Proceedings of the Ninth (2010) ISOPE Pacific/Asia Offshore Mechanics Symposium
Busan, Korea, November 14-17, 2010

ISBN 978-1-880653-79-1: ISSN 1946-004X. www.isope.org

Improvement of Straight-bladed Vertical-axis Water Turbine for Tidal Current Power Generation

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ABSTRACT

Considering the tidal-current power generation in a narrow strait, a water turbine of vertical axis is preferred, since the multiple-stage system is applicable in the depth direction. The straight bladed vertical axis water turbine (S-VAWT) is appropriate in such system because of its simplicity in manufacture.

On purpose to improve the performance of the S-VAWT a Gurney flap was attached on the trailing edge of the rotor blades. The modified turbine was tested in both the wind and water tunnels. Consequently, the attachment of the Gurney flap on the lower surface is effective to enhance the dynamic characteristics of the S-VAWT.

KEY WORDS: Fluid Machinery; Natural Energy; Tidal Current; Power Generation; Vertical Axis Water Turbine; Darrieus-type turbine; Gurney Flap

INTRODUCTION

Tidal Current

Considering to stabilize energy supply and to protect the earth-environment, the importance of the technologies of natural energies is getting higher on these days. Among them, ocean energy has received greater attention in natural energies because Japan is surrounded by the sea. The methods of power generation using ocean energy include tidal current, ocean current, tidal, wave and ocean thermal power generation. Above all, the tidal current power generation is regarded as a method of power generation suitable for Japan because there are number of straits where the strong tidal current exits.

A tidal current is a flow of seawater characterized by strong regularity. The flow velocity curve in Kanmon Strait was shown in Fig.1, for example (Japan Coast Guard hydrographic office, 1974). The tidal current reverses its direction every six hours, and the current velocity varies like a sine wave. The tidal current energy is regarded as stable source of energy because the velocity changes are predictable to some extent from the positional relation of the earth, moon and sun. In addition, as a density of seawater is 800 times greater than that of air, the current velocity of 1 m/s corresponds to the wind speed of 9 m/s in air because fluid energy is proportional to the density and the cube of the current velocity. Based on these, the tidal power generation is expected as a power generation method by using steady and high-density energy.

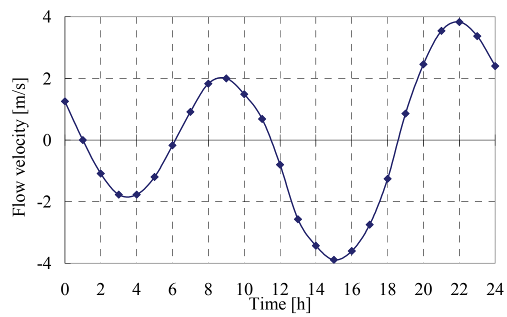

Fig.1 Current velocity curve in Kanmon Strait

Power Generation

The water turbine used in the tidal power generation is divided into the horizontal-axis water turbine (HAWT) and the vertical-axis water turbine (VAWT) (Seki and Ushiyama, 2008). Fig.2 shows outline drawing of HAWT and VAWT. The HAWT has advantages of the higher power coefficient and good self-starting characteristics. However it has the disadvantages of a direction control and large overturning moment at the substructure. The VAWT has the advantage in that respect. But, the power coefficient and the self-starting characteristic of VAWT are poorer than those of HAWT. Currently, HAWT is used mainly in the tidal power generation. However, there is the problem that the HAWT would block the ship course in a narrow strait when the projected area is increased for larger power. In contrast, VAWT can achieve higher output by the multiple-stage system in the depth direction, as shown in Fig.3.

In the present work, the straight bladed vertical axis water turbine (S-VAWT) was selected because it has higher output and simpler structure than other VAWTs. The aim of this study is to improve the performance of S-VAWT. First, the S-VAWT was fabricated, and the preliminary experiment was conducted. In addition, on purpose to improve performance a Gurney Flap was attached on the trailing edge of the rotors. The modified turbine was tested both in the wind and water tunnels.