the SLIM secondary have been identified forming the basis for practical developments.

The results confirm that the linear motor with the compound material secondary has better thrust performance than that of the single material secondary. For the compound secondary, it has an optimal thickness of conductive plate, and an optimal thickness of the back iron plate according to the exciting voltage to reach the biggest force, and the length of secondary with even poles has better thrust performance than that with the odd ones. Comprehensive analytic results obtained verify the design principle of a SLIM to be practically applied in HTS maglev and propulsion systems.

More detailed analyses and results will be presented in the full paper.

Keywords

Single linear induction motor (SLIM), High temperature superconducting (HTS), Magnetic levitation, HTS propulsion

6 Linear Motors, Presentation

Design of Single-Sided Linear Induction Motor for Low Speed Maglev Vehicle in 160km/h and Variable Slip Frequency Control

He Yun-Feng
Co-Authors: Wang You-Sheng, Lu Qin-Fen, Zhang Lei, Fang Liang

Short Description / Abstract

The low-speed Maglev vehicle adopts the single-sided linear induction motors (SLIMs) as driven part, which design and control method become research hots along with the increasing of velocity. This paper introduces the design scheme of SLIMs for 160km/h low-speed maglev vehicle and proposes a novel variable slip frequency control method. SLIM uses low slip frequency at starting to produce large starting traction force, and high slip frequency during high velocity area to obtain a greater power. In the same time, the normal force is also changed. With this method, the capacity of the system can be effectively reduced and the lightweight design of SLIM is realized, which meets the requirement of both high starting acceleration and the residual acceleration requirements for 160km/h low-speed maglev vehicle.

Keywords

Medium and low speed maglev vehicle, Linear induction motor, Slip frequency, Traction force, Normal force

6 Linear Motors, Presentation

Linear Vernier Actuator with Two Movers

Heya Akira
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Short Description / Abstract

Linear motion mechanisms for industrial machines and robots are expected to realize their high drive efficiency and structural simplification. Usually, a feed screw mechanism composed of a rotary motor and a ball-screw or slide-screw is employed, however, it has some problems such as the decrease of the drive efficiency, flexibility against external forces, noise and so on. Then, various linear actuators and motors have been developed utilizing the feature of direct drive.

In this study, we propose a novel linear actuator which can be independently controlled the two movers for decreasing the size and weight of the system. The actuator is driven by the operating principle of a Vernier motor which is expected to achieve a high thrust force density per volume of permanent magnets. The movers can be independently driven using 3-phase and 6-phase superimposed currents. Firstly, the basic structure and operating principle of the proposed actuator are described. Next, the static thrust force characteristics are analyzed by the electromagnetic field analysis using 3-D finite element method, and the dynamic characteristics under position feedback control are also analyzed. Finally, the effectiveness of the proposed actuator is verified.

Keywords

Linear actuator, Vernier motor, Electromagnetic actuator, 3-D FEM, Superimposed current

6 Linear Motors, Presentation

Constant Switching Frequency Model Predictive Control for Permanent Magnet Linear Synchronous Motor

Ma Zhixun
Co-Authors: Yuanzhe Zhao, Yan Sun, Zhiming Liao, Guobin Lin

Short Description / Abstract

Constant switching frequency model predictive control (CSF-MPC) for a permanent magnet linear synchronous motor (PMLSM) is proposed in this paper. The conventional finite control set model predictive control (FCS-MPC) can be combined with a pulse width modulation (PWM) modulator due to an effective cost function optimization algorithm which is from the idea of dichotomy. In the algorithm, all the voltage vectors in the constrained vector plane are dynamically selected and calculated through iteration. With the modern digital processors or control hardware such as digital signal processors (DSPs) or field programmable gate arrays (FPGAs), the algorithm can be easily executed in less than 10 microseconds. This is very proper for industrial applications. The proposed CSF-MPC for PMLSM not only keeps the same dynamic transient performance as FCS-MPC but also greatly decreases the torque ripple in steady state. Furthermore, CSF-MPC is also robust to parameter variations. Simulation and experimental results illustrate that CSF-MPC has an attractive performance for PMLSM drives.

Keywords

Permanent magnet linear synchronous motor (PMLSM), Model predictive control (MPC), Optimal control, Cost function, Digital control

6 Linear Motors, Presentation

Multifunctional Linear Asynchronous Motor with Longitudinal-Transverse Magnetic Flux for Magnetic Levitation Transport

Vladimir Solomin
Co-Authors: Andrey Solomin, Viktor Koledov, Nadezhda Trubitsina

Short Description / Abstract

The traction linear motors (TLM), at the present stage of the development of the society, are the most promising for the high-speed magnetic levitation transport (MLT) and are already being operated in a number of commercial projects. The linear asynchronous motors (LAM) may be arranged with a longitudinal, transverse and longitudinal-transverse magnetic flux and have a large number of constructive options. Apart from traction force, LAM reach magnetic levitation and lateral stabilisation (self-stabilisation) forces. The magnetic levitation forces with the longitudinal and transverse magnetic fluxes are highly significant in the zones of sliding (at low speed of running) and they decrease as the speed of the maglev transport increases. To a lesser extent, the decrease of sliding (at high speed of running) influences the magnetic levitation forces, reached by a number of constructive options of the linear asynchronous motors with the longitudinal-transverse magnetic flux, where magnetic fields running towards each other in transverse direction are additionally used. This is explained by the fact that both at low and high speeds of MLT, the sliding of LAM relative to the magnetic fields running towards each other in transverse direction, will equal to one, and the magnetic suspension effort will be maximum. The magnetic fields running towards each other in the direction transverse to that of the MLT, cross the electroconducting secondary element (which is the guideway of the high-speed transport system) and induce electromotive forces there, under influence of which the currents will run. As a result, the transverse counter-directed mechanical efforts arise, which, provided that the MLT vehicle is symmetrically located relative to the guideway, are mutually balanced and exert no influence on the running of the MLT. At lateral (transverse) displacement of the high-speed maglev transport relative to the guideway, the balance of the transverse mechanical efforts will break, with the MTL vehicle automatically returned to the initial symmetrical position under the action of the difference of efforts.

The distribution of the magnetomotive forces (MMF) of the linear asynchronous motor with the longitudinal-transverse magnetic flux, the magnetic system of which is arranged by virtue of the combination of longitudinally and transversely laminated core, on the teeth of which the three phase concentric winding coils are located, has been considered. The relationship in the form of double Fourier series for calculation of the resulting value of the EMF in the air gap of the linear asynchronous motor with the longitudinal-transverse magnetic flux has been presented.

Keywords

Linear asynchronous motor, Longitudinal-transverse magnetic flux, Magnetic levitation, Magnetomotive force

6 Linear Motors, Presentation

New Technology of Manufacture of Linear Asynchronous Motor Inductors for Magnetic Levitation Transport

Vladimir Solomin
Co-Authors: A. Solomin, L. Zamshina, N. Trubitsina, A. Chekhova

Short Description / Abstract

The magnetic levitation transport (MLT) has prospects of becoming widely used in passenger and freight transportation in the foreseeable future. As the traction electric machines of the MLT the linear motors are used, which may be either asynchronous (LAM) or synchronous (LSM). In the combination with the electromagnetic levitation of high-speed trains (successfully used in China) it is reasonable to use the linear asynchronous motors. The maglev which is operated in China has a 30 km long guideway, arranged of the inductors of the LAM.

Given the increasingly wide operation of the high-speed MLT, the issues of manufacture technology of the LAM (LSM as well) inductors are becoming acute. The conventional technology of the LAM inductors, just like that of other electric machines, involves manufacturing individual junctions and details with their subsequent assembling into a finished product.

The authors suggest a new technology of manufacturing the inductors for the LA, which excludes the intermediate manufacture operations of individual elements of construction of the electric machine and their subsequent assembly operation. The basis of the new, cutting-edge technology is constituted by the well-known methods of spraying of materials: the flame spraying (thermal spraying) and the plasma spraying. The LAM inductor is manufactured by virtue of an alternate spraying onto the pre-fabricated “substrate” of the ferromagnetic (forming of the magnetic core), isolation (laying of the slot insulation, minor insulation and inter-coil insulation) and electroconducting (manufacture of the winding) materials. Laying of the materials onto the substrate is performed with the help of the pre-prepared stencils.

First, by either the thermal or plasma spraying, the yoke of the core in the LAM is sprayed, then using another stencil, the tooth area of the LAM inductor is made. The next replacement of the stencil allows laying the slot insulation, whereas to make the winding, a set of stencils should be made which will enable a layer-by-layer spraying of the coil, separated by the layers of the insulation material, and forming coils of the winding before the final product, the LAM inductor, is obtained. The proposed integrated technology of manufacturing the LAM inductors may be automated, and the industrial robots are suitable for its realisation.

The materials suitable for the application in the new, integrated technology of the manufacture are considered in this paper. The details on the types of the stencils for spraying the materials and the relation for the determination of their sizes are presented.

Keywords

Magnetic levitation transport, Inductor of linear asynchronous motor, New technology of manufacture, Material spraying, Stencils

6 Linear Motors, Poster Session

The Variable Slip-Frequency Control of Linear Induction Motor Applied in Fast Speed Maglev Train

Deng Jiangming
Co-Authors: Ying Yang, Laisheng Tong, Qibiao Peng, Xiaochun Li, Jianguo Suo

Short Description / Abstract

The equivalent circuit model (ECM) based on d-q rotary reference frame for linear induction motor (LIM) applied in fast speed maglev train was established. The related control parameters including variable slip-frequency were theoretical analyzed. The overall performance of LIM was calculated according to given top indicators. Three-dimensional finite element analysis (3D-FEA) was carried out, and the results were compared to the actual tests to verify their consistency.

Keywords

Equivalent circuit model (ECM), Linear induction motor (LIM), Variable slip-frequency, Three-dimensional finite element analysis (3D-FEA), Fast speed maglev train

6 Linear Motors, Poster Session

The Linear Motor Driven Container Transport System

Fang Jiarong
Co-Authors: Bruce Montgomery, Guobin Lin

Short Description / Abstract

The MagCargo container transport system using new-generation permanent magnet linear synchronous motors will be developed by Magplane Technology, Inc. and China Railway Rolling Stock Corporation in 2018. The MagCargo system is designed to carry the containers from the seaport to the cargo distribution center in order to resolve the congestion of the seaport transportation.

Based on the successful cycling running of 1km linear motor driven MagTrack system using the linear synchronous motors in Zhangjiakou demonstrated since 2013, a series of innovations had been made to increase the transport capacity from 10 to 50 million ton/year, which presents a challenge for the motor deign and guideway structure.

The MagCargo consists of 12m-long standard modules which can contain one to four 3m-long standard non-continuous motor winding modules. The 350m demoline has totally 36 modules to simulate the straight section with switch, horizontal and vertical curves, and an artificial hill to fully demonstrate slope-climbing capability. Upon completion of the 350m demoline, a 6km-long commercial MagCargo system is expected to be constructed.

Keywords

Cargo transport, Linear synchronous motor, Propulsion, Permanent magnet

6 Linear Motors, Poster Session

Control of Three-Degree-of-Freedom Resonant Actuator Driven by Novel Vector Control

Kato Masayuki
Co-Author: Katsuhiro Hirata

Short Description / Abstract

Linear resonant actuators (LRAs) have been used in a wide range of applications because they can reciprocate in a comparatively short stroke in spite of their compact size and lightweight. In order to broaden the application range of LRAs, various kinds of multi-degree of freedom (DOF) resonant actuators have been developed. Authors have also proposed a two degree-of-freedom resonant actuator that was able to be independently driven in x- and z-axes by vector control. Additionally, authors have designed a three-DOF resonant actuator driven by conventional vector control. However, the previous control method did not completely control the thrusts in three directions (x, y, and z) because the magnetic circuit for each axis was not independent.

In order to improve controllability of the thrust, this paper proposes a novel vector control method using a four-phase system. Four fundamental voltage vectors (Vx, Wx, Vy, and Wy phases) are defined in a stationary three-dimensional (3-D) coordinate systems. 3-D rotation using Euler angles achieved a spatial dq transformation. Electromagnetic field analysis by 3-D finite element method suggested that x- and y-axes thrust did not affect each other strongly when the proposed vector control was applied. Additionally, the higher controllability of the thrust contributed to a precise amplitude control in the three directions under three axes oscillation. Finally, the effectiveness of the proposed method was verified by comparing with the conventional method.

Keywords

Resonant actuators, linear actuators, vector control, electromagnetic actuators, amplitude control

6 Linear Motors, Poster Session

Investigation of Linear Induction Motor System with Matrix Converter for High Efficiency Operation

Kubota Aiko
Co-Authors: Toshimitsu Morizane, Noriyuki Kimura, Hideki Omori

Short Description / Abstract

Linear induction motors (LIMs) are a kind of linear motor which have a simple structure and an easy maintainability. On the other hand, they are generally less energy efficient than normal rotary motors.

A matrix converter is a convenient device to compensate the high loss of LIMs. It is a direct AC-DC converter, thus it can return power to the input power line when the motor decelerates. And it can connect to the input power line directly without conversion when the output frequency and voltage match that of the input. In addition, it has advantages including more compact size and longer lifespan than usual inverters. A linear motor system with a matrix converter has the potential to utilize under a various condition and to increase the efficiency of the entire system.

In our previous experiments, it was confirmed that the matrix converter can operate LIMs both in the powering and regenerative state. Although the matrix converter has more switches than a usual inverter, there is no large difference between two conversion efficiency in the case of the powering state. Moreover, when the output frequency of the matrix converter matches the input frequency, the matrix converter switches to the direct connect mode. Under this mode, the efficiency was increased compared to the normal conversion mode. However, a current shock causes by abrupt increase of voltage utilization factor when the direct connect mode was switched. We will evaluate the stability and efficiency of a LIM system by using a matrix converter.

Keywords

Linear induction motor, Matrix converter, Direct connect, Conversion device, Efficiency

6 Linear Motors, Poster Session

The Influence of the Secondary Construction on the Harmonic Air-Gap Magnetic Field in the Linear Induction Motor

Lyu Gang
Co-Authors: Tong Zhou, Dihui Zeng

Short Description / Abstract

The high-order space harmonics exist in the air-gap magnetic felid of the linear induction motors, and the large harmonic components could lead to increase of the vibration and noise in the motors. The secondary conduction is a very important factor which influences the harmonic components of the air-gap magnetic felid. In this paper, the 3-D finite element method is adopted to calculate the air-gap flux densities of the linear induction motors with the flat secondary. The distribution of the harmonic in the air-gap magnetic felid is given, and the harmonic distortions with the different reaction plate thickness and are calculated and compared, as well as the influence of the reaction plate with different materials and the different frequencies are presented.

Keywords

Harmonic, Air-gap flux density, Linear induction motor, Secondary, Finite element method

6 Linear Motors, Poster Session

A Method of Thrust Ripple Suppression for Long Stator Linear Synchronous Motor

Mu Siyuan
Co-Authors: Wang Shuo, Liu Yusong, Kang Jinsong

Short Description / Abstract

With the advantages of high speed, low noise and high efficiency, the EMS maglev train has a good prospect in railway transportation. It is based on the long stator linear synchronous motor (LSLSM). However, due to the harmonic in the stator current and flux density distribution around the air-gap the thrust generated by the LSLSM fluctuates. The thrust ripple brings noise, drop of control accuracy, even with the resonance of train. In this paper, the thrust ripple produced by the harmonic current is analyzed. Then a method of harmonic injection is proposed to reduce the harmonic of the stator current and reduce the thrust ripple. Meanwhile, because of the decrease of the harmonic of the stator current, the iron loss in stator core is reduced, and the traction and suspension system can be better decoupled. Finally, the validity of the method is verified by simulation on Simulink.

Keywords

Maglev, Long stator linear synchronous motor, Thrust ripple, Harmonic current injection

6 Linear Motors, Poster Session

Current Mode Performance of a Traction Linear Induction Motor Driven from the Voltage Converter

Ryszard Palka
Co-Authors: Konrad Woronowicz, Jan Kotwas

Short Description / Abstract

Traction Linear Induction Motor (LIM) has been deployed worldwide in driver-less transit systems requiring very short headways for all weather conditions. The systems based on LIMs have proven to be, by far, the least expensive in operations and maintenance (including energy consumption). Electromagnetic FEA (Finite Element Analysis) calculations are crucial to optimize the LIM system performance as they provide information about its mechanical characteristic, force versus speed, shaped by the so-called end effect, and allow for the most efficient controls. To simplify the FEA model and to minimize time to numerical solution, the symmetrical three phase current can be used, however, this does not reflect the reality when LIM is driven from the voltage inverter. This paper shows differences in slip versus thrust characteristics between the simplified FEA approach and the one where asymmetry of phase currents arises naturally from real supply conditions.

Keywords

Linear induction motors, Electromagnetic FEA, Power supply

7 Superconductors, Application of Superconductivity, Presentation

Competition between the Antiferromagnetic Phase and the Superconducting Phase and the Effect of the Magnetic Fluctuations in the Underdoped BaFe2-xNixAs2

Abbassi Abdellatif
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Short Description / Abstract

We report a comparison between the results obtained by three different measurements of the temperature and RF frequency dependence. The results of the relative change of the ultrasonic attenuation and the electrical conductivity show respectively the competition between the antiferromagnetic and superconducting states and the effect of magnetic fluctuations in the underdoped superconducting BaFe2-xNixAs2.

These results concern the measurement of the surface impedance in the underdoped superconducting BaFe2-xNixAs2 crystal in the 5<T<30K temperature range using two methods based on the radiofrequency reflection technique and by Ultrasound technique. The measurements by induction were done with LC resonant circuit at 92 MHz and with impedance measurement using impedance and network analyzers in the frequency range 10 MHz–1.5 GHz.

Keywords

Superconductivity, Iron superconductors, Surface impedance, Ultrasonic attenuation, Electronic conductivity

7 Superconductors, Application of Superconductivity, Presentation

Recent Activities of HTS Maglev in ASCLab

Deng Zigang
Co-Authors: Jun Zheng, Ruixue Sun, Hengpei Liao,
Xinxin Zheng, Jianghua Zhang

Short Description / Abstract

New superconductor materials have been constantly found since the discovery of superconductivity in 1911. With the critical temperature and inherent flux-pinning property improved continually, the practical high temperature superconducting (HTS) magnetic levitation (maglev) technology in rail transit became possible. The development history and the current state of the HTS Maglev in Applied Superconductivity Laboratory (ASCLab) are elaborated in detail. On the basis of the test vehicle “century” born in 2000, improvements and new technologies need to be investigated. First of all, a 45-m-long HTS Maglev ring test line, named “Super-Maglev”, was successfully developed focusing on the high-efficiency and low-cost. Then, aiming to eliminate the obstacle of air resistance, a test platform for HTS Maglev-Evacuated tube transport (HTS Maglev-ETT) was established in June 2014, in which the HTS Maglev and the ETT had been successfully combined. Recently, a hybrid maglev vehicle with both permanent magnetic levitation (PML) and superconducting magnetic levitation (SML) was proposed for enhancing load capacity. We continue to promote the HTS Maglev technology, and offer a new rail transit tool with high speed, energy efficiency, environmental friendly and low cost.

Keywords

Bulk high-temperature Superconductors, Superconducting maglev, Evacuated tube, Low pressure, Hybrid maglev

7 Superconductors, Application of Superconductivity, Presentation

Next Generation Transportation System for Istanbul

Metin Guenes

Short Description / Abstract

The project is designed as a superconducting maglev, which is defined as a next generation transportation system with very good energy performance compared to similar transportation systems, which is mainly suitable for non-contact transportation, capable of stable operation at high speeds, capable of moving within very sensitive tolerances and controllable.

In the project, it was considered to use Niobyum-Titanium alloy superconducting material, which is superconductive by being cooled to 269 ° C, with Helium, which is a ready-made technology developed by the Japanese.

With its unique tunnel technology, its own station design, its own vehicle design and its own operation design, it can be said that this project which is prepared for Istanbul with the features of being able to go horizontally and vertically in the vehicles used in the system, is a first in the world.

The total line length of the project is 240 Km and consists of 19 stations.

With this project, Sabiha Gökçen Airport is connected directly with İstanbul 3rd Airport which is one of the pride projects of our country. The two international airports of Istanbul can be reached in 19 minutes by this project.

The project can be completed within 5 years after the feasibility study project preparations are made and the place has been delivered.

This can be said to be very ambitious compared to similar projects, but we can easily say that the progeny may be dependent on the content and construction technology.

In order to give an idea of this, it is only necessary to open a tunnel with a cross-sectional area of only 12 m2 for a single-tube tunnel in this project, for example, if the single-tube tunnel excavation in the existing subway systems is carried out at a cross-sectional area of 36 m2. This also means that the cost of tunnel excavation is reduced by three times.

In the project, 6 tube tunnel between Altunizade and Mecidiyekoy and throat passage is planned as a tunnel. It can also be operated as a second line between Mecidiyeköy and Altunizade for 15 seconds at frequent intervals.

If the system is operated completely for 15 seconds, the daily passenger carrying capacity reaches 21,168,000 passengers in 18 hours' operation. This capacity is currently a passenger carrying capacity well above the daily total passenger carrying capacity of all public transport systems.

Currently, the number of vehicles planned for the system is 900 units. The vehicles defined as F100 are 100 passenger capacity.

All of the vehicles will be designed as intelligent and special design suitable for the system. It is thought that the vehicle body material is equivalent to the airframe material. Vehicles used in the system can move horizontally and vertically.

Every vehicle will have an ID registered with the system. It will automatically serve on routes and stations where it is registered to the system.

Thanks to the dedicated station design and operation system, vehicles can transit between stations.

For example, Sabiha Gökçen Airport Station is directly towed to Istanbul Airport 3, and the vehicle can go without waiting in any interstate.

Tunnel excavation is planned to be done with TBM and it is considered to be made as a tunnel coated with insulation prepared modularly in the fabrication environment.

Tunnel drainage and many other issues have been resolved during the project design phase. For example, there are no water leaks in the tunnels. Since there is no contact, there are no problems such as noise and vibration.

One of the most important features of the project is that the boarding and landing of vehicles is designed from the passenger compartment (Ticket Hall)

In addition, the riding and descending passengers do not meet each other because of the special station design.

There are no passengers on the vehicle floor at the station where the line passes through the system.

Thanks to the special station design, there is no need to build thousands of m2 stations as it is in existing subway stations

The location of the passenger floors will be planned after the clearance of the station locations. My desire is that if the proper place for the station construction is provided, the floors of the passengers are completely on the earth.

Passengers will drive on the ground and will land on the ground in the passenger station. This means that there is no need to install dozens of stairs, escalators, elevators and walkways and environmental control systems at the stations.

Another important feature of the project is that the main lines are constantly open except for very short time periods, as passenger lowering, lapping and waiting are not done in the main lines.

One of the important features of the project is that there are no cross passes at any point in the tunnels. All transitions and directions are planned as modular depending on the automation on the truck floor. Possible cross lines due to tunnel cross section and modular structure can be done without intersection with difference of elevation.

Another different feature of the project is that the tools are individual. The tools are not used in any way as 4 or 8 li. If necessary, 2,3,4,5,6,7,8 vehicles in the same direction can be sent in sequential order with intervals of 15 seconds. Another important feature of the project is that the entire system is connected to automation. It can be said that the system has a kind of artificial intelligence. All operations can be controlled twice at the moment and can be commanded twice at the moment.

In addition, all movements in the system move within 0.1 mm tolerances and can be controlled. This is a zero error in the system of a different meaning. The human factor is the only surveillance position. In short, the system as a whole can be described as a transportation robot.

The project can return the investment cost within 7 years. The end result is that if the project is given by build-operate-transfer model, the project content can easily find the necessary financing with 25 years lease time without putting our state under any financial obligation and also without the need for a guarantee of the number of passengers. In addition, due to taxation throughout the enterprise, our state will also have a significant income gain.

Keywords

Superconducting, Maglev, Next generation transportation system, Istanbul, Cryotech, Magnet

7 Superconductors, Application of Superconductivity, Presentation

Design of a Superconducting Electromagnet with 2G HTS Wire for the Propulsion and Levitation of the Subsonic Transportation System

Lim Jungyoul
Co-Author: Changyoung Lee

Short Description / Abstract

We are developing core technology of the transportation system that operates vacuum tube above 1000 km /h. For the subsonic propulsion and dynamic stability magnetic levitation techniques are essential, and consequently the subsonic capsule train requires superconducting electromagnets (SCMs) to be used for efficient propulsion, levitation and guidance. In the design of the superconducting electromagnet (SCM), 2G HTS wire operating around 35K is aimed for developing detachable cryocooler system. While operating temperature and current can be improved by using 2G HTS wire, there remains a relatively high price for the HTS wire and the securing stability of the mechanical structure.

The purpose of this study is to design multi-pole SCM for the propulsion and levitation of a subsonic capsule train. Specifically, for the SCM designs with various shapes and sizes, the critical magnetic field and the critical current are analyzed, and then an efficient design is determined in the view of optimal magnetic field distribution on target space. In addition, an effective supporting structure which limits the strain of the SCM wire to a certain level can be determined by analyzing the deformation of the SCM wire due to the self and external magnetic fields under operating conditions.

Keywords

Superconducting Electromagnets, Hypertube, Hyperloop, 2G HTS design, Magnetic levitation

7 Superconductors, Application of Superconductivity, Presentation

Multilayer Superconducting Nb50Ti Tape Made of Cu/Nb/Ti Composite by Solid-Phase Method

Valery P. Korzhov
Co-Author: V.N. Zverev

Short Description / Abstract

By virtue of the diffusion welding and pack rolling, in two cycles the test samples of the multilayer superconducting tape of the Nb–50%Ti alloy were fabricated. In the first cycle, a multilayer Nb/Ti pack, assembled of Nb and Ti foils, was exposed to the diffusion welding at 1050 °C during 10 minutes at a pressure of 16.5 MPa and was rolled to an 0.2 mm thick tape. In the second cycle, the pack was assembled of the patches of the tape from the first cycle, several Cu plates and thin (≤100 mm) Nb foils, serving as the diffusion barriers between the titanium and the copper during the next heating of the pack. The temperature of the diffusion welding in the second cycle was sustained at approximately 1000 °C.

Then the package rolled to a tape thickness of 0.1 mm. The stratified laminate structure of the tape formed after two cycles consisted of (•) layers of the Nb50Ti alloy that had inherited the Ti-foil, which alternated with (•) layers of the Ti solid solution in niobium (Nb), which inherited Ti layers, (•) several copper layers stabilising the superconducting the state of the tape, and (•) Nb interlayers bordering the Cu layers and the Nb50Ti/(Nb) arrays.

Measurements of the critical current of the I_C tape were carried out in a cryostat with liquid helium in a magnetic field H produced by a superconducting solenoid for parallel H || (ab) and perpendicular H ⊥ (ab) orientations of the direction H and the plane of the tape (ab). The transport current I running through the sample in both cases was perpendicular to H. At H ⊥ (ab) I_C sharply fell with the field increase already in the range from 0 to 1 T. While at H || (ab), it gradually decreased, remaining at 5 T at ~ 30 A, which corresponded to the engineering critical current density of $3 \cdot 10^4$ A/cm^2.

The anisotropy of IC, equal to the ratio $I_{C||}/I_{C\perp}$ at H = 1 T, was >82. This indicates that the pinning of superconducting vortices localised in the NbTi alloy occurs at the boundaries of the (Nb)-NbTi, i.e. nonsuperconducting layers (Nb) and the NbTi alloy carrying the superconducting current.

The resulting conductor did not require a long, ~300 hours, low-temperature annealing at 280–300°C, which is necessary for the deposition of the α-phase in the Nb–Ti alloy, which serves as the centres for pinning of superconducting vortices in wires and tapes fabricated using traditional technology. The second advantage and novelty of the method is the exclusion of energy-consuming the garnisazh smelting of the NbTi alloy.

Keywords

Superconducting tape, NbTi alloy, Diffusion welding, Layered structure, Composite, Critical current, Superconducting vortex, Pinning

7 Superconductors, Application of Superconductivity, Poster Session

Magnetic Fluctuations in BaFe2-xNixAs2 Superconductors

Abbassi Abdellatif
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Short Description / Abstract

Anomalies found in the electronic conductivity and the elastic constants C33 and C44 around the superconducting phase transition in the underdoped BaFe1.93Ni0.07As2 compounds are re-examined.

The large anomalies in the elastic constant C33 and C44 modes the unusual temperature dependence of the real part of the electric conductivity found around the superconducting phase transition Tc ~16 K are attributed to magnetic fluctuations.

The establishment of a magnetic order at TM~21 K results in a marked decrease of the scattering of electronic carriers.

Such a magnetic ordering at TM=21 K has an effect on the electrodynamic properties in the superconducting state below Tc=16 K.

A similar anomaly in C33 was observed in the optimally doped Ba(Fe 0.94Co0.06)2As2 crystal around the superconducting phase transition by the Japanese team of M. Yoshizawa.

Keywords

Iron superconductors, Superconductivity, Surface impedance, Ultrasonic attenuation, Electronic conductivity

7 Superconductors, Application of Superconductivity, Poster Session

Design and Experiments of Cryocooler-Free High-Tc Superconducting Electromagnet for Linear Synchronous Motor

Lee Chang Young
Co-Authors: Jeong-Min Jo, Su-Yong Choi, Jungyoul Lim, Kwan-Sup Lee

Short Description / Abstract

Korea Railroad Research Institute (KRRI) has researched on GdBCO-based High-Tc superconducting linear synchronous motor (HTS LSM) applicable from high-speed Maglev to Hyperloop of 1000 km/h. In our previous research, a small-scale HTS LSM of 10 m was successfully demonstrated and proved the reliability of HTS electromagnet in which non-insulated GdBCO HTS coils were used. Based on the test results, about 150 m-length LSM test track with a moving vehicle, which is able to test at the speed of over 100 km/h, is planned to build in 2020. A prototype HTS electromagnet was newly designed for the LSM track.

This paper introduces the prototype designed and experimental results to prove its design feasibility. The prototype consists of a pair of non-insulated HTS coil and a vessel containing LN2 in cryostat. Helium gas blower is used as the cooling system to initially cool LN2 to solid state of below 35K and then removed from the HTS electromagnet. The cooling temperature to operate HTS coils is maintained only by thermal capacity of solid nitrogen. In order to extend the maintaining time below the operating temperature of HTS coil, we embodied persistence-current mode operation for HTS coil which makes it possible to eliminate joule heat by disconnecting current leads from HTS coil. With this operation scheme, the HTS electromagnet can be operated without on-board cryocooler and power supply system, which is also advantageous in designing vehicle bogies lightly.

Keywords

Linear synchronous motor, High-Tc superconductor, Cryocooler-free

7 Superconductors, Application of Superconductivity, Poster Session

Optimization of HTSC Suspension under Permanent Magnet Guideway

Grigorii Lenkov
Co-Authors: A.E. Shitov, M.P. Volkov

Short Description / Abstract

To create reliable transport systems based on magnetic levitation (Maglev) using high-temperature superconductors (HTSC), it is necessary to solve a number of technical problems. One of them is increasing of clearance between the magnet guideway and superconducting unit (levitation gap). This levitation gap increasing can be achieved by replacing the levitation of the superconductor over the guideway with the suspension of the unit under the guideway.

The magnitude of the levitation gap depends on the magnetic moment of the superconductor and on the magnetic field configuration [1]. Analysis of magnetization of type II superconductors shows that a large value of the magnetic moment can be obtained in small magnetic fields. This situation can be realized by HTSC suspension [2]. We analyze factors that allow increase of the levitation gap when we suspend the superconductor under a magnetic track assembled from permanent magnets:

1) The assembling of permanent magnets in a magnetic track that creates optimal configuration of a magnetic field;

2) The magnetic and thermal prehistory of a superconductor that leads to a large magnetic moment.

For magnetic guideways with different configuration of NdFeB permanent magnets, distributions of magnetic fields were measured by Hall probe scanning. Magnetic properties of YBaCuO were measured by VSM magnetometer at liquid nitrogen temperature. The levitation gap measurements were performed for each magnet guideway design for both levitation over guideway and suspension under guideway. The magnetic behavior of the superconductor was analyzed on the base of the critical state model.

Optimal configurations of the magnetic track and the magnetic-thermal history of the superconductor were determined, leading to a maximum levitation gap. This levitation gap was substantially larger when the superconductor was suspended under the track than in the case of levitation over the track.

Keywords

Magnetic guideway, Superconducting suspension and levitation, Permanent magnets, Levitation gap

7 Superconductors, Application of Superconductivity, Poster Session

An Improved Halbach Electromagnetic Turnout Design for HTS Maglev System

Liu Xiaoning
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Short Description / Abstract

The turnout is a crucial track junction device of the high temperature superconducting (HTS) Maglev System. Due to the special permanent magnet guideway (PMG), the non-mechanical electromagnetic turnout is a good choice. Therefore, it is vital to investigate the electromagnetic turnout. In this paper, a splayed electromagnetic turnout based on the Halbach PMG is completed in order to prove its continuous operation capability. And then, a new type of electromagnet is designed, which could achieve a better magnetic field. Magnetic field adjustment electromagnets are introduced into Halbach PMG, so as to eliminate sharp turning in electromagnetic turnout to improved vehicle passing stability. Finally, a new turnout method for double Halbach PMG is proposed. These works provide significant references for future Halbach PMG electromagnetic turnout design in the HTS maglev transportation practical application.

Keywords

Electromagnetic turnout, High temperature superconducting maglev, Halbach, Magnetic field, Bulk high temperature superconductors

7 Superconductors, Application of Superconductivity, Poster Session

Progress in the Research of Copper-Oxide Superconductors

Pan Hongliang
Co-Authors: Tang Shaoqiang, Xu Zhao

Short Description / Abstract

Since H·Carvalin·Onnesse discovered the superconductivity of mercury in 1911, we have made progress in the research of the superconductor and the superconductor have evolved from single element, alloy to complex compounds with multiple elements. With the development of the research about new superconducting materials, the research of iron based superconductors, copper-oxide superconductor and magnesium boride superconductor is the latest research trend. So far the proved highest superconducting transition temperature of copper-oxide superconductor is 130K under normal pressure and could reach more than 160K under high pressure. Based on the experience accumulated in past decades, we propose some general introduction about the main structure type, the superconducting principle and the application of copper-oxide superconductor. It is expected that a positive effect would be made in the research of copper-oxide superconductor.

Keywords

High temperature superconductors, Copper-oxide superconductor, Superconducting principle, Application

8 Permanent Magnets, Presentation

Modeling and Controller Design for Permanent Magnet-Electromagnetic Hybrid Suspension

Yu Peichang
Co-Authors: Cui Peng, Li Jie, Zhou Danfeng

Short Description / Abstract

Nowadays, our team is developing the medium-speed maglev train with 160km/h adopts permanent magnet-electromagnetic hybrid suspension (PEMS). With the addition of permanent magnet, the suspension energy consumption can be reduced significantly. This paper discussed the modeling of PEMS system with uncertain parameters and disturbance. Firstly, the linear model of PEMS is built, in order to investigate the uncertain range of the model parameters, some experiments are designed. Furthermore, based on the preliminary designed controller, the static environment disturbance range is also measured by experiments and theoretical calculations. With the linear model with uncertain range, the robust controller is designed and tested.

Keywords

PEMS, Medium-speed, Maglev train

8 Permanent Magnets, Presentation

Experimental Researches on Magnetic Levitation Forces in Permanent Magnet-Based Suspension System

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Short Description / Abstract

The development of the manufacture technology of permanent magnets has revived interest to the creation of systems employing them. At Emperor Alexander I St. Petersburg State Transport University, a test stand was created for conducting researches that model the interaction between a movable guideway, made of a conductive material, and the suspension system employing permanent magnets. On this test stand, a number of experiments was conducted to assess the levitation, braking and lateral shift forces, which arise during movement of the guideway along the Hallbach array at various speeds, levitation gaps and location of the magnet array relative to the guideway. During the test following results were obtained.

At low speeds (V<8 m/s) the braking force arises, which intensively increases with the increase of speed. The maximum force was detected in the diapason of V=(6…12) m/s. At speeds V>12 m/s, the braking force decreases as the speed increases. The increase of the levitation gap in the diapason δ=(6…16) mm results in the decrease of the maximum value of the braking force and shift of this extremum towards the area of greater values of speed.

At low speeds (V<8 m/s) and a fixed levitation gap of δ=16 mm, the attraction of the guideway to the magnet array takes place. At increase of speed of more than 8 m/s, the steady increase of the levitation force was observed, which, as it was mentioned above, was accompanied by the decrease of the braking force at the speed of V>12 m/s, which indicates at the improvement of the levitation quality of the system at high speeds.

Apart from this, the influence of the location of the magnet array relative to the guideway on the transverse forces was investigated. During the test, at a fixed levitation gap, the magnet array was rotated around its vertical axis by the angle α=(0…45)º and shifted in the transverse direction along the longitudinal axis of the guideway. It was found out that the greatest transverse force would arise at the angles of α=(25…35)º. This circumstance may be used during the creation of the combined magnetic and dynamic levitation and stabilisation system on the basis of the twin magnet arrays, symmetrically displaced relative to the guideway.

Keywords

Permanent magnets, Halbach array, Dynamic levitation system, Dynamic stabilisation system

8 Permanent Magnets, Poster Session

Analysis of Inductance Due to Improved Power of Spoke Type Permanent Magnet Synchronous Motor for Electric Bicycle by Applying Non-Magnetic Material

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Short Description / Abstract

In this paper, the inductance change was analyzed from spoke-type permanent magnet synchronous motor (PMSM) which torque was improved by using non-magnetic material, without any changes of motor parameters. Magnetic flux leakage occurs from the permanent magnets (PMs) where inserted into rotor of a 330W spoke-type PMSM for electrical bicycle. In order to minimize the magnetic flux leakage, ribs and barriers are necessary. However, stainless steel was chosen as non-magnetic material. Also, it was substituted to outer ribs and barriers at the end of rotor to reduce magnetic flux leakage.

As applying stainless steel to ribs and barriers, magnetic torque was enhanced because magnetic flux leakage decreased and magnetic flux linkage increased due to increase in magnetic flux flowing to the airgap. At 1325 rpm, Torque was 4.3% improved from 2.379 Nm to 2.482 Nm after applying stainless steel at the same constraint condition of the spoke-type PMSM. However, inductance of d-axis and q-axis were changed from 0.281 mH to 0.302 mH and from 0.242 mH to 0.231 mH, respectively. Also, current phase angle was moved 5.9 degree to 4.9 degree and saliency of inductance was decreased from 0.862 to 0.765.

Even though saliency of inductance decreases, stainless steels those were inserted into outer barriers and ribs prevented magnetic flux leakage and enhanced magnetic flux linkage from 0.023 Wb to 0.024 Wb resulting increasing magnetic torque. Finally, power was increased from 330 W to 344 W with inserted stainless steel to outer barriers and ribs.

Keywords

Rare-earth magnet, Inductance, Non-magnetic material, Magnetic flux linkage, Magnetic flux leakage

8 Permanent Magnets, Poster Session

Mathematical Modeling Non Circular Tampering Structure of Permanent Magnet

Lee Gang Seok
Co-Authors: Hyeong Gwan Jang, Won-ho Kim, Ju Lee

Short Description / Abstract

BLDC Motor (Brushless DC Motor) is used in various applications like scientific studies, industrial and many applications. BLDC Motor has many advantages over other motors- high torque to weight ratio, constant power, low maintenance cost, control simplicity and high efficiency. BLDC motor has trapezoidal back EMF and harmonic waves are included in back EMF. But, in case of small electric motor, there are many restrictions. Small BLDC motor is highly sensitive to each parameter. So, effect of harmonic wave to small BLDC motor is bigger than effect to big BLDC motor. As effect of harmonic wave increase, performance of BLDC motor decrease. Analysis of harmonic wave reduction is underway. This paper shows mathematical modeling technique considering permanent magnet and tampering structure for harmonic wave. Tampering structure of permanent magnet Tampering structure has many types (step-type, non-circular-type, segmentation-type). Each type has each mathematical modeling technique. This paper presents non-circular-type tampering structure. This paper shows SPMSM which has non-circular-type tampering structure. Mathematical modeling of permanent magnet tampering structure Non-circular type tampering structure consists of curve. Curve is difficult to be divided in section. To divide curve, very small section division is used. Curve is aggregate of very small section and can be divided in very small section. If length of very small section is defined L. L can be calculated by number of very small section. With a permanent magnet symmetrically, permanent magnet is divided into n sections. Total number of permanent magnet section is 2n+1. Magnetization direction of permanent magnet defines magnetization direction of very small section permanent magnet. Considering very small section permanent magnet and magnetic electric equivalent circuit, mathematical technique modeling and analysis can be defined.

Keywords

Mathematical modeling, Tampering, Permanent magnet

8 Permanent Magnets, Poster Session

Comparison of Interior Permanent Magnet Motor with Different Permanent Magnet Topologies for Traction Applications

Li Weili
Co-Authors: Cao Zhaobin, Li Dong, Li Jinzhou, Li Qiusheng, Guo Xiaoming, Tian Dashan, Wang Jiajun

Short Description / Abstract

Reluctance torque is a common problem of permanent magnet motor, and it is one of the most important problems to be considered in the design of this kind of motor. The permanent magnet in the permanent magnet traction motor is built in the rotor core, which causes the salient pole effect caused by the asymmetrical magnetic flux between the d-axis and the q-axis. The protruding rate of Xad/Xaq directly affects the starting performance of the motor. In this paper, by analyzing the shape of the permanent magnets to adjust the salient pole ratio, the analytical expressions of the armature reaction reactance of the d-axis and the q-axis are deduced, respectively. The armature reaction reactance values of the d-axis and the q-axis with different rotor structures are given. The starting torque multiples, starting current multiples. The influence of the salient pole rate on the starting torque multiplier and the starting current multiplier is obtained. The results of finite element calculation show that the above-mentioned different rotor structures have different starting performance parameters in the starting process. The conclusions obtained are references to promote the practical application of permanent magnet traction motors.

Permanent magnet traction motor (PMTM) in actual use to achieve high starting torque and maintain speed operation, rotor structure design is more complicated. The existing literatures on permanent magnet traction motor research includes: the rotor magnetic circuit topology, starting performance and pull-in performance, armature reaction reactance calculation, traction motor loss calculation and so on.

This paper studies the influence of rotor magnetic circuit change on the starting performance of permanent magnet traction motor from the angle of rotor magnetic circuit topology. First, the analytical expressions of the d-axis and the q-axis armature reaction reactance of the permanent magnet traction motor are given. Then, by changing the arrangement of permanent magnet and the presence or absence of the cage inside rotor, the influence of different rotor magnetic circuits on the motor's armature reaction reactance of the d-axis and the q-axis and salient pole ratio are studied. The influence of rotor magnetic circuit changes on motor starting performance is obtained. Finally, two permanent magnet traction motors with different magnetic circuit structure are used as the prototype, the validity of the above measures is verified by the finite element method.

Keywords

Permanent magnet traction motor, Armature reaction reactance, Protruding rate; Starting performance

8 Permanent Magnets, Poster Session

Influence of Solid Rotor Alloy Material on Starting Performance of Permanent Magnet Traction Motor

Li Weili
Co-Authors: Cao Zhaobin, Li Dong, Li Jinzhou, Li Qiusheng, Guo Xiaoming, Tian Dashan, Wang Jiajun

Short Description / Abstract

Solid Rotor Permanent Magnet Traction Motor (SRPMTM) have a good starting ability and synchronization capability in heavy load starting, frequent stops, repeated short-term work and other occasions. In this paper, the starting process of SRPMTM is theoretically analyzed. The two-dimensional electromagnetic field equation is solved by the time stepping finite element method, and the starting current multiplier and starting torque multiplier under the rated load are obtained. On this basis, the influence of different solid rotor alloy materials (conductor for electric and magnetic) on the starting performance of the SRPMTM are studied and the change law of starting performance of the motor under different solid rotor alloy material are obtained. Through the comparison of schemes, the reasonable rotor material is selected to verify the validity of the 315kW, 6-poles SRPMTM prototype.

The SRPMTM is widely used in various industrial fields. However, the starting cages and permanent magnets exist in the rotor of SRPMTM, which makes the starting process of the motor more complicated. At the same time, the starting performance of SRPMTM is related to the resistivity and magnetization curve of solid rotor material. In order to obtain better starting performance, the 315kW, SRPMTM as an example, the theoretical research on the different permeability alloy material (conductor for electric and magnetic), BH curve and resistivity of solid rotor are carried out. The influence of the alloy material on the starting performance of SRPMTM are compared and studied. It provides a reference for the design and optimization of this type of motor.

Keywords

Alloy material, Conductor for electric and magnetic, Permanent magnet traction motor

8 Permanent Magnets, Poster Session

A Model Predictive Direct Torque Control for a New Kind of PMLSM

Lin Guobin
Co-Authors: Zhao Yuanzhe, Liu Xiufei

Short Description / Abstract

In this paper, a new kind of permanent magnet linear synchronous motor (PMLSM) with concentrated windings for freight train is introduced. For this PMLSM, the model predictive direct torque control (MPDTC) based on a cost function is proposed. The discrete-time state-space prediction model of PMLSM is established in the dp reference frame. By evaluating the cost function considering the torque error and the stator flux error for each switching state in a two level inverter, the voltage vector and switching state are selected and set for the following sampling period. The simulation results validate the performance of the proposed control scheme.

Keywords

Freight maglev, PMLSM, MP-DTC, Cost function

9 Guideway and Infrastructure Technologies, Presentation

Influence of Track Irregularities on Ride Comfort of Low-Speed Maglev System

Huang Jingyu
Co-Authors: Xiong Zhou, Zhewei Wu

Short Description / Abstract

Track irregularities of low-speed maglev line have great influence on the vibration of vehicle, and the ride comfort will be reduced. In this paper, by using the method of dynamic simulation, a EMS low-speed maglev model with multi-degree of dynamic freedom was established. The track irregularities are taken into consideration in the model to calculate the vibration acceleration of vehicle. Then by analysing the comfort index, the impact of track irregularities on ride comfort is investigated. The results can be a great significance on the vibration control of vehicle in the subsequent researches.

Keywords

Track irregularity, Comfort, Line maintenance, Vibration control, Dynamic simulation

9 Guideway and Infrastructure Technologies, Presentation

Parametric Analysis in Dynamics of Structures with Uncertain Damping

Arkady Livshits

Short Description / Abstract

Damping is an important parameter that has significant influence on dynamic behaviors of the structures. Actual damping of the structures is not known for certain and in some cases may depend on applied dynamic loads. To obtain a feasible solution of the real problem, parametric analysis, where structural damping serves as one of variables, is often used in engineering practice. Two examples of parametric analysis application for different structural dynamics problems are discussed.

The first problem is dynamic stability of the Maglev main beam torsional vibrations. Equations of torsional as well as torsional-bending vibrations of the concrete beam loaded by controlled electromagnetic forces are obtained. Electromagnetic suspension system consists of two kinematic chains (built of rigid pinned-connected modules with two electromagnets and two sensors mounted on each one), that was developed in historical "VNIIPI Transprogress" for the first Soviet magnet levitation vehicle, is taken into consideration. The modified torsional vibrations equations are reduced to ordinary differential equations (ODE) system using the Bubnov-Galerkin method. Dynamic stability of the closed non-conservative system "concrete beam – electromagnets – control automation" is investigated by an approximate method, which was originally developed for space craft stability analysis. The area of instability in plane "fundamental torsional vibration frequency – logarithmic decrement of torsional vibrations" is obtained by parametric analysis. It allows the possibility to establish requirements for structural damping of the concrete beam that serves as the main member in Maglev system infrastructure.

The second problem is across-wind load for grouped chimneys due to vortex shedding. The Israel Electric Corporation Ltd (IEC) equipped existing Units 1-2 at Rutenberg Power Station [which is named after Pinhas (Peter) Rutenberg – vice-mayor of Petrograd in July-October 1917 and later founder of the IEC] with FGD (Flue Gas Desulfurization) system. The new concrete chimney is located in close proximity to two existing concrete chimneys of 250 m height. Wind tunnel testing for 3 grouped chimneys has been performed by RWDI in Canada. It has been found that bending moment at grade due to across-wind load is significantly greater than the code-prescribed value, especially for existing Units 1-2 chimney. Height reduction and other structural modifications of the new designed chimney are described. Interference effect investigation by RWDI semi-empirical model is presented. Parametric study of bending moment as function of damping ratio and wind speed (10-min average) is provided. Results of full-scale measurements of existing Units 1-2 chimney vibrations are used for verification of actual damping ratio.

Keywords

Concrete beam, Electromagnetic forces, Structural damping, Concrete chimney, Across-wind, Grouped chimneys effect

9 Guideway and Infrastructure Technologies, Presentation

The Design of the New Transport System

Evgenya Milovanova

Short Description / Abstract

The vehicle is offered the body of which it is made to create during the movement an aerodynamic elevating force, and is supplied with mechanical means of communication with a motionless carrying track. The distinguished feature of this vehicle is that it uses current conducting track being on high-speed sections of the track as a unit of transport system suspended to the vehicle in the function of cable-current conductor.

The aim of the work is the creation of the monorail-based, suspended cable-way and air transport of essentially new type of transport combining their best properties and strengthening them: - reliability, weatherproof, opportunity of complete automation of management transportation process and cargo handling works; - high carrying capacity, speed and range of action without increasing capacity of bearing(carrying) ways; - meeting the high requirements with regards to ecology and profitability in an expenditure of energy carriers, arising from the application of various means from the electric power up to energy of natural gas; - flexibility of formation of structure of transport.

The new vehicle, uses a monorail as track; its body can be made to create the elevating force in it on the basis of aerostatics, and in addition it is supplied with constructive elements, to create aerodynamic elevating force during the movement. Thus the track can be made as a combination of powerful sections for an acceleration and facilitated mid-flight sites. The monorail of a transit can be supplied with current conductor, feeding power installation, and on mid-flight sections of a way it can be made, as a cable-current conductor. The power(force) installation can be made as a combination of engines of electrical draft with engines of jet draft or draft of the air screw, to change the position of a vector of draft in planes from horizontal up to vertical.

Keywords

New transport system, Mainline transportation, Aerodynamic elevating force

9 Guideway and Infrastructure Technologies, Presentation

Bimodal Maglev Interoperable with Conventional Rail Infrastructure

John Van Rosendale

Short Description / Abstract

One major obstacle to maglev deployment is the large amount of infrastructure required. Maglev infrastructure is completely different than existing rail infrastructure—maglev trains cannot operate on conventional track nor can conventional trains operate on maglev guideways. Given the estimated 1,370,000 km of rail right-of-way worldwide this is a real issue, and is especially acute in urban areas where obtaining new right-of-way is difficult and expensive.

Addressing this issue, we are developing a high-speed train designed to operate on both maglev guideways and conventional track. The heart of this design is an articulated undercarriage component we call a "bimodal truck." A bimodal truck consists of a conventional powered bogie surrounded by two maglev bogies. When the train is operating on conventional track, the conventional bogie carries the load and the maglev bogies play no role. When the train is operating on a maglev guideway, the maglev bogies carry the load while the conventional bogie functions as a span bolster; the bimodal truck functions like the undercarriage of a Schnabel car. The planned maglev bogies are based on our MagFlite permanent-magnet-based maglev technology.

Bimodal trains of this new design will be compatible with existing rail infrastructure and would satisfy a standard passenger load gauge. Transition from conventional rail to maglev and back is done at speed by running through a special transition section. This transition section, US Patent 41817123, contains parallel rail and maglev guideway components. Running through this section to transition from rail to maglev, the maglev system gradually lifts the train off the rails. Conversely, running in the other direction, the maglev bogies gradually set the train back on the rails. This paper outlines some of the engineering issues involved in high-speed transition between modes. A short video illustrating the operation of this system will also be included.

Keywords

Interoperability, High-speed transition, Conventional rail infrastructure

9 Guideway and Infrastructure Technologies, Poster Session

A Dynamic Detection Method for the Guideway of Middle-Low Speed Maglev Train

Yang Ming
Co-Author: Guobin Lin

Short Description / Abstract

According to the irregularity of the guideway on middle-low speed maglev train, this paper brings forward an irregularity measurement system based on the levitation gap sensor and the acceleration sensor. Hardware system, including sensor communication module, GPS module, signal acquisition board, is designed to collect data. By processing and analyzing the data, the geometric shape of guideway is obtained.

Keywords

Middle-low speed maglev train, Guideway, Irregularity, Detection

9 Guideway and Infrastructure Technologies, Poster Session

Preliminary Study on Vertical Rigidity of Guideway for Medium Speed Maglev Transportation System

Fu Qingxiang
Co-Authors: Liang xiao, Wang wuliang, Li Ye

Short Description / Abstract

Rigidity of guideway for maglev transportation system is an important issue. The guideway with proper rigidity not only ensure the operation safety and riding comfort, it's also the key to the cost of the maglev transportation system. The preliminary study on vertical rigidity of guideway for medium speed maglev transportation system is conduct by means of finite element analysis on guideway of operating low speed maglev transportation. Also, the load and dynamic characteristics of medium speed maglev vehicles are considered. Finally, the reference limit of vertical deflection and rotation angle at beam end is proposed.

Keywords

Medium speed maglev transportation, Guideway, Rigidity

9 Guideway and Infrastructure Technologies, Poster Session

Analysis of the Substructure Deformation of Shanghai Maglev Line Due to Urban Municipal Engineering

Ye Feng
Co-Authors: Wanyu Tang, Guoqiang Wang

Short Description / Abstract

Shanghai Maglev Demonstration Line is the first and exclusive commercial operation line with conventional-conductive high-speed maglev technology in the world. Due to rapid urban development, the construction activities in the protection zone of maglev line are increasing frequently. Affected by various construction activities, deformations of the substructure may happen, thus result in bad influence on the operation of maglev train, so it is necessary to evaluate such kind of influence quantitatively. In this paper, a municipal project near Shanghai maglev line is illustrated and finite element analysis software is used to estimate the additional deformations of the substructure during the construction and operation. The deformation results are compared with the preset threshold values, in order to provide a reference for the monitoring and protection of maglev line.

Keywords

High-speed maglev, Urban municipal engineering, Protection zone, Finite element analysis, Deformation

9 Guideway and Infrastructure Technologies, Poster Session

Girder Type Selection in the Test Line of Medium-Speed Maglev Transportation

Ye Feng
Co-Authors: Zhihui Wu, Wanyu Tang

Short Description / Abstract

New medium-speed maglev transportation is being developed by CRRC Zhuzhou Locomotive Co., Ltd, who is planning and preparing a test line longer than 4 km. Guideway girder type selection is an important work in the construction of test line. Overview of the girder history and discussion for medium-speed maglev transportation are introduced in this paper. Concept design for the selection has been developed and the key technologies in the manufacture are analyzed. The works abovementioned are valuable for the development of infrastructure of maglev transportation.

Keywords

Medium-speed maglev transportation, Girder type, Concept design, Key technology, Manufacture

9 Guideway and Infrastructure Technologies, Poster Session

Stress Analysis and Structural Comparison of Local Position for Elastic-Bending Guideway Switch

Zhu Zhiwei
Co-Authors: Feng Ye, Laisheng Tong, Zhihui Wu, Guofeng Zeng

Short Description / Abstract

In high- and medium- speed maglev transportation field, elastic-bending guideway switch is getting more and more attention because of its smooth line and high permitted maximum speed value. The special function of elastic-bending guideway switch leads to complex force of steel beam and regular maintenance of welding seam. It is necessary to carry on detailed analysis on steel beam, especially on local position. In this paper, guideway switch of SHA is taken as an example to analyze the local stress and maintenance condition of steel beam. Through the analysis, different local structural schemes are put forward and compared. And, the analysis results provide guidance for the future engineering application of the elastic-bending guideway switch.

Keywords

Elastic-bending, Guideway switch, Local stress, Schemes comparison, SHA

10 Reliability, Safety and Operational Control, Presentation

Non-Stationary Reliability Models of Elements and Nodes of the Magnetic-Levitation Transport System

Vladimir Bubnov
Co-Authors: Sergey Sergeev, Valeria Solovyova

Short Description / Abstract

The report presents non-stationary models for determining the reliability indicators of elements and nodes of the magnetic-levitation transport system. The use of such models is due to the uniqueness of the magnetic-levitation transport system and the inability to obtain a sufficient number of statistical data. Mathematical models are represented in the form of a system of Chapman-Kolmogorov differential equations. The system of Chapman-Kolmogorov homogeneous differential equations describes the behavior of a non-stationary service system in vector-matrix form:

$$\dot{x}(t) = Ax(t), \quad (1)$$

where x (t) is the vector of probabilities of finding non-stationary service system in one of the states at time t; A is a square matrix that depends on the arrival intensity of the failure flow and the parameters of the distribution law of time intervals for fault diagnosis and connection of reserve facilities. Setting the initial conditions, we can solve the system (1). The questions of forming a matrix of coefficients of a system of equations for various models are discussed. Using a specially developed recurrent numbering of states of a non-stationary model, a numerical-analytic solution of system (1) is possible. For a numerical-analytical method, the accuracy of a solution is compared with existing integrators, for example, with Matlab. Table 1 shows the probability of an operative condition calculated using Matlab, analytical method and the Runge-Kutta method implemented in Java with a different value of step *h* on the time grid.

Table 1. Comparison of accuracy

	$t = 50$	$t = 100$	$t = 150$
Matlab	$4{,}24408126 \cdot 10^{-8}$	0,47343746	0,99999197951
Analytical method	$2{,}24023344 \cdot 10^{-11}$	0,47343780	0,99999199164
The Runge-Kutta method ($h = 0.4$)	$3{,}64428442 \cdot 10^{-11}$	0,47343753	0,99999199068
The Runge-Kutta method ($h = 0.2$)	$2{,}23763751 \cdot 10^{-11}$	0,47343778	0,99999199158

The report presents the structure and features of the implementation of the software package for calculating the reliability indicators of elements and nodes of the magnetic-levitation transport system.

Keywords

Non-stationary reliability model, Differential equations, Probability of operative condition

10 Reliability, Safety and Operational Control, Presentation

Operational Breakdown and Performance Measure of the Transcontinental High-Speed Maglev – a Recipe for Service Safety and Reliability

Chao Eugene
Co-Author: Jim Venturi

Short Description / Abstract

Magnetic Levitation (Maglev) systems have a noticeable operating track record in about a dozen countries. Higher speed maglev technology has been built for many intercity and regional lines in China, Germany, Japan, South Korea, United States, Brazil, and other countries. Maglev developers claim that the transcontinental high speed system can outperform the existing HSR and air transport and can achieve higher speed, have lower energy consumption and life cycle costs, attract more passengers, and boost regional economy. The article presents a systematic breakdown of the proposed transcontinental high speed Maglev system and pinpoints critical operational components and implementation measures. The analyses reach the following discussions on the three most important system characteristics. First. The economic gravity and productivity of the transcontinental high speed Maglev station must serve as the multimodal transportation hub. To attract passengers; therefore, increase the ridership and farebox recovery, a unified transfer service on schedule coordination has to be incorporated into the system. Timed Transfer Systems (TTS) had the proven capability of increasing service reliability across different modes. Second, the transcontinental high speed Maglev had to make many trade-offs among area coverage to ridership attraction, station density to daily maximum operating speed, and operating strategy to daily skip-stop, partial express, as well as other accelerated services. The planning, design, and operation of the entire network efficiency has to be openly discussed. Third, the correlation between systems capacity management and vehicle interior space design (e.g. seats) has a serious impact on operators' long-term financial condition. The involvement of identifying the equilibrium between these two factors in a linear algebra method is substantial. Based on these discussions, the framework and direction of transcontinental high speed Maglev strategic planning methodology is becoming sensible.

Keywords

Transcontinental maglev, Strategic planning and implementation measures, Operation design, System performance

10 Reliability, Safety and Operational Control, Presentation

Optimization of Assistant-stop Area Planning in the Middle-to-high Speed Maglev with Energy-Saving

Liu Jun
Co-Authors: Qingying Lai, Lingyun Meng, Qunyan Wang, Yazhi Xu

Short Description / Abstract

The assistant-stop area (ASA) is the special section that possesses power supply rail and personnel evacuation facilities, whose quantities and locations in a line are of great significance to reduce construction cost and improve transportation efficiency for the middle-to-high speed maglev. This paper focuses on the optimization problem of ASA quantities and locations in a line of middle-to-high speed maglev. The influence mechanism of the ASA on the two-dimension speed-protection curve for the maglev is analyzed, and a mathematical model of the ASA and train trajectory is constructed, in which energy-saving, time-saving of the train trajectory, and construction costs are considered. Furthermore, the genetic algorithm is used to solve the nonlinear model. Numerical examples are given to illustrate the effectiveness of the proposed methods.

Keywords

The middle-to-high speed maglev, Energy-saving, Assistant-stop area, Genetic algorithm

10 Reliability, Safety and Operational Control, Presentation

Risk Assessment Model of the Guideway Switch System of the High Speed Maglev System

Zeng Guofeng
Co-Authors: Xingtai He, Zhiwei Zhu

Short Description / Abstract

High speed maglev system is a highly complex transportation system composed of four tightly coupled subsystems, which are vehicle, guideway, propulsion and power supply, and operation control. In order to make reasonable evaluation on the reliability of high speed maglev system, especially after years of operation, it is indispensable to build risk assessment model of the four tightly coupled subsystems, and then the whole system. However, there are still no applicable assessment model and corresponding codes for high speed maglev system at present. In this passage, risk assessment model based on the operation experience of Shanghai maglev line was discussed, taking guideway switch system as an example. Based on the analytic hierarchy process (AHP) and fault tree model (FTA) method, a multi-layer structure model for assessment of guideway switch was proposed. Factors of man, machine, environment and management are considered. Effects of system redundancy design, balance and state maintenance are also taken into account. Considering interaction between guideway switch and other systems, interfaces were considered as special assessment units. Because the assessment of the four subsystems is logically similar, the model and corresponding method can easily apply to the assessment of the whole high speed maglev system.

Keywords

High speed maglev system, Risk assessment model, Guideway switch system

10 Reliability, Safety and Operational Control, Poster Session

Information Flow Analysis on Data Transmission of High-Speed Maglev Operation Control System Based on Data Priorities

Chen Yijun
Co-Authors: Zhiming Liao, Hongliang Pan

Short Description / Abstract

Operation control system is a large complex train control system which involves a large number of operational data during the operation. If the same transmission strategy is adopted for the running data of the operation control system, the real-time performance of the core control data will not be guaranteed. Firstly, the operation data of the high-speed maglev operation control system is systematically analyzed. Next, the classification and priority are built up. And then the information flow is analyzed to meet the transmission of high-speed maglev operation control system requirements of real-time and safety data transmission. Finally, a brief conclusion is given.

Keywords

High-speed maglev, Operation control system, Data transmission, Data priority, Information flow

10 Reliability, Safety and Operational Control, Poster Session

Recognition of Obstacles on High-Speed Highways in Real Time by Intelligent Vision System

Anatoly Khomonenko
Co-Author: Evgeny Yakovlev

Short Description / Abstract

There is a large number of technical systems that improve safety on Railways. However, these systems cannot prevent collisions of trains in the same and opposite directions. There are no technical systems on high-speed Railways able to identify the barriers and the degree of danger in real time. This task is mainly assigned to the driver, and the quality of its solution depends greatly on his care and fatigue, weather conditions and day and night light. Intelligent vision systems are suitable for solving the problem of detecting and assessing the degree of danger of obstacles at a distance that will make it possible to take measures to prevent a collision.

The algorithm of detection and recognition of obstacles in the system of technical vision with the use of convolutional neural networks, with the subsequent assessment of the degree of danger on the basis of fuzzy inference is proposed. Detection and recognition of obstacles includes a pre-trained convolutional neural network that can recognize objects in images obtained by cameras mounted on motion composition. Information about the object obtained from the neural network and containing such information as: the type of object, its velocity vector, position relative to paths, dimensions serve as input to the fuzzy rules base, on the basis of which the optimal solution is proposed.

Keywords

Convolutional neural networks, Object recognition, Machine vision system

10 Reliability, Safety and Operational Control, Poster Session

Research on the Medium and Low Speed Maglev Suspension System Based on Unified Utility Model

Pan Hongliang
Co-Authors: Xu Zhao, Tang Shaoqiang

Short Description / Abstract

In order to ensure the cost and efficiency of medium low speed maglev transportation system during its entire operation life, we need to make a decision balance between the reliability and maintainability of the system. Therefore, maintainability is used to get the best cost effect, so that maglev train can repair at the shortest time to meet the requirements of stable and safe operation of the system, and consume the minimum guarantee resources. In this paper, in the low-speed maglev train system as an example, to build a unified utility model, the number of components of suspension system of full cycle value relationship, the complex value problem in a unified scale, decision utility function to get the full cycle cost suspension system. The MATLAB is used to simulate the simulation, so that all the alternatives can form a full order on the basis of the utility function, and then get the best solution.

Keywords

System maintainability, Unified utility model, Utility function, Suspension system, Medium and low speed maglev train

10 Reliability, Safety and Operational Control, Poster Session

Study on Reliability Analysis of Suspension Controller of the Medium and Low Speed Maglev Vehicle

Pan Hongliang
Co-Authors: Xu Junqi, Hao Yiwei, Xu Zhao

Short Description / Abstract

Suspension controller is the core device of suspension system of the medium and low speed maglev vehicle, its reliability directly affects the stability, reliability and safety operation of the whole medium and low speed maglev train. Reliability analysis is of great theoretical and practical value for improving the performance of the suspension controller.

Taking Hunan Changsha maglev express as an application case, based on the mechanism and functional structure of the suspension controller, the reliability of the suspension controller is analyzed and studied. According to the Chinese standard GJB/Z 299C, the reliability prediction handbook for electronic equipment, the reliability of the suspension controller is calculated and analyzed by synthesizing the stress analysis method, the component counting method and the RBD reliability block diagram method. The reliability weak points of the suspension controller are analyzed, and the design optimization proposal is suggested to improve the suspension controller reliability.

Keywords

Medium and low speed maglev vehicle, Suspension controller, Reliability analysis, Reliability prediction, Maglev transportation

10 Reliability, Safety and Operational Control, Poster Session

Gray Relational Analysis between the Maglev-Structural Deformation and Construction Parameters of the Shield Tunnel Crossing the Shanghai Maglev Protected Area

Wang Guo Qiang
Co-Authors: Song-Tao Hu, Feng Ye, Guo Feng Zeng, Wen-Li Xu

Short Description / Abstract

Shanghai maglev has been running safely for 15 years, during which multiple external construction entered into the maglev protected area. If effective measures could not be taken to do the comprehensive technical monitoring, it would cause severe deformation of the maglev structures and serious effect on the safe operation of Shanghai Maglev. On the background of the project shanghai metro line 13 shield tunnel crossing the shanghai maglev, from the cause of the deformation of maglev and for the deformation requirements of the maglev structures, this thesis has studied the gray relation between deformation and shield parameters (earth pressure, thrusting speed, grouting volume, cutterhead torque and so on) and has found sensitive parameter sequences, therefore, shield parameters can be optimized and adjusted to control the deformation actively. In this paper gray correlation degrees are calculated between the deformation of the maglev structures and shield parameters, then the sequences of the correlation degree between parameters and deformation are given to direct the construction. Practice has proved that the method in this thesis has guiding effects on the control of the maglev deformation caused by the shield construction and the results have a certain reference value for similar projects.

Keywords

High-speed maglev, Deformation monitoring, Protected area, Gray correlation degree, Shield construction parameters

10 Reliability, Safety and Operational Control, Poster Session

UML Based Test Cases Generation for the Centralized System of High Speed Maglev

Zhao Wenwen
Co-Author: Lun Zhang

Short Description / Abstract

The high speed maglev Centralized Control System (CCS) is very critical as an assurance for the safety of maglev train, so it is necessary to test the system before put into use. Currently, according to the knowledge of authors, there is limited systematic test cases for CCS. In the light of this, the generation of test case of CCS using Unified Modeling Language (UML) is proposed in this paper, and the scenes of operation process of CCS are divided based on the function features. Then the corresponding UML models, use case diagram, state diagram, activity diagram and sequence diagram, are developed, and according to these models, the test cases of the specified case are generated. At last, the generated test cases are all executed in the developed lab-test system. The results show that the generated test cases can fully simulate the common situations of the operation scene, and effectively improve the test efficiency and test quality.

Keywords

CCS, Function features, UML, Scenes of operation, Test cases generation

10 Reliability, Safety and Operational Control, Poster Session

Practice of Comprehensive Technical Monitoring and Protection for Shanghai Maglev Line in the Crossing of Metro Line 13

Ye Feng
Co-Authors: Guoqiang Wang, Feng Ye, Guofeng Zeng, Zhiwei Zhu, Yihong Yuan, Wanyu Tang

Short Description / Abstract

Shanghai high-speed maglev demonstration line is an important component of the rail transit network. Range of 30m beside the rail outer edge is defined as the protection zone. Once there are some construction works in the protection zone, comprehensive technical monitoring and protection, which covers the construction target and maglev track, continues from the pre-construction to the post-construction, is necessary to control the influence to maglev structure and ancillary facilities. Main contents of the comprehensive technical monitoring and protection are introduced in this paper. As an example, it was applied in the crossing of Metro Line 13, thus the engineering practice is illustrated and some key links are analyzed. This practice is valuable for the reference of future similar engineering.

Keywords

High-speed maglev, Protected zone, Comprehensive technical monitoring and protection, Deformation monitoring

11 Maglev Elevators and Escalators; Magnetic Bearings, Maglev Wind Turbines, Presentation

MULTI® - Rope-less Elevator Demonstrator at Test Tower Rottweil

Appunn Rüdiger
Co-Authors: Jürgen Frantzheld, Friedrich Löser, Markus Jetter

Short Description / Abstract

The world's first linear motor driven passenger elevator system MULTI® goes into operation at test tower Rottweil. A full scale showcase has been installed, the commissioning is finished and extensive testing activities are performed. The new test tower in Rottweil provides the perfect test and certification environment to get this ground-breaking product onto the market.

The propulsion of the cabins is based on an ironless long-stator linear motor with distributed active drive, motor and sensor elements. This technology allows cars to move individually in the same elevator shaft without any ropes. The same type of linear motor will also be used to exchange cabins horizontally from one shaft to another. Herewith a movement of the cabins in a loop or any vertical and horizontal travel path can be realized. Special horizontal shafts are used for parking and maintenance of cabins. The testing procedures to characterize the operation of the MULTI® include measurements of electrical, mechanical and thermal quantities.

Smart energy management distributes power of descending cabins for ascending cabins. To overcome the high power demand for acceleration cabins, a high power energy storage system is installed. This paper presents first measurement results of the MULTI® showcase manly focusing on the linear motor propulsion system.

Keywords

Ropeless elevator system, Distributed linear drive technology, Multiple cabin operation, Vertical and horizontal movement

11 Maglev Elevators and Escalators; Magnetic Bearings, Maglev Wind Turbines, Presentation

Empirical Investigation of Possible Concerns Regarding the Use of Magnetic Levitation Elevators

Kirchner Manuel

Short Description / Abstract

This study focuses on an issue regarding an innovation of magnetic levitation elevators, which is by different media coverage indicated as being unresolved:

Are potential users of magnetic levitation elevators concerned about the safe use of these elevators and, if so, what kind of concerns exist? To contribute a first scientifically sound assessment to this, a three-day face-to-face interview at the elevator test tower in Rottweil (Baden-Wuerttemberg), where aforesaid elevator technology is tested, has been conducted. There, (touristic) visitors of the tower and the observation platform on it have been surveyed on a standardized questionnaire.

The results have shown that the average tendency of prospective conceivable users tends to be free of concerns. In addition, a share of about one-sixth has both expressed and concretized concerns. Those relate mainly to new characteristics of this elevator technology – absence of ropes, magnetic levitation, magnetic field presence – partially associated with known aspects such as power loss.

The study provides an explorative contribution to the topic described and therefore seems to be particularly interesting for both researchers willing to look further at this or similar areas and manufacturers or future clients of the technology in the context of, for instance, communicating its prospective implementations.

Keywords

Maglev elevators, Concerns of use, Multi, Prospective use, Safety

11 Maglev Elevators and Escalators; Magnetic Bearings, Maglev Wind Turbines, Presentation

Analysis on Riding Quality of Maglev Shanghai Demonstration Line

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Co-Authors: Yanyun Luo, Feng Ye, Zhiwei Zhu,
Guoqiang Wang, Guofeng Zeng

Short Description / Abstract

This article made a description on the riding quality test applied in Shanghai Maglev Demonstration Line in November 2017 and the analysis of the result. Kept running daily at 300km/h ~ 430km/h for about 15 years, SMTDC (Shanghai Maglev Transportation Development Co., Ltd.) wanted to know the riding quality of the maglev train in Shanghai currently and invited NMTC (National Maglev Transportation Engineering R&D Center) to apply the test. After the test NMTC made a series of analysis based on the result. Different operation conditions like running directions, maximum speeds, different tracks and different measuring points were compared, also some rules were found during the analysis. The result showed after those years' operating even with much less maintenance than conventional wheel-rail train system the contactless Transrapid system was still working properly.

Keywords

Riding quality, High speed maglev, Shanghai

12 New Ideas on Levitating Device Applications, Presentation

Electromechanical Battery with an Electrodynamic Magnetic Bearing

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Co-Authors: Rech E., Soares E., Ferreira L.T., Forte G.M, Costa E.A.

Short Description / Abstract

This work describes a flywheel system designed to use a suspension based on electrodynamic magnetic bearing. The proposed equipment consists of an electromechanical battery composed of a motor-generator system, based on brushless machines. This system is attached to a rotating mass suspended through electrodynamic magnetic bearings. On the levitation system, the guidance is obtained through magnetic fields induced by currents, produced in metallic non-ferromagnetic materials, this effect is called electrodynamic levitation. Permanent magnets with a high superficial magnet field intensity are also used to suspend the rotating mass.

The system used to control the generator-motor is implemented in Field-Programmable Gate Array (FPGA) digital device associated to a microprocessed system. It allows great flexibility on the development of the system used to control the machine. Considering that the kinetic energy stored is proportional to the square of the speed, the system can be compact, with a high density energy being stored. The structure of the stator is fixed in the center of the device. This way the mass of the rotor will be positioned on the region with the largest radius in the system, ensuring a greater capacity to store energy. All of the set will be built inside a structure to allow the removal of the air inside it, reducing even more the friction forces.

Keywords

Electromechanical battery, Electrodynamic levitation, Brushless motor, Magnetic bearing

12 New Ideas on Levitating Device Applications, Presentation

A Bearingless PM Synchronous Machine with a Zero-Sequence Current Driven Star Point-Connected Active Magnetic Thrust Bearing

Dietz Daniel
Co-Author: Andreas Binder

Short Description / Abstract

Common cylindrical bearingless drives require a separate thrust bearing, which is fed by a DC supply. Here, a technique is presented, which enables the feeding of the thrust bearing by an artificially generated zero-sequence current between the two star-points of the two parallel windings of the bearingless PM synchronous machine. This way, no additional DC supply for an axial active magnetic bearing is needed. It is replaced by two three-phase inverters as stator winding supply, which are needed in any case to generate torque and lateral rotor force in the motor.

The principle is shown for the following configuration: A bearingless PM synchronous motor with a combined winding of two three-phase systems for torque and lateral force generation is fed by two asymmetrical three-phase current systems. Two standard three-phase PWM-inverters are used with field-oriented control. In a first step the time instants of the active stator voltage vectors, required for torque and lateral force generation, are calculated. The arbitrary zero voltage time spans can be arranged differently for the two star-connected three-phase current systems. This way, the difference of potential between the two star-points during the zero time instants cause a controllable current. This current feeds the thrust bearing. However, the function depends on the modulation index, which determines the zero voltage time span. Moreover, the resulting axial force depends on the relation between the bearing impedance and the zero-sequence motor impedance. Therefore, the aim is to illustrate the feasible inverter operation limits on the one hand and the special design requirements of the motor and the thrust bearing for efficient axial force generation on the other hand.

Since each bearingless motor needs two three-phase current systems, either for a separate drive winding and a suspension winding or for the here considered two parallel three-phase windings, the principle of a zero-sequence current supply for an axial active magnetic bearing is generally applicable.

Keywords

Bearingless drive, Combined winding, Zero-sequence current, Star point-connected thrust bearing

12 New Ideas on Levitating Device Applications, Presentation

High Speed Vacuum Air Cehicle

Mishra Rajat
Co-Authors: Himanshu Sharma, Harshit Mishra

Short Description / Abstract

There is a number of problems in the prior art, those are topics of research inputs like ranges of the drag force generated by the vehicle, lift force at high vehicle motion velocities for compensation of the vehicle weight, Aerodynamic aspects of operation of the vehicle, Stream wise stability of vehicle motion and levitation and breaking of the vehicles and supersonic speed is not achieved in any mode of transportation.

But this present invention related to high speed magnetic levitating transportation. More particularly, present invention is related to high speed magnetic levitating transportation using compressed air chamber in the transportation vehicle. The present invention is more particularly related to high speed vehicle levitated on a vacuum tunnel by using electromagnetic levitation.

As this vehicle will move from one place to another in a vacuum environment and this vehicle will levitate above track with the help of electromagnets. And the important thing is its motion, which is possible due to reaction force of high pressure air, coming out from compressed air chamber present in vehicle. And it can give us the acceleration as per load requirement. AND IT CAN ACHIEVE SUPERSONIC SPEED IN FEW SECONDS.

Keywords

Magnetic track, Inlet ports, Outlet ports, Compressed air chamber, C-clamp

12 New Ideas on Levitating Device Applications, Presentation

The Maglev – Systems on the Basis of Trestle of Arch Type

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Short Description / Abstract

We will call the overpass having an arch in cross section by trestle of arch type. The monorail in the city of Wuppertal can serve as prototype of an arch trestle. The trestle of arch type allows to realize various limiters of movements.

In the cargo transport systems various decisions which are directed to reduction of cost of construction and operation of maglev-system can be applied. In particular, the containers can be transported at their levitation in the top part of an arch trestle ("the driving on a ceiling"). The liquids or gases in cylinders can be transported by means of a levitation concerning of beam trestle placed under an arch ("the driving along a beam").

For passengers the main thing to ensure safety and comfort. Protection against electromagnetic radiations can be reached by an arrangement of a passenger cabin at «safe distance» from a stator winding of the overpass. However, it will lead to increase of trestle height and cost of her construction. Some actions, for example, installation of protective screen, allow to reduce a «safe distance». As the result the cost of construction of a trestle falls, but the cost of a vehicle increases.

In all cases it is necessary to look for a compromise between achievement of the goal of functioning of maglev-system and costs of its construction and service.

Keywords

Maglev systems, Trestle of arch type, Driving on a ceiling, Driving along a beam, Safe distance

13 Standardization Issues, Presentation

Standardization of Maglev Transportation Systems in Russia

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Co-Author: Vladimir Shmatchenko

Short Description / Abstract

Existing regulatory framework in Russia does not include a full set of rules and standards needed as the main document is absent – Safety Regulations on maglev transportation systems. However, in such the case Russian regulatory framework has the possibility to start the development through preparation of «project specific technical specifications» (PSTS). PSTS will include main norms for subsystems of the maglev transportation system for specific line. The ways of such the norms justification are investigations and experience analysis. As the result of the works, the following generic PSTS were developed: "General requirements", "Guideway", "Substructure, structures, junctions and crossings", "Terminals and stations", "Propulsion and power supply system", "Train control system", "Communication systems", "Vehicles", "Integrated safety system". English-Russian (Russian-English) thesaurus became another result of the works.

Keywords

Standardization, Maglev transportation system, Regulatory framework, Project specific technical specifications

13 Standardization Issues, Poster Session

Progress Made and Prospect of Maglev Transportation Standardization in China

Yan Peiliang

Short Description / Abstract

With the development of urbanization in China, the demand for public transportation is increasing. As a new type of rail transportation, Maglev (including medium and low speed Maglev, high speed Maglev) gradually shows its technical and economic advantages in improving China's rail transportation system. Research on related technologies have being deepened and expanded, and engineering applications are accelerating. In order to standardize the construction of Maglev transportation engineering and guide the related technical research and product development, the research and compilation of the key technical standards for Maglev transportation in China have been getting the attention of government departments, research institutes, trade associations and enterprises. As of the end of 2017, 9 professional standards and 2 provincial standards related to Maglev transportation technology and products have been issued in China.

In this paper, combining with the practice of Maglev transportation standard development of Tongji University (National) Maglev Transportation Engineering Research Center (as chief development unit or participating development unit), summed up the progress made in Maglev technology standard system research and the development of the key Maglev transportation technical standards, show the prospect of Maglev transportation standardization in China.

Keywords

Maglev transportation standardization

14 Economic Aspects of Maglev, Presentation

Socio-Economic Premises of the Magnetic Levitation Use in Transport Systems

Boris Lapidus

Short Description / Abstract

The creation of new transport systems is an urgent task, the success of which will largely determine the dynamics of improving the quality of life and the trade and economic efficiency of regions, cities, states.

Macro- and mega-economic requirements for the transport system are characterized by factors that have a decisive influence on the evolution of transport. There are five such factors:

- raising the standard of living of the population;
- Increase the value of human capital;
- deepening interregional demographic imbalances;
- increasing the demographic and production load on the natural environment;
- reduction of resource intensity of the economy, deepening of processing of raw materials, increase in the share of finished products in the structure of transport.

Based on these factors, the global requirements for advanced transportation systems are increasing speed, reliability, energy efficiency, environmental friendliness.

The growth of population, the increase in the cost of human capital and the value of time increase the demand and requirements for the development of high-speed passenger transportation.

In these conditions, the use of magnetic levitation in transport systems is promising, especially in combination with the use of a vacuum medium.

The existing replacement of railway passenger transportations in the segments from 150 to 1000 km can occur due to magneto-levitation transport systems, therefore in the long term they can occupy almost all existing niches, provided the physical principles of creating the levitation effect are finalized. These risks are significant, therefore railway science and railway management should be interested in the introduction of magneto-levitation and, especially, vacuum magneto-levitation transport systems, since otherwise they will replace the railway business.

Thus, the expediency of using magnetic levitation in transport systems is reinforced by existing trends in socio-economic development and the evolution of transport.

It is necessary to ensure their convergence with traditional railways, which will make the introduction of magnetic levitation the most effective and will serve the development of the railway business.

Keywords

Perspective transport systems, Quality of life, Value of time, Magnetic levitation, Vacuum environment, Transport evolution, Railway business

14 Economic Aspects of Maglev, Presentation

Theoretical Base and Methods of the Complex Optimization of Maglev

Arkadij Lascher

Short Description / Abstract

Currently, with the ever-growing competition in the world market of transport services and dynamically developing new transport technologies, will be able to compete only those maglev-systems that will use their technical and economic advantages. And if we take into account that modern maglev-systems are complex and high-tech multi-functional designs, which is constantly updated with new developments, then the existing evaluation methods were not always able to identify the maximum benefits of the aforesaid transport technologies.

Thus, a new tool has been proposed in this paper, which allows scientifically based methods to find the most optimal solution for maglev-system, depending on its application. This scientific instrument, as a full virtual model of the entire maglev-system, allows you to simulate any work processes of such a transport system, taking into account the introduction into it of new technical developments. As a result, at the lowest cost maglev-system ensures its maximum performance and the required traffic safety, which ultimately creates a good preconditions for considered maglev-system not only maintain a good position in the competition with other transport systems, but also to expand its scope of application.

Keywords

Maglev system, Optimization, System analysis

14 Economic Aspects of Maglev, Presentation

Results of the Complex Optimization of MAGLEV

Arkadij Lascher
Co-Authors: Evgeni Frishman, Mark Umanov

Short Description / Abstract

Maglev-systems are regarding expensive and have low profitability to investment costs what substantially restricts the use of such systems in existing transport infrastructure.

Therefore, in this paper the usefulness of the technology of complex optimization of transport to reduce costs of maglev-systems is justified. This will improve their chances in competition with traditional modes of transport on the existing transport market.

Keywords

Maglev system, Function model, Optimization

14 Economic Aspects of Maglev, Presentation

Analysis on Economic Benefit of Shanghai Maglev Line

Zhang Xiyu
Co-Author: Lun Zhang

Short Description / Abstract

A huge economic influence has been carried in Shanghai where maglev train as a new alternative of public transport. Attracting passengers efficiently is the key to increase passenger volume for stable operation. In the background of Longyang road station-Shanghai Pudong International Airport maglev line, firstly, this paper analyzes the distribution rate of passenger flow between metro line2 and maglev line after a multinomial Logit model has been established to research factors about travelers' mode choice behavior. Then, it has the important practical significance to have a study on economic benefit of maglev train operation condition. The study results show that income and on-time requirement are the most influential factors on traveler' mode choice. Although maglev is somewhat little inferior to metro in terms of fares and awareness, maglev traffic indeed plays a positive role of economic development in Shanghai.

Keywords

Maglev line, Metro line2, Multinomial logit model, Travel behavior, Economic benefit

14 Economic Aspects of Maglev, Presentation

Assessment Methodology for Intermodal Effects of High-Speed Magnetic Levitation Transportation Systems

Natalia Zhuravleva

Short Description / Abstract

Actual transport systems, the distinguishing feature of which is the high speed, significantly affect the formation of a new technological wave. According to new 4.0 industry requirements, modification of these systems forms a new economy of high speeds, in which the main effect is detected through estimating the cost of time as the main non-renewable resource.

It should be considered that in the near future a value of traditional transport as the mediator will be reduced in favour of consumer appeal for goods, technological rent, and population mobility growth.

The economy tends to high production and travel speeds; therefore, in the methodology for estimation of speed growth effect, the significant changes in waiting process for new goods and services should be taken into account as well. Within this framework, high-speed transportation systems development projects based mainly on magnetic levitation acquire other properties and, accordingly, require fundamental changes in approach for assessing their value.

The research objective is to describe the procedure of measurement of intermodal economic effects of high-speed transportation based on magnetic levitation. Speed assessment is the key of cost determination procedure for the transportation as a part of high-speed economy infrastructure, i.e. an aggregate of effects arisen in production and consumption of high-speed transport services, and in multiplication effect to be achieved as well.

In terms of actions directly related to consumption of high-speed transportation services, a theoretical background of this research is based on the theory of consumer behavior and marginal utility.

Assessment methodology for effects of high-speed transportation utilizing magnetic levitation is based on the fact that this traffic type is included into optimum transportation chain by different means of transport: combined and multimodal. In this case, there is an interspecific competition of different means of transport and uniform value of transportation for consignor and passenger.

Income effect of magnetic levitation transportation is formed as the result of fluctuations in level of costs for transportation in overall consumer income associated with the preference for high speed. The transport modes substitution effect in multimodal transportation is to increase in growth of magnetic levitation transportation, while reducing the consumption of other types of transport if the price of transportation decreases.

Keywords

Intermodal economic effects, High-speed transport, Magnetic levitation

The Maglev 2018 is supported by

15 Health and Environmental Issues (Electromagnetic Fields, Noise, Vibrations), Presentation

Environmental Issues Related to High Speed Transportation Systems

Roland Kircher
Co-Authors: Johannes Kluehspies, Kenji Eiler, Ryszard Palka, Michael Witt, Eckert Fritz

Short Description / Abstract

As a side effect of the increasing speed of mass transportation systems environmental concerns in the society are rising. Stray fields along the path of electromagnetic systems may not be neglected anymore. Another concern is the emission of noise due to the high speed.

The presentation compares the electromagnetic fields and the emission of noise of different high speed transportation systems based on available data.

Keywords

Electromagnetic compatibility, Noise emission, High speed transportation, Maglev, Railway systems

15 Health and Environmental Issues (Electromagnetic Fields, Noise, Vibrations), Presentation

The Biological Model Provides the Study of the Negative Effects of Magnetic Fields (for the Project " Russian MAGLEV»)

Artemy Rubinskiy
Co-Authors: Timur Vlasov, Natalya Chalisova

Short Description / Abstract

In the modern, extensive scientific literature devoted to operational developments and problems of Maglev, the main attention is paid to the energy analysis of the applied and developed technologies, search of optimum technical solutions on safety, however, among of problems questions of medical safety are paid much less attention.

The purpose of this work is to establish locations and levels of field characteristics around the development of "Russian Maglev" (RM), carrying out model biomedical research to establish the impact of non-radiation physical fields on various systems of the human body, the development of scientifically based proposals and recommendations for the establishment of regulatory standards in this form of transport, to protect against harmful anthropogenic field effects on passengers and service personnel.

To achieve the goals have been studied and presented characteristics of the main sources of magnetic fields (MF) used in the technology of the RM that can affect the human body. The differentiated estimation of influence of a MF in organotypic culture of various tissues of mammals is carried out. This method has the advantages that there are no neurohumoral effects. It turned out that the constant magnetic field (CMF), relevant with the induction in the cabin of the RM, has different effects on various cells and tissues (used tissue rats Vistar line). CMF inhibits proliferation of cells of spleen, brain, kidneys, while in liver, heart, prostate and some other explants the activity of cells does not change.

The obtained data are compared with the current regulatory and technical documents in the Russian Federation to ensure electromagnetic safety in various industries (unfortunately, regulatory norms in the Russian Federation on transport have not yet been developed).

Based on the preliminary analysis, it can be assumed that weak PMP selectively affects various tissues of the body. In the applied aspect system RM needs protection from its own man-made magnetic fields and the development of methods and measures of medical prevention for passengers and staff.

Keywords

Russian Maglev, Magnetic fields, Organotypic culture of various tissues

16 Influence on Regional and Urban Development, Architecture, Presentation

Applicability and Future Development Prospect of Medium-Speed Maglev Technology in Suburb of Shanghai Metropolitan Area

Hong Shaozhi
Co-Authors: Wanming Liu, Xiaohong Chen

Short Description / Abstract

In 2016, Shanghai released its "Global City" strategic plan, which aims to build a comprehensive transportation system of "safety, convenience, green, high efficiency and economy", taking the important traffic corridors as the skeleton to promote the integration of urban and rural areas by urban town system, and finally form a overall spatial structure of "network, multi-center, group-type and intensive type". Basically, the coverage of rail transit in new towns with more than 100,000 people reaches 100%, and the average commuting time is expected less than 40 minutes. At the same time, the areas with close ties with Shanghai will be covered as the scope of the Shanghai Metropolitan area, forming a 90-minute travel circle, actively promoting the development of the Shanghai Metropolitan area with a view to leading the Yangtze River Delta to a world-class urban cluster with global influence. Therefore, Shanghai plans to build more than 1000 kilometers of rail transit lines respectively among urban area, suburban area and regional area, and to improve the bus priority strategy dominated by multi-mode rail transit. Among them, the 1000km suburban area lines will serve the rapid commuting and mid-and long-distance connection among urban center, the new city, and the cities and towns near Shanghai. Suburban railways in Paris and Tokyo have provided good examples for this.

Presently, there is only one suburban railway line in Shanghai. The two rail transit lines, which respectively connect Suzhou in Jiangsu Province, and Lingang area in the coastal areas, are widely criticized since they adopted urban subway technology. Therefore, it is urgent to plan and build a rapid rail transit network linking the suburbs and surrounding areas with urban areas. The Medium Speed Maglev(MSM) technology, which has a speed of about 160-200km/h, will be the very suitable technology meeting the requirements of the above-mentioned suburban rail lines. It is suitable to replace the suburban railway technology used in other metropolitan areas such as in Paris and Tokyo, and to provide rapid and environmentally friendly transportation requirements within a range of 50-80 km to urban area.

The MSM system has the advantages of low noise, low electromagnetic radiation and other environment-friendly characteristics. This also makes it possible to make full use of the existing highway corridors in the suburbs, adopt the elevated guideway structure forms, and thus greatly reduce the engineering costs compared with subway systems. The technologies related to the vehicles, the propulsion & power supply system and operation control system have very good technical accumulation of the existing maglev and railway technology and industrial foundation. In addition, the general characteristics of maglev system such as simpler operation & maintenance, and low cost etc., also provide MSM lower life cycle costs, so that MSM has better financial advantages. Meanwhile, the rapid development of MSM will enable China to gain the technological and industrial opportunities in this field.

Keywords

Maglev technology, Medium speed maglev, Global city, Maglev industry, Life cycle cost

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17 Transport Policy Issues, Marketing, Aspects of Transport Psychology, Presentation

Environmental Safety Issues of High-Speed Ground Transport

Stanislav Apollonsky

Short Description / Abstract

Over the last years, an increasing number of highly developed states (Japan, China, etc.) have been developing and operating different modes of high-speed ground transport (HSGT), including maglev transport, in order to unload the airlines and ground mainlines and accelerate the travel time of the workforce to the employment sites. For instance, Israel is now planning to launch a transport line for carrying passengers at a hypersonic speed in the years to come.

The expansion of the area of the use of HSGT sets new tasks for ecologists, to ensure environmental safety both on the transport itself and in the area it runs through.

Ensuring environmental safety of the operation HSGT is feasible on the condition that both the physical fields and radiation, created by the transport, and ecological features of the area where this transport operates, are considered.

Unfortunately, at present the environmental safety on electrified railway transport (including HSGT) is considered in the context of the environmental safety problems in electrical power engineering. Despite the similarity of the problems on transport and in electrical power engineering which are caused by pollution of technosphere by physical fields and radiation, there are significant differences which are necessary to be considered: at high speed the significant increase of diapason of high-frequency and non-stationary fields and radiation is observed. Consequently, when considering environmental safety on HSGT (including maglev transport), much more attention should be directed to the research of non-stationary fields and radiation, than to stationary electrical power engineering. It is not sufficient to create HSGT. On the contrary, it is necessary to develop technologies by virtue of which ecological safety might be ensured for passengers and the personnel, and for the environment.

This article deals with the types of physical fields and radiation of maglev transport, their impact on the environment. The article also deals with the problems of monitoring, prognosis and survey of these fields, in order to decrease their impact on the technosphere (industrial objects and the people).

Keywords

High-speed rail transport, Transport of MAGLEV, Electromagnetic interference and radiation in the technosphere, Rational layout of the elements of the MAGLEV transport system

17 Transport Policy Issues, Marketing, Aspects of Transport Psychology, Presentation

Reactive and Personal Anxiety when Making Management Decisions on the Transport

Nikolay Grigorev

Short Description / Abstract

The issue of reducing transport accidents, continues to be relevant. Efforts aimed at the reduction of accidents are of a multidimensional nature.

Experts rightly perceive the solution to the problem of reducing accidents in the design and commissioning of automated control systems.

The current level of the current state of automation in transportation is at a high level. But any automation requires control of the person, in the event of extraordinary situations.

Not today, there is an urgent need to know the strengths and weaknesses of man in general and, as a consequence, projecting to them the physiological parameters of the specific person who makes the decisions, which is especially important for the operator in the standby mode, which generates a state of uncertainty. Uncertainty will introduce to accidents.

First, you need to conduct research on the problems of human factor that lead to the adoption of inadequate solutions.

Of course, the human factor issues need to be addressed comprehensively. Only an analysis of synthetic data can yield results, to isolate the problem and thoroughly exploring it.

The human factor is a function of many variables, among which are such as anxiety.

Under psychology anxiety understand the emotional states personal and reactive anxiety.

Personal anxiety represents a stable tendency to perceive the surrounding world with suspicion. Both low and high levels of personal anxiety contribute to the manifestation of inappropriate responses to the situation. Very high personal anxiety is positively correlated with the presence of neurotic conflict and neurotic emotional outbursts and psychosomatic diseases.

Reactive anxiety is characterized by mental state of high tension, due to the specific situation. High level of reactive anxiety contributes to deterioration of operational of memory, attention and so on.

Charlis D. Spielberger method of testing among sea captains showed that normal (average) level of reactive anxiety is 62,7%, and trait anxiety – 52,6%

There is no doubt that measures to control the anxiety may lead to the reduction of accidents in transport.

Keywords

Human factor, Transport accidents, Reactive and personal anxiety

17 Transport Policy Issues, Marketing, Aspects of Transport Psychology, Presentation

Perspectives and Major Barriers to an Innovation of Maglev Transport Systems

Johannes Kluehspies

Short Description / Abstract

The idea of considering Maglev systems challenges established ways of thinking on how to deal with an increasing transport demand. Today, the railway industry seems focused on traditional business models that profit from friction, wear and tear of established conventional transport systems. Maglev Systems have begun to challenge those traditional business concepts. Maglev is a fundamentally different concept of transport – which might explain the reluctance, even ignorance, which Maglev systems continue to face. Sooner or later, a paradigm shift in transport in favour of Maglev seems more than likely.

High speed ground transport requires a wide-ranging and interdisciplinary discussion in order to promote a sufficiently broad spectrum of opinion. Today, a realization of any kind of high-speed transport infrastructure cannot be justified anymore just through system technical advantages alone, if they are to find acceptance with the general public and politics.

Keywords

Innovation barriers, Transport policy, Acceptance, Business case, Market forces

17 Transport Policy Issues, Marketing, Aspects of Transport Psychology, Presentation

Perspectives and Limitations of Maglev Technologies: Results of an International Survey Among Experts and Transport Professionals

Matthias Wenk
Co-Authors: Larry Blow, Eckert Fritz, Martina Hekler,
Roland Kircher, Johannes Kluehspies, Michael Witt

Short Description / Abstract

Between March and July 2018, an international study will be conducted on the trends and prospects of Maglev technologies. For this purpose, experts and interested transport professionals will be asked about their opinions about relevant Maglev technologies in a worldwide survey. Main topics are the suitability of certain Maglev systems, acceptance aspects and realization periods. How do the experts see the coming developments? Which systems do they prefer? For example, how do international experts rate current Hyperloop projects? What prospects do cargo maglevs have? And what is seen as limitations or barriers to relevant Maglev projects?

The survey is internet-based and uses the newsletter address pool of the International Maglev Board. The study is being carried out by scientific staff and students at Deggendorf University of Applied Sciences and accompanied by experts from the International Maglev Board.

Keywords

Experts' opinions, Survey, Maglev technology trends, Acceptance issues, Maglev image

17 Transport Policy Issues, Marketing, Aspects of Transport Psychology, Poster Session

Fare Sensitivity of Passengers on Changsha Maglev Express Line

Fu Ji
Co-Authors: Wanming Liu, Guoxin Sun

Short Description / Abstract

Urban maglev, as a public transport mode, its ticket pricing is a cautious decision-making process. The fare sensitivity is one of the important factor for consideration.

Changsha Maglev Express Line, open on May 2016, is in China the first urban maglev line in commercial operation. As it connecting Changsha South Railway Station with Changsha Huanghua International Airport, the maglev line is mainly taken by air passengers of Huanghua International Airport, while they transfer to or from the high-speed rail and other modes of transport at Changsha South Railway Station. Except staffs working at the airport, urban commuters rarely take the maglev line.

Before the opening of Changsha Maglev Line, we conducted a sample survey on air travellers in Huanghua International Airport, taking them as the main target passengers of Changsha Maglev Express Line. In this paper, based on the survey results and informed the travellers' willingness of taking the maglev line, we analyzed the fare sensitivity of passenger demand, which provided an important reference for ticket pricing of Changsha Maglev Express Line.

Keywords

Fare sensitivity, Urban maglev, Target passenger

18 History of Development of Maglev Transport, Presentation

The 18-year Course of Maglev in China and the New Spring: Enlightenment for Future Development

Hong Shaozhi
Co-Authors: Wanming Liu, Xiaohong Chen

Short Description / Abstract

So far, the most important and practical application and development of Maglev technology, including high-speed maglev technology and low-speed maglev technology, took place in China. Japan and South Korea are respectively operating a low-speed maglev technology commercial line. From now on, Japan's Central Shinkansen Project, which adopts superconducting high-speed maglev technology, is expected to operate at least 10 years later. Although China has over 30 years experience in maglev technology research area since early 1980s, the historic milestone in maglev development should begin in August 2000 when the company of Shanghai Maglev Transportation Development Co. Ltd.(SMTDC), and National Maglev Transportation R&D Center(NMT) were founded one after another. Since then, it can be divided into four stages for maglev technology development in China.

During the period, the two of teams STMDC and NMT, which are core teams of maglev technology development in China, have abundant experience of success, delightfulness, long-term awaiting as well as depression, especially concerning the project of Shanghai-Hangzhou High-speed Maglev Project. Therefore, it is of great practical value and significance for China and other countries who intend to promote and develop maglev transportation technology in the future. The authors are proud and fortunate to have experienced the whole above-mentioned process, and would like to extend comprehensive discussions which focus on strategic, technical, economical and social aspects in the paper.

Keywords

Maglev technology, Strategic development, Technology innovation, Maglev industry, System optimization

18 History of Development of Maglev Transport, Presentation

Retrospective and Perspectives of the Superconducting Magnetic Levitation (SML) Technology Applied to Urban Transportation

Richard Stephan
Co-Authors: Felipe Costa, Elkin Rodriguez, Zigang Deng

Short Description / Abstract

A review of the Superconducting Magnetic Levitation (SML) technology applied to urban transportation will be presented. The historical time line will be highlighted, pointing out the pioneering efforts at Southwest Jiatong University (SWJTU), China, followed by the Supra Trans project in IFW-Dresden, Germany, and the MagLev-Cobra project in UFRJ, Brazil.

Details of the MagLev-Cobra project, the first, and until today the single one, applying the SML technology that counts with a real scale prototype, operating regularly in open air, will be disclosed. The inauguration of the MagLev-Cobra project was on the 1st October 2014, the last day of the "22nd International Conference on Magnetically Levitated Systems and Linear Drives (MAGLEV)" held in Rio de Janeiro. Curiously, this day coincides with the 50th anniversary of the successful operation of the Shinkansen in Tokyo. On the 1st October 1964, the first high-speed wheel and rail train in the world was inaugurated in time for the first Olympic Games that took place in Asia. This historical coincidence is a good omen for the MagLev-Cobra project. In fact, since October 2014, the system operates regularly for demonstration at the UFRJ Campus, every Tuesday. More than 9.000 visitors have already had the opportunity to take a test ride.

The Proceedings of the MAGLEV conferences, which first edition dates back to 1977 (http://www.maglevboard.net), are the documentary files of the importance of this achievement. Initially, the methods named Electromagnetic Levitation (EML) and Electrodynamic Levitation (EDL) were considered. At the end of last century, due to the availability of Rare Earth Permanent Magnets and High Critical Temperature Superconductors (HTS), an innovative levitation method, called Superconducting Magnetic Levitation (SML), started to be considered. This method is based on the diamagnetic property of HTS in the proximity of magnetic fields given by rare earth permanent magnets. The first experiments with SML, asexpected, were small scale prototypes, or laboratory vehicles for one, two or four passengers, proposed mainly by researchers from Germany, China and Brazil. The Proceedings of the 16th MAGLEV, held in year 2000, confirms this fact. After 14 years of research and development, the team of the Laboratory of Applied Superconductivity (LASUP) of UFRJ achieved the construction of the first real scale operational SML vehicle in the world.

This retrospective will be followed by a comparison with the Electromagnetic Levitation (EML) technology, that has already four urban commercial systems, will be presented and the application niches delimited.

The perspectives of the MagLev-Cobra project and the cooperation efforts to turn it a commercial experience will finish the paper. As will be explained, before the commercial application of the MagLev-Cobra technology, the system must be certified and the technical, economic and environmental viability for a first deployment concluded.

Keywords

Superconducting magnetic levitation, Superconductors, Rare earth magnets, Maglev-Cobra

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18 History of Development of Maglev Transport, Presentation

Professor Weinberg and his Installation for "Motion without Friction" (Siberia, Tomsk University, 1911)

Mikhail Volkov

Short Description / Abstract

The university in the city of Tomsk was the first university established in the Russian Empire in the territory of Siberia. In 1909, an employee of the St. Petersburg University Boris Petrovich Weinberg was invited to the Tomsk University as a professor of physics. B.P. Weinberg distinguished the breadth of scientific interests - he dealt with issues of terrestrial magnetism, ice properties, solid state physics and problems of using solar energy. One of the first works of Professor Weinberg at Tomsk University was the creation of an experimental installation for electromagnetic transport.

In 1911, Weinberg builds an installation with a 10-kilogram iron carriage moving along a 20-meter ring road from a copper pipe 32 centimeters in diameter. In order to get rid of aerodynamic drag, the air from the pipe was pumped out and the movement of the carriage was in a vacuum. Movement along the pipe the carriage began, receiving a push from the system of solenoids. To get rid of the friction on the rails, the carriage was suspended in space using a system of solenoids placed on top of the copper pipe, which in turns attracted the carriage. An important part of the installation was the switch system, which enabled the current to be turned on in the next solenoid, when the nose of the carriage approached this solenoid, and turned off the current when the carriage stern passed past the solenoid. Thus, the carriage was transferred from one solenoid to another.

Two years later, the installation was successfully completed - it was possible to organize the operation of switches so that the carriage flew inside the pipe without touching the walls and reached a speed of 6 km per hour.

In his work "Motion without friction," published in 1914, Professor Weinberg described the successful experiments with this vacuum magneto-levitation unit and proposed a draft route for passenger traffic at a speed of 800-1000 km per hour.

The route was an evacuated pipe, along which the carriage moved, representing a cigar-shaped steel cylinder with a diameter of 0.9 meters and a length of 2.5 meters, in which the passenger (in a lying position) and a supply of oxygen for breathing were placed. At each station, the carriage was accelerated or braked by linear induction solenoids of about 3 km in length, which, according to Weinberg, would led to the carriage speeds of about 800 km per hour.

The World War, which began in 1914, interrupted work on this installation. Professor Weinberg was sent to the United States as a military representative for the acceptance of artillery shells for Russian army. During his stay in the USA, Weinberg published the results of his studies in American journals in the article "500 miles per hour", which aroused great interest among American engineers.

Keywords

Boris Weinberg, Vacuum train, Magnetic suspension, Electromagnetic acceleration

19 Project Status Reports, Presentation

Axial Force and Rotation in the Electrodynamic Bearing

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Short Description / Abstract

This work presents the experimental results concerning the homopolar low-loss electrodynamic bearing characterization. The system configuration represents part of the structure of a patent pending electromechanical battery being developed at the Instituto Federal de São Paulo – Brasil. The objective of the experiment was to characterize the axial forces acting between a core composed of a ring-shaped neodymium magnets set, corresponding to the stationary part of the battery, and a cooper metallic body which is the rotating component of the battery. The experiment consists on fixing the two parts that compose the system in a machine tool. The copper cup was fixed to the spindle, allowing its rotating speed to be controlled, and the aluminum rod containing the magnets was fixed to the table, allowing the control of its relative position. The experiment allows the copper cup to rotate up to 5000 rpm.

On the rod, there are two neodymium ring magnets and three ferromagnetic rings. At the beginning of the experiment, the rod was placed centered in relation to the spinning body. From this initial position it was moved axially to generate a force, due to the electrodynamic effect of the currents induced on the copper cup body. To measure this force, strain gauges were installed on the rod that holds the magnets set. The voltage measured on a Wheatstone bridge allows quantification of the generated force. The experiments were conducted after the calibration of the measuring system. The data collected can be used to generate a precise model that relates the quantities: body rotational speed, axial displacement between the bodies and dimension of the generated force.

Keywords

Electromechanical battery, Electrodynamic levitation, Magnetic bearing, Magnetic levitation

19 Project Status Reports, Presentation

Status of Maglev Projects in North America

Larry Blow

Short Description / Abstract

The United States has been a leader in the study and development of maglev systems for passenger and cargo transport for many years. Several speed ranges have been investigated, from so-called "urban" speeds of 100-160 km/h (60-100 mph) up to regional/intercity speeds from 240-500 km/h (150-310 mph). Even though no commercial systems have been installed yet, many technologies continue to be analyzed for potential commercial readiness and construction around the country.

- The overview will cover the following topics:
- High-speed intercity maglev projects
- Low-speed projects proposed for installation and also those in research
- Updates to individual company-led technology development efforts
- High-profile efforts involving start-up companies (e.g., ET3, Hyperloop, Magnovate, etc.)
- Innovative maglev technology applications (military use, consumer products, etc.)

Keywords

Urban maglev, High speed maglev, United states

19 Project Status Reports, Presentation

The New Status of 1km MagTrack Demoline

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Short Description / Abstract

One 1km-long MagTrack demoline using permanent magnet linear synchronous motors was built at the campus of Zhangjiakou Mining Machinery Co. Ltd. by Magplane Technology, Inc. and China Coal since 2013. After four years of manufacture, construction, and testing, two trains of coal-loaded six-capsules can be operated independently and fully demonstrated with all the functions of MagTrack systems, including loading, unloading, starting/stopping, switching, and 10 degree slope climbing.

The Zhangjiakou Demonstration Line has the objectives of demonstrating all systems operations necessary for a commercial system, including the initial startup, a restart after an unplanned shutdown following a power failure and management of all fault conditions identified in commercial operation by simulated faults on the demonstration. It also contributes to a determination of demo system operating cost projected to a commercial system, including power consumption, scheduled maintenance, and necessary operating personnel. The test results of 1km demoline will be described and analyzed in the full paper. The projected operating cost needs to have a satisfactory return on investment and successful market penetration against both truck and rail transport.

Keywords

MagTrack system, Linear synchronous motor, Permanent magnet, Propulsion, Demoline

19 Project Status Reports, Presentation

Status of Two Key Maglev Projects in the USA

Husam Gurol
Co-Authors: David O'Loughlin, Miller Hudson, Mike Riggs

Short Description / Abstract

This paper discusses the status of two key U.S. projects using the General Atomics (GA) maglev technology: 1) The Advanced Guideway System (AGS) in Colorado, and 2) The Hazelwood Green Maglev Shuttle System in Pittsburgh, Pennsylvania. These projects have been in the planning stages for several decades and are recently showing promise of moving forward. This paper will summarize the on-going efforts to bring these projects to commercialization and the status of the GA maglev technology.

Since 1998 the Colorado Department of Transportation (CDOT) has spent more than $50 million on studies that analyzed alternatives for reducing the persistent and expanding congestion on the I-70 freeway (which serves major resorts) during skiing season. All five reports concluded that only an Advanced Guideway System, utilizing maglev technology, could provide the capability and capacity required to restore ready access to Colorado's world-class recreational facilities. CDOT's 2014 AGS Feasibility Study specifically identified a medium speed (120-150 mph) maglev system as best suited to the demanding topography of the corridor while producing minimal environmental impacts. Twenty proposals were submitted and evaluated. Only project funding was identified as an obstacle to deployment. While an initial operating segment from Denver's western suburbs to Breckenridge would be 60 miles in length, the eventual 150-mile system would connect Denver International Airport (DIA) with the Eagle County Airport (ECA).

The city of Pittsburgh has been at the forefront of changing its image from a steel town to a high technology center for many years. Over $100 M has been invested in building new infrastructure and cleaning up industrial waste that was created from its days as a LTV coke and steel making facility. The proposed Hazelwood Green Maglev Shuttle System is approximately 2 miles in length and designed to connect key medical, research, university, and tourist sites. These include Carnegie Mellon University, University of Pittsburgh, University of Pittsburgh Medical Center, and the Hazelwood Green development. The 178 acre Hazelwood Green site, along the Monongahela River is undergoing development with over 6,500 housing units proposed. The proposed maglev system will consist of 100-passenger vehicles, traveling at speeds up to 80 mph, with ridership estimated at 10,000 passengers per day.

Maglev is an "enabling" technology for these two diverse applications. The technology provides high speeds, ability to climb long, steep grades, creates no local pollution, has a small foot-print, and is quiet. These features make maglev ideal for implementation in environmentally sensitive areas. GA has been working on these two projects since their inception. The technology has been undergoing testing for a number of years at the GA test track site in San Diego, California. All the key technologies involving the levitation, propulsion, and control systems have been successfully tested and are ready to transition to commercialization.

Keywords

General Atomics, Colorado AGS, Pittsburgh shuttle system

19 Project Status Reports, Presentation

Application and Further Development of Maglev Transportation Technology in China

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Short Description / Abstract

Since the Shanghai Maglev Demonstration Line was put into operation at the beginning of 2003, it has been running safely for 15 years, keeping the record of public ground traffic of 430km/h top speed and 99.8-99.9% punctuality. Since 2001 China Ministry of science and technology has been supporting the research and development of high speed Maglev transportation technology. In 2016, under the support of the Ministry of science and technology, the China Railway Rolling stock Corporation started to lead the engineering research of Maglev program, the goal the program is the development of 600km/h high speed Maglev system and 200km/h medium speed Maglev system till 2020.

Since the Changsha Maglev Airport Express Line in May 2016, Hunan province has planned to build more than 1000km long Maglev line with the maximum speed 100 or 160km/h till 2030. Following the operation of urban Maglev in Changsha and Beijing, the third urban Maglev line in China, began to be built in Guangdong province at the end of 2017. The new Maglev line will connect the downtown of Qingyuan city and the theme amusement park in suburban in 2019.

With the promotion of Hyperloop R & D activities in the United States, China has also started the research and development of the vacuum pipeline Maglev system above the speed of 1000km/h. Several units are planning to build vacuum pipeline test systems with the highest speed of 1200km/h-2000km/h.

This paper introduces the application and construction of Maglev transportation, recent R&D achievements and further plans in China.

Keywords

Shanghai Maglev, Changsha Maglev, Superconductor, Linear drive, EMS, EDS

19 Project Status Reports, Presentation

Development of a Closed Loop Energy Control with a Hardware-in-the-Loop Flywheel

Evandro Rech
Co-Authors: Ferreira L.T., Forte G.M., Campo A.B., Costa E.A.

Short Description / Abstract

This work describes the design of a Hardware-in-the-Loop (HIL) system that is being developed to evaluate the drive of a brushless motor-generator in an electromechanical battery. Electric regenerative systems have been applied in various modern technologies, such as trains, elevators and especially in electric vehicles. HIL Systems also has wide application in the simulation of power systems, enabling a rapid prototyping of control systems without risk of their exposure to high energies and their validation in different operating conditions, adjustable by software. The present system is intended for use in a steering wheel, electromechanical device that has as main characteristic and great dimension of the energy that is developed. The system in development consists of two main modules.

The first one consisting of a program implemented in a reconfigurable logic device (Field Programmable Gate Array - FPGA) called Single-Board RIO, coded in LabVIEW language. This system implements a logic circuit control for the electric motor.

The second module also consists of a electronic circuit, based on a reconfigurable logic device, which implements a first-order solver for differential equations. It is a program that works like a generator-motor and a dynamic electromechanical battery device itself, making use of analog and digital inputs and outputs to receive control and response signals with simulated signals such as electric currents, position of the rotor and counter-electromotive force generated. The second module can be modeled to represent as dynamics and non-linearity present in the electromechanical battery, enabling the development of the drive system implemented without first module for those who deal with different operating situations.

In this work, we present a structure developed as experimental results with a prototype of small dimensions used to validate the model.

Keywords

Electromechanical battery; Brushless motor, Hardware-in-the-Loop, Magnetic levitation

Additional Proceedings of the International Conference Maglev 2018

12 New Ideas on Levitating Device Applications, Presentation

Hyperloop as an evolution of Maglev

Andrea Santangelo

Short Description / Abstract

Hyperloop is often described as the "fifth node of transportation" but, as the race between competitors around the world becomes harsh, investors, governments and scientists remain cold and cautious. An educated guess from one of the first civil engineers dealing with the design of an Hyperloop infrastructure in the real world tries to give some direction between hype and pragmatic design.

Keywords

Hyperloop, Vacuum transportation, Future transportation, Tube, Pump

4 Magnetic Levitation and Guidance in Transport, Presentation

A study on a design method of EDS and LSM of a superconducting Maglev system

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Short Description / Abstract

There are many characteristics that must be assessed in order to design superconducting Maglev systems. There are also many design parameters to be considered. As a fundamental study, case studies to evaluate the characteristics of EDS and LSM are described in this paper. In this study, characteristics of EDS and LSM are evaluated by changing the two design parameters; the electrical gap (lateral distance between the center of the conductor of the superconducting coil and that of the ground coil) and magnetomotive force of the SCM (superconducting magnet). Two case studies are described in this paper.

In the first case study, only the electrical gap is treated as the design parameter and the magnetomotive force of the SCM is treated as a constant value. When the electrical gap is reduced, magnetic flux linkage between the superconducting coils and ground coils becomes larger. Basically speaking, this is treated as improvement of the characteristics of electromagnetic force. Two advantages, smaller magnetic drag and smaller required power of LSM, are described. However, there are also disadvantages when only electrical gap is reduced. Two disadvantages, larger tensile force on the levitation/guidance coil and larger voltage of LSM, are described in this paper.

In the second case study, both the electrical gap and the magnetomotive force of the SCM are treated as the design parameters. By reducing the electrical gap along with reducing the magnetomotive force of the SCM, the advantages are reduced. Two factors, magnetic drag and required power of LSM, become larger by reducing the electrical gap along with reducing the magnetomotive force of the SCM than by reducing only the electrical gap. However, by reducing the electrical gap along with reducing the magnetomotive force of the SCM, the disadvantages are also reduced. Two factors, tensile force on the levitation/guidance coil and voltage of LSM, become smaller by reducing the electrical gap along with reducing the magnetomotive force of the SCM than by reducing only the electrical gap. In the case studies described in this paper, by adjusting the electrical gap and magnetomotive force of the SCM to appropriate values, there is a condition in which only advantages exist and no disadvantages exist. The case studies described in this paper are the results when the parameters for the Maglev system are the values described in the paper. These results do not indicate that in all conditions, there are results for which only advantages exist and no disadvantages exist.

The two case studies described in this paper are examples of design methods of EDS and LSM of the superconducting Maglev system. There are many characteristics and design parameters to be considered in order to design the actual Maglev system. Further studies will be performed with an aim to establish a more optimized design method for the Maglev system.

Keywords

Superconducting maglev system, EDS, LSM, Electrical gap, Magnetomotive force of SCM

6 Linear Motors, Poster Session

The Field Oriented Based Thrust Control of Double Sided Linear Induction Motor with Parallel Connection

Shi Liming
Co-Authors: SUN Xiao, Qiongxuan Ge, Yaohua Li

Short Description / Abstract

1. Introduction

Long primary double sided linear induction motor (DSLIM) connected in parallel and powered by a single inverter is an effective linear drive mode. To improve the thrust performance of the motors, a secondary flux orientation based control strategy is proposed. First, the dynamic model of parallel linear induction motor is established, and the calculation method of total excitation current and thrust current is deduced in the control process. The secondary field oriented control is achieved in thrust control of the motors according to the coupling factor of every linear induction motor and the secondary real-time speed. The simulation analysis and experimental results show that the proposed secondary field oriented control method can effectively overcome the thrust fluctuation and improve the stability of the overall thrust of parallel motor modules. Meanwhile, the method can improve the power factor of parallel linear induction motors and reduce the required inverter capacity.

2. Analysis and experiments

The equivalent circuit of parallel connected DSLSIMs is shown in Fig.1. The weighted excitation magnetic current isd* can be derived as shown in (1) by every excitation current isnd and coupling factor an.

The thrust current reference is derived.

The secondary flux estimation value of every DSLIM is given as (3) and the secondary orientation angle is expressed.

3. Conclusions

The simulation and experiments on a platform of the multiple parallel connected DSLIMs proves that the proposed control method can realize the smooth control of thrust. Details will be given in the full paper.

Keywords

Double sided linear induction motor, Parallel connected long primary, Secondary flux orientation, Thrust fluctuation

11 Maglev Elevators and Escalators; Magnetic Bearings, Maglev Wind Turbines, Poster Session

Verification test of superconducting flywheel energy storage system

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Short Description / Abstract

The flywheel energy storage system (FESS) which does not deteriorate with charge/discharge like a chemical battery, is a power storage system suitable for high-frequency input/output of electric power. The FESS can stabilize the fluctuation of the output of the photovoltaic power generation system. Using the FESS demonstration machine which was modified from CFRP rotor to iron rotor for the improvement of rotational stability, the test was executed from the sunrise to sunset to verify smoothing effect of photovoltaic power and high-frequency input/output of electric power. The key technology of FESS is the high temperature superconducting magnetic bearing (SMB). The SMB is a non-contact type bearing, and there is no mechanical loss and maintenance is easy. The SMB consists of the high-temperature superconducting coils used for its stator and the high-temperature superconducting bulks used for its rotor. The test results of SMB under the condition of the levitation time of more than 9,000 hours, 120 times of magnetization and 24 times of heat cycles between the room temperature and the cooling temperature verified the reliability of the SMB. Furthermore, we succeeded in the demonstration test of the SMB to generate the large load of 15 tons for the large energy storage capacity. Based on the test results at the photovoltaic power plant, we consider that there are many application needs according to the various railway circumstances including an effective countermeasure against lapse of regenerative electric power of the railway system, a countermeasure against a voltage drop for ensuring stabilization of the supply capability of the overhead trolley, and the urgent run to the nearest station when the electricity goes out. We are planning to advance a design of FESS for the railway system, making use of the high degree of freedom of the design by which the energy storage capacity and the output of FESS can be set independently.

Keywords

Flywheel, Magnetic bearing, Superconducting coil, Superconducting bulk, Railway

7 Superconductors, Application of Superconductivity, Poster Session

Liquid-Phase Synthesis, Surface Morphology and Electrochemical Properties of Electrode Material Based On MnO_2

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Short Description / Abstract

Background: The problems of creating pseudocapacitors and microbiological fuel cells are described in the article. The effect of a synthesis method and fabrication technology on the electrochemical performance of a MnO_2-based electrode for a model electrochemical device is considered.

Aim: In this paper, we report on the effect of a synthesis method and fabrication technology on the electrochemical characteristics of a MnO_2-based electrode for a model electrochemical device. These devices have a prospect for the use in a variety of vehicles including the sector of magnetic levitation transport as an alternative to low-speed movement.

Introduction: Transition metal oxides, especially manganese (IV) oxide, are promising electrode materials for electrochemical devices such as pseudocapacitors (PCs) and microbiological fuel cells (MFCs), which can be used to power Maglev trains. As a rule, properties of a material indicate its perspectives. Manganese dioxide is prospective owing to a number of excellent electrochemical characteristics (wide potential window - up to 0.9V in aqueous electrolyte, high specific capacity and charge-discharge rate), high catalytic activity, cheapness and facility of its manufacturing process.

Nevertheless, electrodes based on MnO_2, as well as a number of other transition metal oxides (Fe_2O_3, Ni_2O_3, WO_{3-x}, V_2O_5, Co_2O_3, etc.) lose in stability of electrochemical characteristics. They have low electrochemical reversibility and a high degree of self-discharge (one of the most important electrical parameters of PCs). Moreover, low electronic conductivity with the order of magnitude of 10^{-5}-10^{-6} S/cm is another significant drawback of MnO_2 which limits its practical application. Meanwhile, the selection of an appropriate synthesis method and conditions may affect electrical activity and electrochemical stability of an electrode material.

In this paper, we report on the effect of a synthesis method and fabrication technology on the electrochemical characteristics of a MnO_2-based electrode for a model electrochemical device.

Materials and Methods: Manganese (IV) oxide was obtained by the following methods of liquid-phase synthesis: electrochemical deposition (ED) and chemical deposition (CD).

The ED on a conductive support (steel mesh) was carried out in a solution of manganese sulfate (II), at a constant current of 15 mA with deposition time of 170 s. After the synthesis, the support was washed several times in distilled water and dried at room temperature until it reached a constant weight.

Chemical deposition of MnO_2 was a result of a 6-hour reaction between 0.15 M manganese sulfate (II) and 0.1 M potassium permanganate under constant stirring and a temperature of 25 ° C. Then, the precipitate was filtered off, washed with distilled water and ethyl alcohol, and dried at 60 ° C in the oven for 3 hours.

The MnO_2 obtained by ED is the finished electrode material because it is deposited on a steel mesh as a homogeneous film with thickness of about 200-300 nm, and does not require additional

processing. In this regard, the developed electrode – "MnO_2/steel mesh" was tested in a model electrochemical device as a working one.

Whereas MnO_2 produced by CD is a ceramic non-conductive powder, it was first necessary to prepare an electroactive composite paste for covering the electrode (steel mesh). For this purpose, the following components were taken: electroactive material - MnO_2 (75 wt.%); conductive material - superconducting carbon black (20 wt.%) and binding material – fluoroplastics (5 wt.%). These components were ground to pasty state with the addition of a few drops of n-propyl alcohol.

The resulting paste was ultrasonically processed (22 kHz) for 1 hour and then applied to a conductive support (steel mesh). Thus, composite electrodes were fabricated and further examined in electrochemical tests.

Results: Regardless of synthesis method, the obtained oxides are X-ray amorphous. Analysis of IR spectra indirectly confirmed the composition of manganese (IV) oxide by the absorption band in the 600 cm^{-1} region reflecting the Mn-O bond vibration. Surface morphologies of the obtained oxides are significantly different. MnO_2 (ED) forms agglomerates with length of 2 µm and thickness of 0.5 µm whereas MnO_2 (CD) forms spheres of about 100 nm in diameter. Results of electrochemical tests of the composite electrodes are shown in Table 1.

Table 1. Electrochemical parameters of the developed electrode materials

Type of electrode	Specific capacity*, C/m, F/g	The equilibrium electrode potential**, U, mV	Electrochemical reversibility***, %	Self-discharge rate****,%
MnO_2/steel mesh	200	245	13	87
Electroactive paste /steel mesh	70	170	35	65

*C/m, where C - capacitance (F), m - mass of electroactive film consisting of MnO_2 or mass of electroactive paste, (g); **The equilibrium potential of the electrode was measured in a three-electrode cell in the voltmeter mode; ***Electrochemical reversibility was determined by the cyclic voltammetry method from the ratio of the values of -Q and + Q per a cycle; ****Self-discharge rate was determined by the previously developed method [2].

As seen from the table, the electrochemical parameters of the developed electrodes depend on the method of synthesis and fabrication. It should be noted that although capacity of the second type of electrodes (electroactive paste/steel mesh) is inferior to the specific capacity of the first type, their electrochemical stability is significantly better (based on the values of reversibility and self-discharge rate). This is probably due to the fact that composite paste stabilizes electrochemical parameters of pseudocapacitive electrodes.

Conclusion: Thus, electrodes of the "electroactive paste/steel mesh" type based on manganese dioxide obtained by chemical precipitation, possess higher electrochemical stability compared to electrodes of "MnO_2/steel mesh" type, where MnO_2 is obtained by electrochemical deposition. In the nearest future, we expect to improve the technology of manganese (IV) oxide synthesis and fabrication of electrodes for PCs as well as approbate the developed electrode materials not only in experimental PCs, but also in experimental MFCs in presence of the bacterium *Geobacter sulfurreducens*.

Keywords

Pseudocapacitor, Microbiological fuel cells, Electrode, Manganese dioxide, Electrochemical deposition, Chemical deposition

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2 Urban Maglev, Presentation

Evaluation of Public Efficiency of The Strategy for Development of High-Speed Urban Transport

Maria V. Fiodorova

Short Description / Abstract

Evaluation of the public efficiency of the strategy of high-speed urban transport is the final stage in the formation of the strategy for the development of high-speed transport.

The strategy for the development of high-speed urban transport is characterized by the following main characteristics: significant initial investment, which in some cases is considered as an objective obstacle to the adoption and implementation of the strategy, long duration of the implementation of the strategy and the timing of the achievement of the goals and the use of financial resources make it more important to determine the current value of the project results and compare them with the initial investment, and most importantly, the complexity of the process of measuring the results of the introduction of a new transport product, and often cannot be measured in value terms.

In our opinion, these features prove the urgency of determining the public efficiency of the strategy for the development of high-speed transport. Taking into account the specific nature of the research object, the comparison of costs and results of the innovative transport product implementation should take place within the assessment of its social efficiency.

The aim of the work is to develop a system of indicators for assessing the public efficiency of the strategy for the development of high-speed urban transport.

Study of existing methods of assessing social efficiency, searching for shortcomings and advantages, exploring the advantages of magneto-levitation technology.

Of particular importance is the development of this system of indicators for magnetic levitation transport, which is distinguished by such advantages as the impossibility of derailment, greater route speed, hence less time travel, less noise and vibration than those of light rail transport and metro, and complete absence of dust.

The proposed system of indicators for assessing the public efficiency of the strategy for the development of high-speed urban transport takes into account all the advantages of magnetic levitation technology and makes it a priority when choosing high-speed urban transport.

Keywords

Social, public efficiency, High-speed urban transport, Magnetic levitation

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