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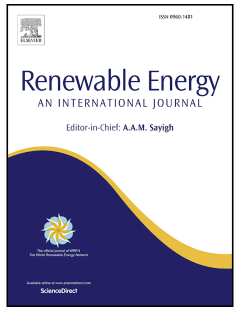

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An Innovative Configuration for New Marine Current Turbine

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Abstract. Researchers have shown growing interest in the development of traditional Savonius turbine due to their numerous benefits such as structural simplicity, self-start ability, relatively low operating speed, bi-directional rotational ability and lower environmental impact. However, Savonius turbines exhibits lower efficiency as compared to other similar marine current turbines. This paper proposes a novel design concept for the Savonius turbine. In addition, this work investigates flow and pressure distribution around the buckets of novel rotor with a two-dimensional unsteady numerical model. The proposed marine current turbine with novel design is named as Reza Turbine. Numerical model employed the Dynamic Mesh Method (DMM) for modelling mesh movement around the blades of rotor for different position with respect to computational domain. Developed numerical model solves the unsteady Reynolds averaged Navier-Stokes equations by using SIMPLE algorithm. In addition, we conducted an experiment in a low speed wind tunnel to obtain important performance parameters namely torque, power and performance for the proposed turbine. A set of flow speed were used as inlet boundary condition for both numerical and experimental model. A comparison between numerical and experimental results shows that the SST k-ω turbulence model gives satisfactory results for the developed novel turbine. The developed ReT is showed 52% improvement in efficiency as compared conventional Savonious turbine. Since the peak of power coefficient obtained was 0.321 for ReT, while 0.21 was reported for conventional Savonius turbine.

Keywords: Flexible and foldable bucket, Numerical simulation, Marine current turbine, Dynamic mesh

1. Introduction

Most countries look to harness the renewable energy sources for sustainable development. Ocean contains huge potential renewable energy sources such as, ocean current. However, according to [1, 2], lower magnitude ocean currents (around 0.56 m/s) flow in the Malaysian waters. Generally two type of conversion devices are used for harnessing energy from the oceanic currents namely, the horizontal axis marine current turbine (HAMCT) [3, 4], and the vertical axis marine current turbine (VAMCT) [5, 6]. Research shows that the Savonius [7] type turbine works in ocean water with lower speed ocean currents. Savonius turbine was originally built for efficiently harnessing wind energy. However, the conventional Savonius turbine exhibits lower efficiency and negative torque, especially at angles of 135^o to 165^o and from 315° to 345^o [8].

Researchers have proposed a number of design improvements in order to improve the efficiency of Savonius turbine such as adding blade stages at two to three steps [9-10]. As a standard practice investigators analyse flow profile around the turbine blades and suggest suitable design for turbines. Zhou and Rempfer [11] used flow results from a two-dimensional numerical model to evaluate the aerodynamic characteristics and analyse pressure distribution on the blades. They used two types of rotors in their study.

Researchers commonly use Computational Fluid Dynamic (CFD) to analyse the performance of turbines. Pope et al. [12] investigated effect of the stator vanes of a Zephyr vertical axis wind turbine (VAWT) by using two numerical methods. Their first set of simulation used a 3-D computational model with Multiple Reference Frame (MRF) taking into consideration the rotor reference frame with respect to the inertial frame. The second set of simulation used 2-D transient computational model with Sliding Mesh Method (SMM). The overall domain was then divided into two sub-domains; a stationary stator domain and another one rotor sub-domain that rotated with respect to the stationary domain. This permitted sliding of the adjacent cells at the boundary between the two sub-domains.

Alfaro-Ayala et al. [13] used the Dynamic Mesh Method of FLUENT software to study pressure on the rotor buckets and aerodynamic torque of rotor for various angular locations and different wind speeds.

Yang and Lawn [14] used numerical and experimental method for testing the performance of a Hunter turbine with six flapping blades. They specified opening and closing process based on their experimental results for a small-scale model. Further, a numerical simulation found that the optimum flow coefficient in the range of 0.44 to 0.47 gives a power coefficient of 0.19.

This study proposes a novel design for VAMCT named as the Reza Turbine (ReT) that could provide an alternative to traditional Savonius-based rotors. The aim of this study was to analyse the Reza turbine for scheduling the opening (expanding) and closing (folding) of the blades with respect to the flow direction and angular position. In addition, this study investigated important turbine parameters such as, power, pressure and torque. Further, we discuss on the benefits of using Dynamic Mesh method. This study uses CFD for obtaining flow and pressure distributions near the folding blade