



Multi objective optimization of horizontal axis tidal current turbines, using Meta heuristics algorithms



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ABSTRACT

The performance of horizontal axis tidal current turbines (HATCT) strongly depends on their geometry. According to this fact, the optimum performance will be achieved by optimized geometry. In this research study, the multi objective optimization of the HATCT is carried out by using four different multi objective optimization algorithms and their performance is evaluated in combination with blade element momentum theory (BEM). The second version of non-dominated sorting genetic algorithm (NSGA-II), multi objective particle swarm optimization algorithm (MOPSO), multi objective cuckoo search algorithm (MOCS) and multi objective flower pollination algorithm (MOFPA) are the selected algorithms. The power coefficient and the produced torque on stationary blade are selected as objective functions and chord and twist distributions along the blade span are selected as decision variables. These algorithms are combined with the blade element momentum (BEM) theory for the purpose of achieving the best Pareto front. The obtained Pareto fronts are compared with each other. Different sets of experiments are carried out by considering different numbers of iterations, population size and tip speed ratios. The Pareto fronts which are achieved by MOFPA and NSGA-II have better quality in comparison to MOCS and MOPSO, but on the other hand a detail comparison between the first fronts of MOFPA and NSGA-II indicated that MOFPA algorithm can obtain the best Pareto front and can maximize the power coefficient up to 4.3% and the produced torque on stationary blade up to 57.9%. The geometries of the first and last members of the Pareto front of MOFPA are compared to each other. These members which produce the maximum power coefficient and the maximum produced torque on stationary blade have hyperbolic and constant chord distributions, respectively.

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1. Introduction

High energy consumption is one of the serious problems in the world today. Recently, this question has taken on not only economic, but also ecological and social importance [1]. Renewable energies which offer a great amount of free energy for most countries of the world can be one of the potential solutions for reducing fossil fuels consumption and emissions. Today, at different points of the world, various renewable energy converters are being used to trap the free energy. Tidal current which is one of the forms of ocean energy, is vast, reliable, regular and the most predictable energy resource [2]. Various global studies have shown that tidal current energy has large potential as a predictable sustainable resource for commercial scale generation of electrical power [3].

Tidal current energy is much easier and cheaper to extract using tidal current converters, with less harmful environmental effects compared to tidal barrages [3,4]. Many devices are being studied for tidal current energy conversion although most are designed around horizontal axis turbines, known as horizontal axis tidal current turbines (HATCT) [5]. The design and operation of HATCT are similar to those of a horizontal axis wind turbine [3,6]. There are however a number of fundamental differences in the design and operation of the HATCT, which will require further investigation, research, and development [7]. These include changes in force loadings and Reynolds numbers, different stall characteristics, depth of immersion and the possible occurrence of cavitation [7,8].

Many developments have taken place in field of horizontal axis marine current turbines during the recent years, moving from model testing to prototype development and installation [3]. Bahaj et al. [5] designed a test model of HATCT for the purpose of studying the characteristics of turbine power and thrust for a different range of RPM, flow speed and hub pitch angle. The

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