Nozzle and Diffuser in Drifting Horizontal Turbine Flow

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ABSTRACT

Based on the characteristic of Kuroshio passing through Green Island, Taiwan, a new type of floating platform has been designed to capture the maximal power of the marine current. The inclusion of nozzle and diffuser in a shrouded duct is frequently used to accelerate, decelerate, or affect flows in a desirable manner. In this study, a shrouded nozzle-diffuser horizontal turbine was designed by Kirke, B, (2005). Matsushima, T et al.(2005). Five geometric parameters are determined to have an optimal power take off (PTO) from the ocean current. The Harmony search technique was used to search for the best combination of the geometric parameters. The parameters needed to be determined are inlet and outlet diameters, the lengths of the nozzle and diffuser and the gap between blade tips and the inner wall of the duct. Ohya, Y et al.(2010). The simulation of the characteristics of flow passing the system and the calculation of the PTO are made by Fluent. The proposed nozzle-diffuser duct and the meshes arrangement and simulated velocity vectors are illustrated in Fig. 1. The simulated results show the proper nozzle-diffuser design can effectively increase the power take off (PTO) and PTO coefficient can be as large as 0.48 which is beyond the reported average values.

KEY WORDS: Ducted, Turbine, Renewable energy, Ocean current energy, Computational Fluid Dynamics, Harmony search

INTRODUCTION

With the global energy gradually disappeared and rising environmental awareness, many developing countries and developed countries start thinking about how to use renewable energy sources, including the so-called "blue gold". The ocean energy development is the natural energy directly or indirectly taken from ocean and conversed to electrical energy. The major ocean energy includes tidal energy, wave energy, tidal/ocean currents, and ocean thermal energy conversion. Taiwan is an island and 98% energy are imported. A branch of North Pacific Gyre – Kuroshio is passing through east coast of Taiwan. The range of Kuroshio is about 170 km wide and 700 m deep with an average speed up to 1.25 m/s and it is equivalent to 5355 GW/h. If 1% of the Kuroshio power is taken, that is 53 GW and can nearly replaces all the power needed of Taiwan. The Kuroshio power is, therefore, a good opportunity to become a major resource of future power generation. Part of the Kuroshio current travels along the west coast through a strip between Penghu and Taiwan. An interdiscipline research team from several universities was formed and chose Penghu water as their field deployment site. The NSYSU-I system was deployed in August, 2013 and power take off (PTO) was successfully monitored up to 5 kW/h. The NSYSU-I system is a partially submerged floating system with a horizontal-axis turbine attached to a magnetic generator. The deployment of NSYSU-I is the first onsite ocean deployment in Taiwan. In this study, a modified system NSYSU-II was developed based on the previous field test experiences. New type is nozzle-diffuser design The ANSYS-Fluent code by Jo, CH et al. (2011) and a Harmony Search algorithm by Lee, KS et al., (2004) were used to determine the optimal geometry of NSYSU-II. Besides, the turbine