Energy Conversion and Management 127 (2016) 43–54

Contents lists available at ScienceDirect

Energy Conversion and Management

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

Performance improvement of Savonius rotor using multiple quarter blades – A CFD investigation

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ARTICLE INFO

Article history:
Received 10 June 2016
Received in revised form 2 August 2016
Accepted 27 August 2016

Keywords:
Savonius rotor
Turbulence
CFD
Performance

ABSTRACT

Savonius rotor is preferred for many power generation applications like tidal, wind and hydro, especially on a small scale by virtue of its simple and inexpensive construction, installation and maintenance. Present study is focussed on the estimation and comparison of the performance in terms of Coefficient of Performance (COP) of a new configuration of Savonius rotor with the conventional one, using numerical simulation approach. New configuration comprises multiple quarter blades added to conventional configuration. A methodology for the numerical simulation of Savonius rotor is developed and validated, that can be employed for comparative study of different design configurations for design based optimization of Savonius rotor. Accuracy of the simulation results, despite of correct methodology, is dependent on accurate estimation of turbulence and meshing parameters. Present work employs Shear Stress Transport (SST) model for modelling turbulence which incorporates the near wall fluctuation capturing capability of k-ω model and robust k-ε model for modelling the bulk domain. Meshing parameters include correct estimation of first layer thickness for boundary layer on the blades based on the desired y^+ value. An improvement in Coefficient of Performance ranging between 8.89% and 13.69% for different inlet velocities is observed for new configuration over the conventional configuration.

1. Introduction

The ever increasing energy demand has forced researchers to look for alternative and renewable energy resources, as conventional ways of power generation are posing a serious threat to the environment. Wind power is a serious contender among the renewable resources and also compliments the other alternative energy resources like solar energy. Mostly on the large scale, wind power is harnessed using Horizontal Axis Wind Turbines (HAWTs) and the power generated is transmitted to a grid for supply. Nowadays, mostly in the rural and less accessible areas of different developing economies, people are using a cost effective, low maintenance way of harnessing wind energy through the Vertical Axis Wind Turbines (VAWTs). The most widely used VAWTs are Darrieus and Savonius turbines. According to [1,2], the alternators or piezoelectric energy harvesters can be directly attached to the wind turbine blades, in order to produce electricity. Darrieus turbine is a lift based turbine and Savonius is a majorly drag based turbine. Savonius rotor was firstly developed and introduced by Finnish inventor S.J. Savonius [3]. A conventional Savonius rotor is a vertical axis wind turbine having good starting characteristics [4]. Vertical Axis Wind Turbines (VAWTs) are omnidirectional [3,5–7], and suitable for low wind speed applications [8]. VAWTs are comparatively more suitable for small scale applications, less expensive and easier to maintain than Horizontal Axis Wind Turbines [9]. Also, VAWTs are affordable due to easy installation, maintenance, and fabrication [6,7]. A lot of performance improvement studies have been done on Savonius rotor in the past by various researchers as the efficiency of a conventional Savonius rotor is poor [10,11]. Many studies are conducted using the experimental approach [3,12]. Effect of various parameters on the performance of Savonius rotor were studied in the previous literature such as aspect ratio, use of end plates, use of deflecting plates, overlap ratio, and number of blades [5]. Aspect ratio, which is essentially the ratio of the height of the rotor to the diameter of the semicircular blade plays an important role in improving the efficiency of the rotor. Use of high aspect ratios is desirable to improve performance [13]. Extraction of power can be enhanced by entraining a larger mass flow of air in the rotor using end plates with Savonius rotor [14]. Performance of Savonius rotor is improved for lower overlap ratios [15]. Two bladed Savonius rotor gives optimum performance than the three bladed rotor regardless of the number of stages [16]. Deflecting plates are more often used to deflect the incoming fluid towards the advancing blade and

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http://dx.doi.org/10.1016/j.enconman.2016.08.087
0196-8904/