Renewable Energy 112 (2017) 35–43

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

A study on the floating bridge type horizontal axis tidal current turbine for energy independent islands in Korea

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ARTICLE INFO

Article history:
Received 14 March 2016
Received in revised form
5 April 2017
Accepted 6 May 2017
Available online 8 May 2017

Keywords:
Tidal current turbine
Hydrofoil
Computational fluid dynamics
Experiment
Performance

ABSTRACT

The tidal currents in the region of South-Western sea of Korea can be utilized for the development of tidal current power, benefiting many fishing nurseries and nearby islands. Furthermore, it can contribute to promoting energy independent islands. This study focuses on floating-bridge type small tidal current turbine, which can be installed between the small islands limited space unlike large tidal current turbines. The aim is to develop a floating-bridge type 15 kW-class small horizontal axis tidal current turbine. As part of the research for the reduced model experiment of hydrofoils, a 50 W-class horizontal axis tidal current turbine model was investigated. Therefore, for this study, blade design was carried out using two different hydrofoils (MNU26 and NACA63421). Performance and hydrodynamic characteristics are investigated by using computational fluid dynamics and experimental methods. Among the two blades, NACA63421 blade showed the best power coefficient at low Reynolds number, whereas MNU26 blade performed better for higher Reynolds number. The MNU26 hydrofoil was applied to the blade design from the previous study. The MNU26 hydrofoil has a 26% thickness in contrast to the NACA63421, which has a 21% thickness. This indicates that the MNU26 can be applied throughout the blade length for the 15 kW-class turbine whilst providing good structural strength.

1. Introduction

Island areas in the south-western coast of Korea heavily rely on diesel power generation which increases cost and environmental pollution. Such problems concerned with the power supply within the region are on the rise. In order to address this problem, the Korean government has developed an interest in the construction of energy independent islands which are powered by eco-friendly energy [1].

Jeonnam Province in the south-western coast of Korea has 275 inhabited islands, among which 107 islands have not been connected to the electric power system. Korea Electric Power Corporation (KEPCO) supplied diesel fuel to 30 inhabited islands in the region in the year 2014 that amounts to 13,223 kl (136.3 billion KRW). Additionally, the local government administration operating in this region also consumes diesel fuel that accounts to 14,000 kl (approximately 165 billion KRW) every year [2].

The type of energy source for energy independent islands requires easy installation and also sufficient energy production. The 15 kW-class small floating-bridge type tidal current turbines can be installed in the limited space between small islands, instead of large tidal current turbines. The small tidal current turbines can be connected by bridge type connection in order to increase output energy. This energy can then be supplied directly to nearby islands in the region contributing to more energy independent islands. Fig. 1 shows the proposed floating-bridge type tidal current turbine. The floating-type tidal current turbine can be easily accessed for installation and maintenance.

During the development of the floating-bridge type 15 kW-class small floating-bridge type tidal current turbine, a 50 W-class tidal

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http://dx.doi.org/10.1016/j.renene.2017.05.025
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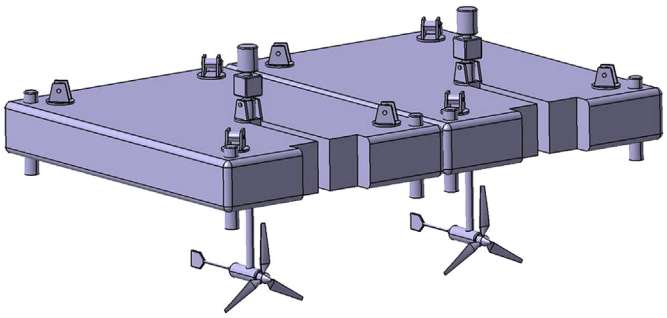

Fig. 1. Proposed floating-bridge type small tidal current turbines.

current turbine model was investigated as part of the research for the reduced model test for the hydrofoil. In blade design, hydrofoil selection is very important. Hydrofoils that have different shapes show different hydrodynamic and structural characteristics. In this study, two hydrofoils were selected, one from the previous study and other from the reference. The first hydrofoil from the previous study is the MNU26 hydrofoil. Singh et al. carried out a study to make a new hydrofoil for the south-western region of Korea [3]. The study developed a new hydrofoil, MNU26, with 26% thickness that can be used throughout the blade length, providing good structural strength. The second hydrofoil is NACA63421 hydrofoil from reference that has 21% thickness ratio. Lee et al. carried out a study to make counter-rotating tidal current turbine, as part of the design for blade, NACA63421 hydrofoil was selected for 40 W-class tidal current turbine model [4]. This is also a small tidal current turbine model and similar to the current study. Moreover, the model test was conducted with the same water tank set up. The blade design was carried out by blade element momentum theory (BEMT) [5]. The performance and hydrodynamic characteristics were investigated using CFD and experimental methods for the selected hydrofoils (MNU26, NACA63421).

2. Status of energy independent islands in Korea

Fig. 2 shows the progress of energy independent islands. Energy independent islands business is the utilization of renewable energy and ESS (Energy Storage System) combined to replace or reduce diesel power generation at the inhabited islands in the region. It is a very promising new business that can be advanced into overseas and domestic markets.

The energy independent business is attempted for the inhabited islands because of the renewable energy generation cost. The islands, where the production cost of electricity is very high, are different from the main land because the electricity for the inhabited islands cannot be connected from main land. The electricity cost is 5 times higher than mainland if electricity generation with small diesel generator is installed by the inhabitants. Moreover, the electricity cost of some islands with smaller number of people is 10 times more. To utilize renewable energy for such islands, power can be supplied at lower cost compared to diesel generators [6].

Tidal current energy can be applied as a renewable energy power source for energy independent islands. Actual generation with

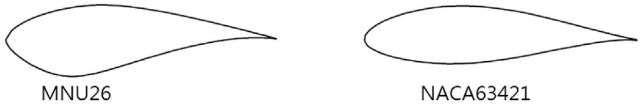

Fig. 3. Shape of hydrofoils.

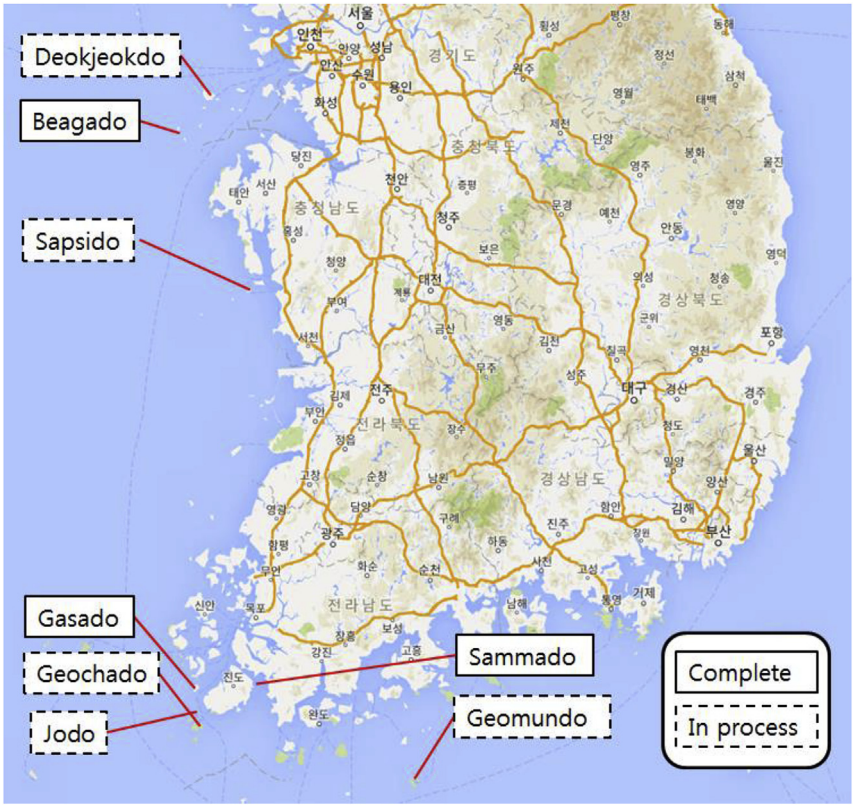

Fig. 2. Energy independent island progress status in Korea.