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Larger Levitation Force Design of Magnetic Levitation Rail based on Topology Optimization of Halbach Array

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In order to increase the diversity of people's travel mode and fill the blank of the travel speed between the aircraft (900km/h) and the high-speed train (300km/h), the high-temperature superconductor magnetic levitation train still needs to be developed. The conventional magnetic rail used for levitation mainly adopts the isometric magnets. Advanced solution uses Halbach Array, which can increase the single-side magnetic density (increase levitation force) and improve sinusoidal distribution (increase the guiding force) of the magnetic field[1-3]. A fact that is easy to neglect is the different widths of the horizontal and vertical permanent magnets (PM) in Halbach array can affect the magnetic density significantly[3-5]. So that in Halbach array application, the structure topology of the PMs can be optimized in order to achieve a better magnetic performance.

In Halbach maglev rail topology optimization, a 2D model has been applied. The magneto-static energy is controlled to be the same, which means the total surface of the PMs section is the same. After the topology optimization by finite element method, when the width ratio between the horizontal and the vertical PMs is 3.182, the improvement of the surface magnetic flux density is the best, and in our research it's about 20% augmentation. A section of the 10:1 suspension rail has been fabricated in order to measure the spatial magnetic flux density and the levitation force distribution, to compared with the mathematical model deduced based on Biot-Savart Law and method of equivalent current sheet.

By presenting the process of our research in detail, we hope to provide positive influence to follow-up scholars who carry out similar works.

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