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A Study on Effectiveness of Straight-wing Vertical-axis Hydro Turbine Generation System in the Tidal Current

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ABSTRACT

Tidal and sea current turbines are potential sources of utilization of renewable energy in addition to offshore wind turbines. They can potentially produce electricity more efficiently because of the high density of water compared with air, and the more steady flow compared with wind. We are studying the application of straight-wing vertical-axis hydro turbine generation systems in sea currents. This paper presents the results of 2-dimensional tank tests of the hydro turbine in the field of current, regular wave and current with wave. The results were compared with the theoretical calculation. The result of field test at sea is also presented.

KEY WORDS: renewable energy, sea current, tidal current, hydro-turbine

INTRODUCTION

In the promising renewable energy of tidal and sea current energy, the density of the fluid, water, is about 800 times that of the fluid for wind generation, air. Also the flow conditions are comparatively stable, and the energy is expected to be reasonably abundant.

The straight-wing vertical-axis turbine (SWVAT) has such features as excellent energy conversion efficiency despite its simple structure, economical manufacturing cost due to the simple structure, and omni-directional performance to the current direction due to the axis symmetrical form. However SWVAT has been widely used as windmill, it is very few to apply to the sea current. In order to recover the energy from sea currents, authors have proposed a tidal power generation system based on the SWVAT.

Since the theoretical background of SWVAT has been established in the field of constant air flow, it is important to confirm the applicability of SWVAT to water current in the sea where the wave also exists in the same field. However it was supposed that the current would be treated as the same manner as wind, it was required to investigate the affect of wave to the turbine rotation because the wave is a cyclic water motion in vertical plane which differs from constant flow. Then, model tests using a 2 dimensional tank were carried out in the current and wave as a basic study. After the tank test, field test at real sea were also carried out.

TANK TEST

In order to investigate the performance of SWVAT in the sea environment, the behavior of the turbine in the current, in the regular wave, and current with wave were studied experimentally. A 2-dimensional test tank (width 0.5m, length 20m, water depth 0.5m) was used to carry out model tests on a hydro turbine. Also, calculations of the rotation response of the turbine in a current were carried out using wind turbine theory based on the simple stream tube theory or the multi stream tube theory. Then, the calculation results were compared with those of the tests. The test model of the hydro turbine had three blades of NACA0018 of airfoil. The principal dimensions were 0.1m of chord length, 0.4m of blade length (hydro turbine height) for each blade and 0.2m of turbine radius. A figure (Fig. 1) shows a schematic photograph of the tests. The hydro turbine test model was mounted on a towing trolley, and towed in the water, which produced a relative flow velocity to the hydro turbine model. Towing tests were carried out and the towing velocity (corresponding to the current velocity), and rotational speed were measured. The towing velocity was measured using a potentiometer, and the rotational speed of the turbine was measured with using a photo sensor.

Fig. 1. Outline photograph of towing test