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Mathematical Design of a Pulsed Power Induction Coilgun System using Taguchi Method

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A pulsed power induction coilgun system is a multi-physics system that is too complicated and difficult to simulate and design. Several studies presented design and simulation schemes of a coilgun system by a finite-element method (FEM) which is not cost-effective and need time-consuming process. The impact on the energy efficiency by capacitance, voltage level, and initial position of armature coil has been presented in other reports. But there are still lack of studies to determine the geometry variables, number of turn-layer, switching time, which have major effects on operation and energy efficiency.

One of the difficulties to design the coilgun system is that the mathematical model of the coilgun system seems unable to be solved by general analytics method. The Taguchi method, one of statistical methods, has been studied and verified as an economical and effective method to improve the quality of manufactured goods, performance of antenna design and network. Therefore, we believe that the Taguchi method could be applied for determining the geometry variables of the coilgun system.

This paper presents a mathematical design of a multi-stage pulsed power induction coilgun system using Taguchi method to maximize its efficiency and reduce cost and time of design process. The coil gun system was analyzed and designed in mathematics using state-space equation. The Taguchi method is applied to evaluate and determine geometry variables, number of turn-layer of both stator and armature coils, and switching time. A FEM model of the coilgun system is developed to compare the results to the mathematical design. The results of the FEM and mathematical design match well. The energy efficiency of the three-stage coilgun system is above 22.6% and expected to be increased along with number of stages. The design method and results are consequential data for research and development of the coilgun system.

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