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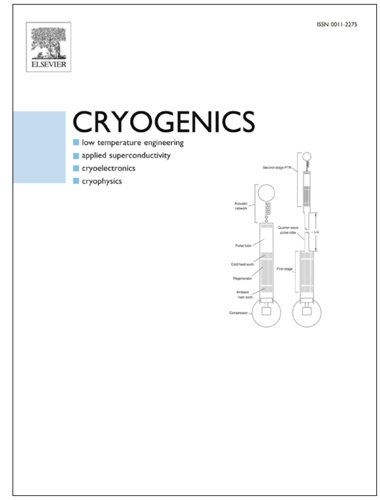

Operating Characteristics and Cooling Cost Evaluation for HTS Receiver Arrays of Wireless Power Charging System in Superconducting MAGLEV Train

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Operating Characteristics and Cooling Cost Evaluation for HTS Receiver Arrays of Wireless Power Charging System in Superconducting MAGLEV Train

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Abstract— **Since conventional power supply unit should be attached to HTS magnet in the MAGLEV, a large thermal loss is indispensably caused by power transfer wires and joints, those have been one of essential obstacles in the superconducting MAGLEV train. As the wireless power transfer (WPT) technology based on strongly resonance coupled method realizes large power charging without any wires through the air, there are advantages compared with the wired counterparts, such as convenient, safety and fearless transmission of power during movement. Above all, the WPT technology in the MAGLEV can reduce the cost of tunnel construction since the space of conventional power line doesn't required. From these merits, the WPT systems have been started to be applied to the wireless charging for various power applications such as transportations (train, underwater ship, electric vehicle). In this study, as a practical approach, authors investigate transfer efficiency and cooling cost for multi-Tx and multi-sized single Tx coils under different size of Rx coils arrays, respectively. Additionally, authors investigated transfer ratio at HTS Rx with helix and spiral Tx coils under different interval. As well as, authors evaluate cooling cost of different sizes of HTS receiver under long single and multi-copper antenna arrays based on nitrogen evaporation method.**

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Index Terms—**Magnetic levitation train; multi antenna coils; thermal loss; superconducting resonance receiver; wireless power transfer.**

I. Introduction

Recently, super high speed magnetic levitation MAGLEV using high temperature superconducting (HTS) magnet has been expected as next generation transportation since superconducting magnet can keep mighty levitation force with low cost [1]. Generally, the HTS magnet has been supplied by conventional electric power persistently to keep fixed levitation gap and low irregularity tolerance [2]. However, a large thermal loss is indispensably caused by power transfer wires and joints [3],[4] in the superconducting MAGLEV train, which system, with a linear synchronous motor, for instance, requires primary windings distributed along the track, resulting in substantial increase in the construction and maintenance cost. If the conventional power line of the high speed MAGLEV train can replace by wireless power charging system, the cost of tunnel construction for the space of the power line can be remarkably reduced. From these reasons, the wireless power transfer (WPT) has received attention in recent years for industrial and high power applications [5]; electric vehicles (EVs) and train [6]-[7]. The WPT technology has received attention in recent years for industrial and high power applications; electric vehicles (EVs) and train [8]. As WPT via magnetic resonance coupling provides a highly efficient mid-range transmission and robustness to misalignment, such a technology is suitable for dynamic charging of high-speed railways or EV system [9], [10]. Eliminating the use of wiring can mitigate complicated charging operation and reduce the risk of accidents such as electric shock, cable disconnection, and so on. An effective power transmission and a stable supply of energy are important issues for implementing an actual WPT system.

Previous research has proposed single-side Tx to Rx coils to simplify estimation of coupling coefficient. Recently, as it makes possible a convenient power charging system based on multi-coil array [11]. The high performance multi-coil Tx coil enhances power transfer efficiency and longer distance. The MAGLEV systems inherently have advantages in higher efficiency due to smaller air gap for wireless power transfer system between guidance and train, and almost no lateral displacement as well as increased attractiveness, and reduced management costs. Additionally, since the Rx coil can be placed on superconducting magnet of traveling train, the installation and cooling proceed of Rx can be simply considered.

In this paper, authors present the approach of design consideration of wireless power transfer technology applications to high speed MAGLEV train and suggest design methodology for high power WPT systems with multi copper Tx coil compared with single copper long Tx coil under moving Rx coils with different sizes. Since the Tx coil should be installed in linear synchronous motor in the guide rail, installation space is limited. From this reason, authors investigated the transfer ratio for different (helix and spiral)