Vertical Axis Turbines for Marine Current Energy Conversion

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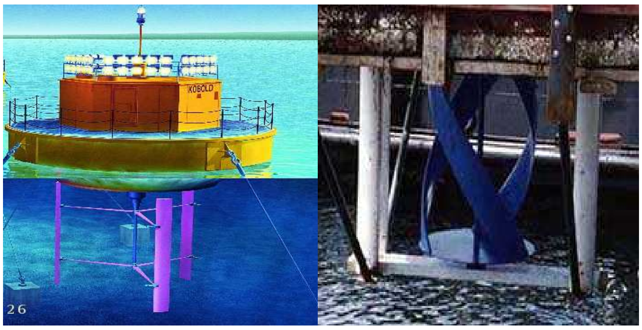
Work stream 2: Optimisation of Collector Form and Response

Introduction

Black & Veatch estimate that the UK commands a technically extractable tidal stream resource of 18 TWh/year [1]. The most advanced attempt to harness this power to date is Seagen, a 1.2 MW dual rotor horizontal axis turbine installed at Strangford Lough, Northern Ireland [2].

Horizontal axis turbines are, however, less suited to shallower waters. So a niche exists for the development of vertical axis turbines.

Classification of Vertical Axis Turbines



(a) Kobold Turbine[3] (b) Gorlov Turbine[4]

Figure 1. Vertical Axis Turbines

There are two basic types of vertical axis turbine, the straight bladed Darrieus-type (such as the Kobold Turbine, see Figure 1(a)) or the helically shaped Gorlov-type Turbine (see Figure 1(b)). The classification can be further broken down into turbines with fixed blades and those where the pitch can vary.

A Darrieus-type turbine will suffer from "torque ripple" causing vibrations in the shaft .The Gorlov turbine ought to avoid this, but will face variable force along each blade. The extents of these forces and torques is key.

Research Objectives

The aim of the research is to provide a set of guidelines to aid the optimisation of a vertical axis turbine depending upon the characteristics of the tidal stream and level of complexity (and cost) desired by a developer.

Methodology

The Double Multiple Streamtube (DMS) method [5] analyses the change in momentum experienced by a fluid flowing through a vertical axis turbine. Input consists of flow velocity, turbine dimensions and section characteristics relating to the shape of blade used.

Key Issue: Availability of section characteristics.

Effective use of DMS requires data for blades at low Reynolds numbers and high angles of attack. Preliminary tests have also suggested that thicker blades provide preferable start up performance. Most existing data sets relate to sections for use in aeroplanes where low Reynolds numbers, high angles of attack and thick blades are not common.

Specialist aerofoil analysis tools (such as Xfoil [6]) generally semi-empirical and unsuited to required flow characteristics. Therefore Reynolds Averaged Navier-Stokes (RANS) solver used (Ansys CFX™).

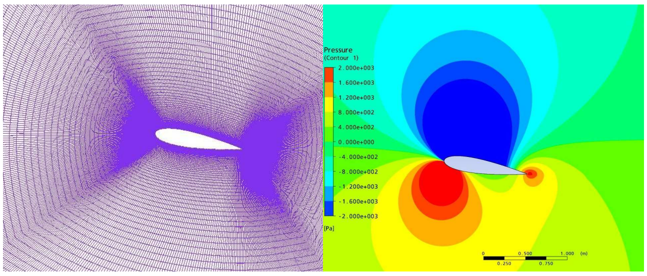


Figure 2. Grid and results for analysis of a NACA0018 blade at 10° angle of attack using Ansys CFX™

Once suitable DMS results are obtained further research will be carried out using the Lancaster University tidal flume for physical experimentation.

References

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3. *http://www.pontediarchimede.com (Accessed* 18/06/08*).*

4. Gorlov, A(2000). *Helical Turbine Assembly Operable Under Multidirectional Gas and Water Flow for Power and Propulsion Systems* [US Patent No. 6,036,443].

5. Paraschivoiu, I(1981). *Double-Multiple Streamtube Model for Darrieus Wind Turbines. [NASA Technical Report No. N82-23684].*

6. *http://web.mit.edu/drela/Public/web/xfoil/* (*Accessed* 02/12/07).

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