

Fundamental experiment and numerical simulation of pre-ionized inert gas plasma MHD electrical power generation

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Translated from Volume 143 Number 8, pages 523–529.

DOI: 10.1541/eqe.2023.143.523 of IEES Transactions on Power and Energy (Denki Gakkaishi Ronbunshu B)

Abstract

The experiments of pre-ionized inert gas plasma MHD electrical power generation are conducted, and the performance and plasma behavior in the experimental generator are examined through time-dependent r_{\perp} two-dimensional numerical simulation. In the experiment, an enthalpy extraction ratio of 4.01% has been obtained with a disk-shaped MHD generator with radio-frequency pre-ionization. In the numerical simulation, at an assumed inlet electron temperature around 5600 K (inlet ionization degree 0.10×10^{-4}), 6600 K (1.36×10^{-4}), the plasma structure is similar to the non-uniform structure observed in the experiment. An enthalpy extraction ratio around 2.5% matches well with that in the experiment. At a suitable inlet electron temperature of 7000 K (3.15×10^{-4}), 8000 K (1.79×10^{-3}), although non-uniform plasma structure still occurs, a high enthalpy extraction ratio over 10% is expected.

KEYWORDS

inert gas plasma, MHD electrical power generation, power generation experiment, pre-ionization, r_{\perp} two-dimensional numerical simulation

1 | INTRODUCTION

With MHD (Magneto-Hydro-Dynamics) power generation, magnetic field is applied to an electrically conductive fluid flowing through a channel; due to the electromotive force produced according to Faraday's law of induction, thermal energy of the fluid is converted directly to electric energy. Since such generators have no turbines or other moving structures, thermal constraints are relaxed to allow using working gases at higher temperatures (2200–2400 K); thus, one can expect electric power generation with an efficiency higher than that of conventional thermal power plants.¹ This study deals with closed-cycle MHD generation systems using inert gases; it was shown that in such systems, the MHD generator itself must have enthalpy extraction (ratio of generated output to thermal input) of about 30% and isentropic efficiency of about 80% in order

to achieve an overall efficiency (higher heating value) of 60%.²

Most previous studies dealt with seeded plasma generators, in which seed materials (alkali metals) were added to working gases (inert gases) to obtain high electrical conductivity through seed ionization. The high output of those generators was already confirmed via generation experiments using a shock tube³; besides, numerical analysis was conducted to propose shapes and operating conditions for high-efficiency commercial-scale generators.⁴ On the other hand, such systems may become complex because it is difficult to add seed materials uniformly in time and space; moreover, they need to be collected and reused.

In contrast, a seed-free pre-ionized inert gas plasma system was recently proposed.⁵ Particularly, current inside the MHD generator flows due to induced electromotive force to promote ionization; in this paper, we use the term

A Fundamental Experiment

**Charles Robert Hicks, Kenneth V.
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Fundamentals of Statistical Experimental Design and Analysis Robert G. Easterling, 2015-10-23 Professionals in all areas business government the physical life and social sciences engineering medicine etc benefit from using statistical experimental design to better understand their worlds and then use that understanding to improve the products processes and programs they are responsible for This book aims to provide the practitioners of tomorrow with a memorable easy to read engaging guide to statistics and experimental design This book uses examples drawn from a variety of established texts and embeds them in a business or scientific context seasoned with a dash of humor to emphasize the issues and ideas that led to the experiment and the what do we do next steps after the experiment Graphical data displays are emphasized as means of discovery and communication and formulas are minimized with a focus on interpreting the results that software produce The role of subject matter knowledge and passion is also illustrated The examples do not require specialized knowledge and the lessons they contain are transferrable to other contexts

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Contemporary Research in the Foundations and Philosophy of Quantum Theory C.A. Hooker, 2012-12-06 To mathematicians mathematics is a happy game to scientists a mere tool and to philosophers a Platonic mystery or so the caricature runs The caricature reflects the alleged cultural gap between the disciplines a gap for which there too often has been sadly sound historical evidence In many

minds the lack of communication between philosophy and the exact disciplines is especially prominent Yet in the past there was no separation exact knowledge covering both scientists and mathematicians was known as natural philosophy and the business of providing a critical view of the nature of reality and an accurate mathematical description of it constituted a single task from the glorious tradition begun by the early Greek philosophers even up until Newton's day but I am thinking of Descartes and Leibniz I The lack of communication between these professional groups has been particularly unfortunate for the past half century has seen the most exciting developments in mathematical physics since Newton These developments hinged on the introduction of vast new reaches of mathematics into physics non Euclidean geometries covariant formulations non commutative algebras functional analysis and so on and conversely have challenged mathematicians to develop the appropriate mathematical fields Equally these developments have posed profound philosophical problems to do with the rejection of traditional conceptions concerning the nature of physical reality and physical theorising

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