論文 / 著書情報
Article / Book Information

題目(和文)	液体金属MHD 発電機の性能と乱流流れに関する数値的研究
Title(English)	Numerical Study of Performance and Turbulent Flows in a Liquid Metal MHD Generator
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出典(和文)	学位:博士（工学）, 学位授与機関:東京工業大学, 報告番号:甲第9851号, 授与年月日:2015年3月26日, 学位の種別:課程博士, 審査員:奥野　喜裕,岡村　哲至,末包　哲也,長崎　孝夫,肖　鋒,小林　宏充
Citation(English)	Degree:, Conferring organization: Tokyo Institute of Technology, Report number:甲第9851号, Conferred date:2015/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	創造エネルギー　　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Numerical study of the performance and turbulent flows in a liquid metal MHD (LMMHD) generator, which is expected to generate power with high efficiency through using the wave energy from natural, have been conducted in this thesis.

Chapter 1 “**Introduction**” describes the background of wave energy utilization and the basic concept of a liquid metal MHD power generation. Mainly, the potential of wave energy resource, along with the status quo of the energy conversion are clarified with a comparison with different electrical power generators. A review of related previous work on a liquid metal MHD power generation is presented and the objectives of this thesis are stated.

In chapter 2 “**Response of a Liquid Metal MHD Power Generation System**”, the responses of a liquid metal MHD power generation system to various (constant (step), square, sinusoidal and Pierson-Moskowitz (P-M) types) external inputs of piston force are mainly examined in the presence of the shape loss. Although the electrical efficiency is reduced owing to the shape loss, the deterioration can be mitigated by using NaK78 with low density and high electrical conductivity and compensated by the increase in the applied magnetic flux density. From the examination about the frequency response, the period of several seconds is suitable from a viewpoint of response of liquid metal and piston (float) motion, which can meet the real ocean wave with the period of the order of seconds and the amplitude of the order of meters. Besides, the irregular force input based on the P-M wave gives no big difference with the regular forces when the effective value of the input is the same in effective value, which can provide a prospect for the utilization of a real ocean wave.

In chapter 3 “**Influence of Working Fluid Characteristics on the MHD Generator Performance**”, the influences of working fluid characteristics on the MHD generator performance are analyzed to observe the electrical performance under various (mercury, NaK78, Galinstan, and U-alloy47) liquid metals as well as the finite electrical conductive electrodes (made of copper). The fluid characteristic, that is the mean velocity profile, is determined by the interaction parameter when Reynolds number Re, magnetic flux density B and electric conductivity of electrodes σ_e are fixed. However, the electrical efficiency differs even with the same interaction parameter owing to the finite conductivity of the electrodes. This discrepancy will be eliminated if the ratio of the electrical conductivities of the liquid metal and the electrode is fixed. As a result, in real situations in which electrodes have finite electrical conductivity, working conditions with a large interaction parameter and a liquid metal with a relatively low electrical conductivity for decreasing σ_f / σ_e are expected to provide better performance.

In chapter 4 “**Turbulent Phenomena in a Liquid Metal MHD Flows**”, the turbulent phenomena in a liquid metal MHD flows with the influence of non-uniform magnetic flux density and various (open-circuit, short-circuit, and the pump) load conditions are compared and discussed. Under the open-circuit condition, with increasing the magnetic flux density an M-shaped velocity profile develops in the plane perpendicular to the magnetic field due to the large eddy currents. The eddies represented by the second invariant Q = 0.04 are curbed by the Lorentz force. At B_{z0} = 0.24 T, the sidewall jets promote the recurrence of turbulence in the downstream region. Under the short-circuit condition, the mean velocity decelerates markedly in the plane perpendicular to the magnetic field. Owing to the concentration of current near the electrodes, the reverse sidewall flows appear gradually as magnetic flux density increase. The strong Lorentz force suppresses the turbulent vortices overall. Under the pump condition, when the external current is not large enough, the mean velocity profile and the eddies present similar distributions like the open-circuit case. For a large applied current of I = 72 A under B_{z0} = 0.24 T, the strong Lorentz force (downward on average) enhances the M-shape velocity. The eddies are curbed in the electrodes area and turbulence appears abruptly again in the downstream region. Generally, external applied magnetic flux density has a laminarization effect on the MHD flows, while the sidewall jets increase the Reynolds stress and Reynolds

number that promote the transition of turbulence again.
Chapter 5 “**Conclusions**” gives the conclusions of this thesis and the issues to be continued in the future. The results of this thesis have confirmed the feasibility of the wave energy LMMHD power generation system. The information of optimal electrical efficiency under different load conditions among various liquid metals should be useful for material selection. And the findings about the transition of turbulence are considered useful for the observation and control of an opaque liquid metal in the MHD applications on a generator or accelerator.