Marine Renewables Infrastructure Network

WP2: Marine Energy System Testing - Standardisation and Best Practice

D2.16: Tidal Test Parameter Overview

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ABOUT MARINET

MARINET (Marine Renewables Infrastructure Network for Emerging Energy Technologies) is an EC-funded consortium of 29 partners bringing together a network of 42 specialist marine renewable energy testing facilities. MARINET offers periods of free access to these facilities at no cost to research groups and companies. The network also conducts coordinated research to improve testing capabilities, implements common testing standards and provides training and networking opportunities in order to enhance expertise in the industry. The aim of the MARINET initiative is to accelerate the development of marine renewable energy technology.

Companies and research groups who are interested in access to test facilities free of charge can avail of a range of infrastructures to test devices at any scale in areas such as wave energy, tidal energy and offshore-wind energy or to conduct specific tests in cross-cutting areas such as power take-off systems, grid integration, moorings and environmental data. In total, over 700 weeks of access is available to an estimated 300 projects and 800 external users.

MARINET consists of five main areas of focus or 'Work Packages': Management & Administration, Standardisation & Best Practice, Transnational Access & Networking, Research and Training & Dissemination. The initiative runs for four years until 2015.

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LEGAL DISCLAIMER

EXECUTIVE SUMMARY

The experimental performance appraisal of tidal energy devices is a crucial aspect of their design and ensures optimality and confidence in performance. The information obtained during testing is used to secure funding and promote device development. The MaRINET project seeks to make available facilities in Europe for testing tidal (and also wave and wind) devices at small, medium and large scales.

This report is concerned with aiding in the identification of the appropriate experimental facility for a scale test of a tidal energy converter. To this end, the principal scaling laws are identified in order to identify the potential penalties associated with scale testing, and then the options available in the MaRINET project for tidal testing are collated. Finally, a decision making tool is presented to aid the process of arriving at an appropriate MaRINET facility for a device test.

CONTENTS

1 INTRODUCTION

Tank testing is primarily to establish at scale the behaviour of a tidal energy converter and the impact of different conditions, configurations and dimensions. The convenience of having a controlled environment where each set of experiments can be repeated is highly valuable. Due to the fact that marine renewables testing centres are not uniformly configured or constructed, standardisation is an important aspect to MARINET. At present there is no pan-European or worldwide consensus on appropriate test methodologies and practices.

This document as part of the Marinet Work Package 2 aims to give within the existing literature a tidal test parameters overview. The parameters identified have a significant input towards design requirements, performances and physical impacts of tidal energy converters.

2 TIDAL TEST PARAMETERS

For this overview, we have considered two main points: the kind of experimental facility used for the trials and the type of tidal energy converters. Both points are discussed bellow.

2.1 EXPERIMENTAL FACILITY

Testing facilities inside laboratories provide a controlled environment for the development of ocean energy devices in the phases of Technology Readiness Levels (TRL) increasing from basic research up to analysis and validation of small scale prototypes. Typically, these phases are coded as TRL levels 1 to 4 or 5.
Dealing with tidal energy converter (TEC) systems, there are basically two types of laboratory facilities where real operating conditions can be simulated to some extent:

- Towing tanks, where the model is towed while water is at rest (calm or wavy, see below);
- Flume tanks, where the model is kept fixed while water is forced to flow through.

For both of them, their main geometrical parameters are:

l_T: the length of the tank (m)

L_T: the width of the tank (m)

W_D: the depth of the tank (m)

2.1.1 Towing tank

In towing tank, towing carriage speed is set in order to reproduce, after scaling, the effects of an onset tidal current at given speed. Carriage velocity can usually be regulated with a precision of mm/s and can be varied in time to simulate currents with variable speed. Given carriage speed, the maximum time that the model can be towed depends on the length of the tank.
Tests can be conducted in calm water, in presence of regular/ irregular waves. A regular wave test is conducted fixing the frequency and the steepness (or amplitude) of the incident wave. Irregular waves are defined by a spectrum whose characteristics reproduce a test site's features (shape, width and peak frequency).

$u = U + u'$: where u is the towing carriage speed or streamwise velocity (m/s), U is the mean velocity (m/s) and u' is the fluctuating part.

2.1.2 Flume tank

Contrary to towing tank, the flow characteristics must be well known in order to be able to characterize the turbine performances [1]. In the following a Cartesian coordinate system is considered with ex, ey and ez as unit vectors. The flow velocity field is denoted by u and is function of the position X and time t at which it is measured. The position and the velocity components are respectively denoted by x, y, z and u, v, w :

$$X = x\,ex + y\,ey + z\,ez = (x, y, z)$$

$$u = u\,ex + v\,ey + w\,ez = (u, v, w)$$

The flow velocity field can be broken down thanks to Reynolds decomposition:

$$u(X, t) = U(X) + u'(X, t)$$

where U is the time average of u and u' the fluctuating part.
From these quantities the Turbulence Intensity (TI) level and the Turbulent Kinetic Energy (TKE) can be calculated.

2.2 TIDAL ENERGY CONVERTERS

The tidal energy converters can be cataloged in three main types:

Horizontal axis tidal stream turbines (HATT),

Vertical axis tidal stream turbines (VATT) and

Oscillating tidal stream systems.

For each of them, a set of are relevant.

2.2.1 Horizontal axis tidal stream turbines

The main parameters of an horizontal axis tidal stream turbines (shown in Figure 1) are:

n: the number of blades

D: the diameter of the turbine (m)

W_T: the depth location of the turbine (m)

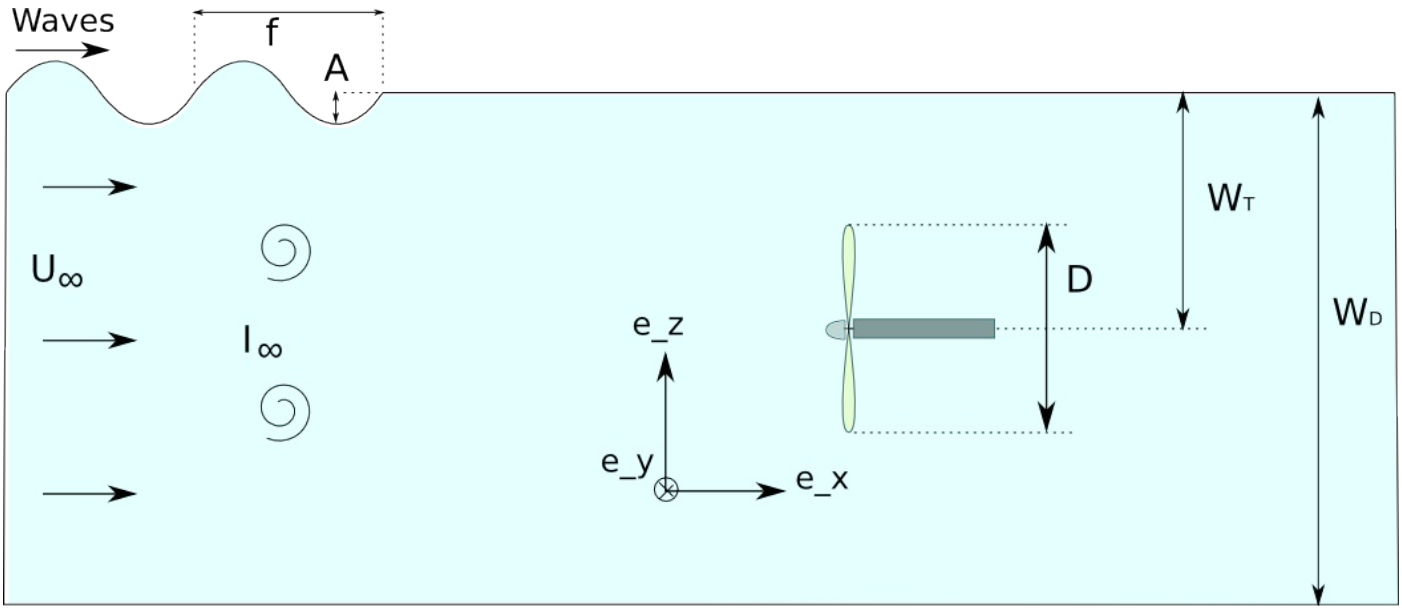

Figure 1 Schematic view of an horizontal axis turbine.

2.2.2 Vertical axis tidal stream turbines

The main parameters of a vertical axis tidal stream turbines (shown in Figure 2) are:

n: the number of blades

D: the diameter of the turbine (m)

L: the height of the turbine (m)

W_T: the depth location of the turbine (m)

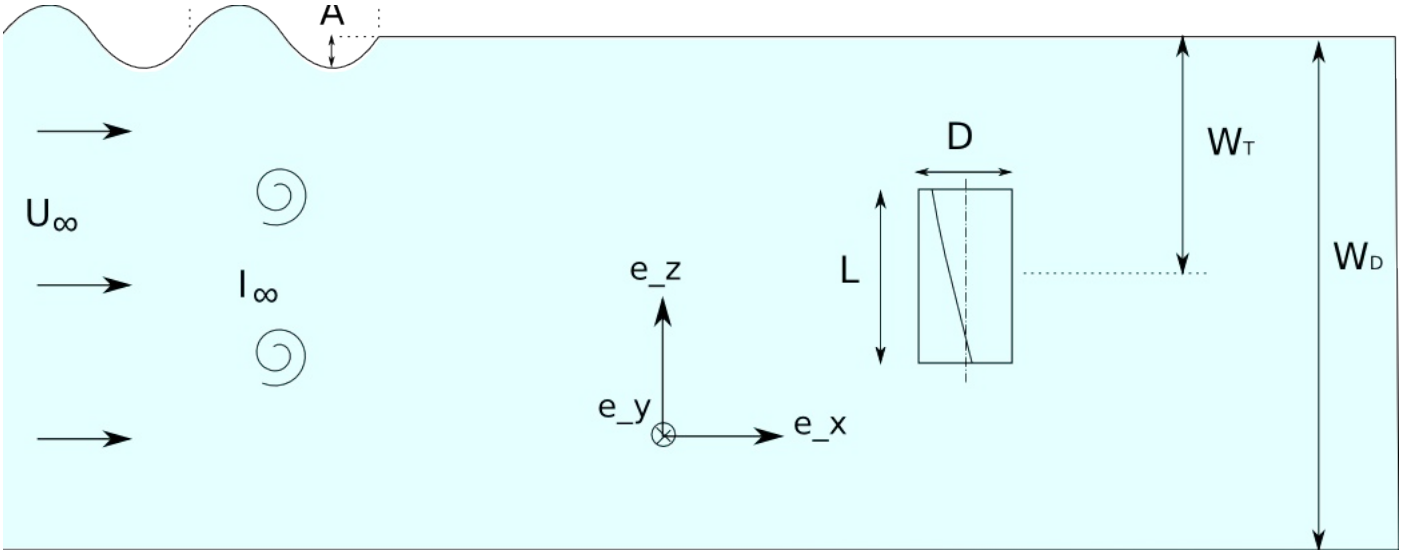

Figure 2 Schematic view of a vertical axis turbine.

2.2.3 Oscillating tidal stream system

The main parameters of a vertical axis tidal stream turbines (shown in Figure 3) are:

L: the lenght of the membrane (m)

l: the width of the membrane (m)

O_A: the oscillating amplitude of the membrane (m)

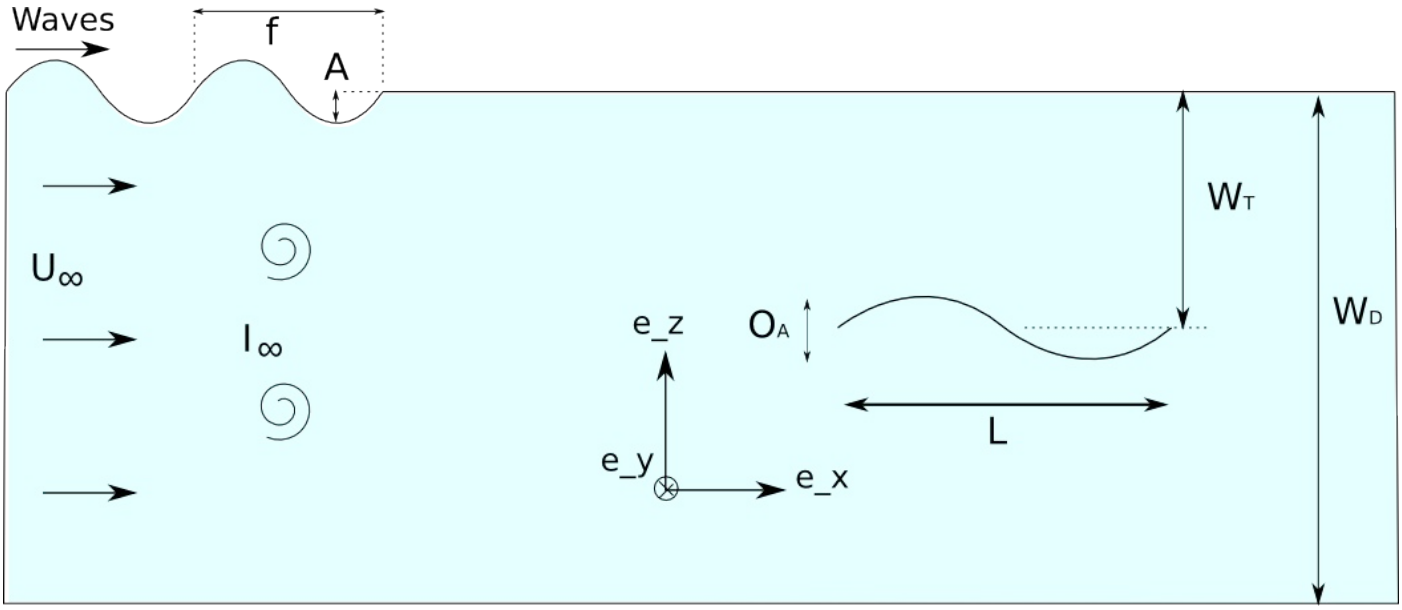

Figure 3 Schematic view of an oscillating membrane.

The blockage ratio α is defined as the ratio between the rotor cross-section area $S = \pi R^2$ or $S = O_A \cdot l$ and the tank transverse area $A = W_D \cdot L$

The Tip Speed Ratio (TSR) is classically defined as the ratio between the tip velocity and the upstream flow velocity.

REFERENCES

[1] P. Mycek, B. Gaurier, G. Germain, G. Pinon, and E. Rivoalen (2013). - Numerical and experimental study of the interaction between two marine current turbines. *International Journal of Marine Energy*.