APP5-1

Magneto-Archimedes levitation of metals by optimized ferromagnetic cylinder arrays in magnetic fields

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We have studied magnetic levitation properties for metals by magneto-Archimedes effect under a high magnetic field gradient. Magneto-Archimedes effect is a phenomenon that materials levitate at a particular position in a paramagnetic medium by applying magnetic field gradient due to the difference of magnetic susceptibility and density between the medium and the materials. In order to enhance the magnetic force factor BdB/dz in a vertical direction, a ferromagnetic cylinder and an array of the cylinders were set into the room temperature bore of a 10 T superconducting magnet. We optimized the shape and the arrangement of the ferromagnetic cylinders to increase the magnetic force. The maximum BdB/dz achieved the high value of over -1600 T^2/m which was about 4 times larger than that without ferromagnetic materials. However, the problem remains that $BdBdz$ only increases just above the ferromagnetic cylinder. We succeeded in solving the problem by using the ferromagnetic cylinder array. The magnetic levitation properties for several kinds of metals in manganese chloride aqueous solution as a paramagnetic medium were studied. Each metal levitated at different height in relatively low magnetic fields. The ferromagnetic cylinder array made the metal grains and powders levitate uniformly in a horizontal direction. That proposes a new magnetic separator for valuable resource recovery from solid mixture in relatively low magnetic fields.

Keywords: magneto-Archimedes, metals, ferromagnetic cylinder array

APP5-2

Localization and Mapping for HTS Maglev Test Vehicle Based on Visual SLAM

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Real-time position information is the future development of high-temperature superconducting (HTS) maglev test system toward intelligence. However, due to the design parameters, drift, magnetic field interference of the system, traditional methods are difficult to maintain real-time performance when the positioning system is simplified. In navigation, mapping and odometry for indoor and outdoor environment, visual simultaneous localization and mapping (Visual SLAM) is the computational problem that constructs a map of an unknown environment and keeping track of real-time location simultaneously by visual sensors. In order to explore the accuracy and robustness of the visual SALM method under the HTS maglev test system, this paper focuses on the different behaviors of multi-sensor fusion SLAM method and monocular SLAM method in the measurement environment. Compared to the monocular SLAM with only a single camera, the multi-sensor fused SLAM method using cameras, IMU and active IR detector is more robust in low-texture and high-frequency texture environments. This method can improve the feature matching precision of the system and provide powerful guarantee for real-time positioning and mapping. On this basis, this work comes strong support for evaluating the driving characteristics of maglev vehicles at different speeds, and offers a fresh idea for the positioning method of rail transit experimental system.

Keywords: SLAM, Multi-sensor data fusion, Localization, High-temperature superconducting maglev

APP5-3

Active Vibration Control of Secondary Suspension Based on High-Temperature Superconducting Maglev System

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High-temperature superconducting (HTS) maglev vehicle system is a kind of self-stable levitation mode which is characteristic of flux pinning of non-ideal type II superconductor, has the outstanding advantages of simple and reliable principle, environmentally friendly and so on. But in HTS maglev vehicle system, the levitation force of the YBCO bulk over a NdFeB guideway is oscillated by the fluctuant external magnetic field, which is easily transmitted to the car body to affect the running comfort. This paper starts with the active vibration absorber of the secondary suspension system of HTS maglev, the electromagnetic linear actuator was applied based on active vibration control. The magnetic force of the electromagnetic linear actuator was controlled to increase the damping of suspension system thus improve the comfort of the maglev system. The experimental platform of active vibration absorber is built, which is composed of four electromagnetic linear actuators and a suspension frame, the electromagnetic linear actuators are placed in four corners of the frame above the four HTS maglev dewars respectively. The magnitude of the electromagnetic force is controlled through AC current to counteract the vibration from the track, the mathematical model of absorber system was built, digital PID control was used to the design of the controller to realize the control of the magnetic force. Then, the designed active vibration absorber of the secondary suspension system was validated under different speed levitation height and field cooling height (FCH). The result of the experiment indicates that the electromagnetic linear actuator will reduce the vibration of magnetic levitation vehicle caused by the fluctuant external magnetic field efficiently. With this method, it can greatly improve the stability of the system and help us to achieve more comfortable.

Keywords: high-temperature superconducting maglev, active vibration control, electromagnetic linear actuator, Simulink simulation

APP5-4

Dynamic modeling of bulk superconductors with different E-J relationships for high temperature superconducting Maglev systems

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Three ***E-J*** relationships describing the electromagnetic behavior of the high-temperature superconducting (HTS) bulk over a permanent magnet guideway (PMG) are discussed in this paper. They are the power law model (PLM), the flux flow and creep model (FFCM), and the flux flow model (FFM). With the aid of the finite element software COMSOL Multiphysics, these models were successfully established combining with the AC/DC module and the Heat Transfer module. The irregularity of the surface of the real PMG is considered in the modeling by applying a small-amplitude vertical vibration function to the guideway which is built as a geometric entity. In view of the application of high-speed HTS magnetic levitation (Maglev) system, compared with the experimental data, the dynamic response of the levitation force, the temperature distribution and the current density distribution of the HTS bulk under different vibration frequencies was analyzed. This work can provide a reference for the modeling of the dynamic response of the electromagnetic-thermo-force characteristics of the HTS Maglev system.

Keywords: high temperature superconducting bulk, power law model, flux flow model, flux flow and creep model

APP5-5

Simulation Study on Maglev Performance of High Temperature Superconductors in Low Pressure Environment

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High temperature superconducting Maglev evacuated tube transport (HTS Maglev ETT) system has significant potential for rail transit applications, due to the advantages of self-stable levitation, no contact friction and low air resistance, which combines HTS Maglev and ETT technology. It is necessary to study how the Maglev performance of high temperature superconductors (HTSCs) will change in low pressure environment. In this paper, the applicability of the Power Law Model (PLM) and Flux Flow and Creep Model (FFCM) is compared when studying the Maglev performance related to air pressure, as well as different J_c-T models. The simulation model applicable to analyze the Maglev performance of HTSCs in different pressure environment is established. This simulation demonstrates the beneficial effect of low pressure environment on the Maglev performance of HTSCs, and provides an effective approach for HTS Maglev simulation in further lower pressure and low temperature environment.

Keywords: high temperature superconductors, maglev performance, simulation model, low pressure environment

APP5-6

Load characteristics of contactless bearing based on HTSC tape

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By now there are many studies aimed to finding of possibility for using of novel superconducting flexible tapes in magneto-levitation systems instead bulk high temperature superconducting materials. In this report we present design and results of investigations of superconducting magnetic bearing on the base of HTSC flexible tapes. The bearing consists of a cooled by liquid nitrogen cylindrical stator and concentrically placed rotor. The HTSC tape with 12 mm width and 150 cm length is wound on the cooling stator in a few layers as a pancake. The rotor consists of a simple set of permanent magnets. The magnetizations of adjacent layers have opposite directions. We tested the bearings with various configurations of superconducting windings which differ in numbers of pancakes and number of tape layers in one pancake. The loading characteristics, i.e. dependencies of axial and radial levitation force components on displacements were measured. We compared the obtained dependencies with the values of the levitation force for stacks of HTSC tapes in a similar configuration of permanent magnets and found a good agreement for both cases.

Keywords: HTSC, Flexible tapes , Levitation, Bearing

APP5-7

Moddeling of thrust magnetic bearings for levitation systems

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Currently, the main construction material for levitation bearings and suspensions are bulk high temperature superconducting samples. But bulk HTS has several drawbacks such as brittleness, the complexity of sample preparation, when samples of desired shape are needed. Also critical current density of the bulk samples is significantly less than it for the HTS tapes. Thus, an alternative way to construct levitation systems is to use HTS tapes stacks that has high strength, simplicity of thermal stabilization and the ability to vary the geometric parameters of the stack Special attention is paid to the HTS magnetic bearings development in various technical applications, such as gas-turbine installations, electric motors, high-speed rotor systems, where the magnetic bearing is one of the main components determining technical characteristics and durability. The complexity of this type magnetic systems need to take into account the superconducting materials properties in gradient magnetic fields. Therefore, using the special software taking into account the features of the three-dimensional magnetic system and sharply non-linear hysteresis materials properties is necessary. This work presents the complex results of the FEM H-formulation modeling of the thrust magnetic bearing based on 2G HTS tapes, which consist of HTS stator and PMs rotor. In view of the required size production problem, ring PMs magnetized radially replacing with sectoral PMs, as well as cubic PMs, were proposed and justified. Load characteristics and losses in the system for various bearing configurations were obtained. In this work we present a computational model for a magnetic levitation system based on the second generation HTS tapes GdBa2Cu3O7-x. In our the model we have used the magnetic and transport characteristics of industrial superconductors and also took into account the thermal properties of each layer of high-temperature superconducting tape and the features of the layered structure of whole stack. The numerical simulation was performed using the finite element method. We compared the simulation data with the experimental results and got good agreement of results.
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Keywords: levitation, bearing, HTS, moddeling