Proceedings of the Eighteenth (2008) International Offshore and Polar Engineering Conference
Vancouver, BC, Canada, July 6-11, 2008

ISBN 978-1-880653-70-8 (Set); ISBN 1-880653-68-0 (Set)

Analysis of Liquid Metal MHD Wave Energy Direct Conversion System

Yan Peng, Zuowei Lin, Lingzhi Zhao, Ciwen Sha, Ran Li, Yuyu Xu, Baolin Liu and Jian Li
Institute of Electrical Engineering Chinese Academy of Sciences
Beijing, China

Jason Jia
TransUniv Machinery Co.Ltd, Shanxi, China

ABSTRACT

A new way to generate electric power directly from ocean wave motion is presented in the paper. It makes use of the liquid metal magnetohydrodynamic generator, and provides an excellent match to the mechanical impedance of an ocean wave, which is impossible to supply in other wave power systems. Therefore, the system is highly efficient and can be a very compact device with very high power density, and it is expected to be one of the best ways to convert ocean wave directly into electricity. Performance analysis, such as current and voltage, power output and efficiency, has been carried out when the wave has amplitude of 1 m and period of 6 s. The results show that the electric current and voltage periodically vary with the wave oscillation, the maximum output power of 3.35 kW and conversion efficiency of 68% can be obtained at load factor of 0.85 and 0.6 respectively while the magnetic field is 0.5 T.

KEY WORDS: Liquid metal; MHD generator; Wave energy direct conversion; Performance analysis.

INTRODUCTION

Ocean wave energy is a renewable energy source with a huge potential, harnessing the immense power of ocean waves to do useful work has been a dream of mankind for millennia. In recent decades, this goal has become more specific, i.e., conversion of ocean wave motion into electricity via practical and cost-effective means. There are various ways to convert ocean wave energy into electric energy, such as oscillating water column (OWC) wave energy converter (Bonke, 1985), overtopping wave energy converter (www.oceanpd.com), Pelamis (Yemm and Henderson, 2000; Pizer and Retzler, 2000) and etc. Another way worthy of notice is AWS that can directly converts wave motion into electricity (Rademakers and Schie, 1998; Polinder and Mecrow, 2005).

Magnetohydrodynamic (MHD) power technology supplies a new method to convert the thermal energy directly into electrical power. Principle of MHD power generation is shown in Fig.1. An electrically conducting fluid (plasma or liquid metal) passes through an MHD channel in the presence of an intense magnetic field (B). An electromotive force (EMF) is induced between the channel wall electrodes, thus producing electric power. In liquid metal MHD (LMMHD) power generation systems, liquid metal with higher conductivity is used to be working fluid, it makes possible higher power density with moderate magnetic fields, so that relatively small size generators are possible.

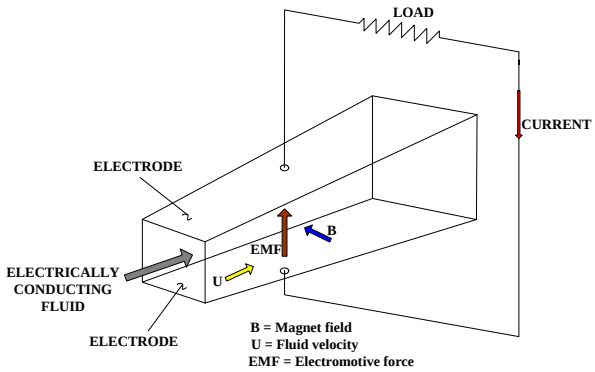

Fig.1 principle of MHD power generation

With the increasing demand of energy economization and environment protection, the LMMHD power system is applied in a number of new areas. In 1995, Haaland applied the LMMHD power system into the automobile and put forward a LMMHD engine with variable stroke according to the car's output (Haaland, 1995, 1997, 1999). In the LMMHD engine, the liquid metal sealed in the channel by pistons is forced to flow back and forth by the internal combustion process. Japanese researchers are also investigating applying a LMMHD generator to the distributed energy system of the residential sector with a pulse-like power demand to increase the utilizing efficiencies of the distributed generators and energy. Their analyzing results show that the efficiency of the LMMHD generator can get to 87% with the magnetic field strength of 1T (Maeda and Shimizu, 2003; Maeda and Kakizaki, 2005). In 2005, a reciprocating MHD generator was applied into ocean wave energy direct conversion system and a MHD Wave Energy Conversion (MWEC) system was brought forward by the Scientific Applications & Research Associates Inc. (Koslover, 2005). In the MWEC system, there is no hydraulic transmission mechanism usually used by the conventional wave conversion system and the wave force