SURFTEC

Survivability and Reliability of Floating Tidal Energy Converters

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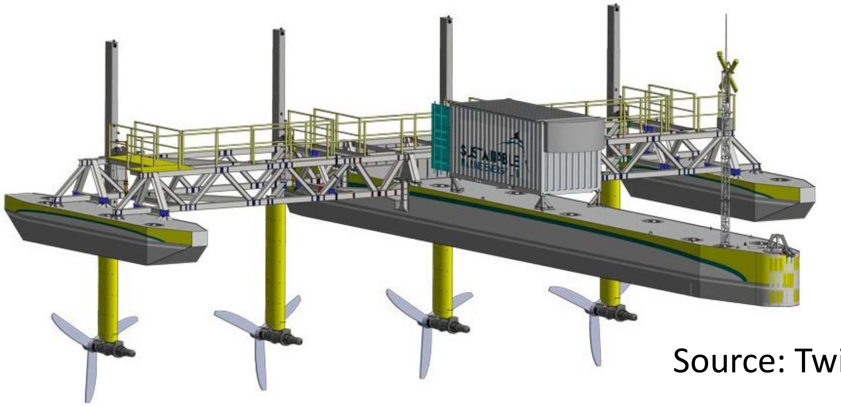
[2]Sustainable Marine Energy Ltd
[3]EMEC
[4]Black & Veatch

Overview

- Project focuses on Floating Tidal Energy Converters (FTECs)
  - Devices that move in relation to changes in sea level
  - One or more turbines suspended from a floating structure
- Issues associated with costs and operation
  - Identifying and understanding extreme loads
    - Environmental extremes
  - Determining accessibility, serviceability, fault intervals and device life cycles
- Aim is to produce a design optimisation tool and operational strategy
  - Reliability and Survivability of FTECs

Objectives

- Carry out a data measurement campaign with FTEC developer
- Develop numerical model that couples Swansea University's BEMT code with a floating platform model
- Produce a generic FTEC design and operational strategy document



Source: Twitter@SustainMarine

Industrial Partners

- European Marine Energy Centre (EMEC)
  - Environmental data for range of conditions
  - Link to FTEC developers
- Black & Veatch
  - Guidance on effect of loads on fatigue damage and failure
  - Component costs
- Sustainable Marine Energy Ltd (SME)
  - FTEC Developer
  - Allowing instrumentation of a prototype device and providing data

Data measurement campaign

- In collaboration with SME
  - PLAT-I (PLATform for Inshore applications)
    - Floating surface platform
    - Four turbines suspended from the platform
  - Deploying at Connel Bridge, Oban in late November

Source: Twitter@SustainMarine

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Data collection campaign

- Require synchronous data measurements for
  - Flow conditions
  - Position of device
  - Loads on device
- Working with SME to provide data-logging equipment and sensors
- Will also have ADCP and load measurements

Datalogging Equipment

- Core datalogging system based on an automotive datalogging system
  - 3 axis accelerometer, GPS and supports various external data sources
  - Remote access and monitoring provided by a Raspberry Pi
  - Also recording data from a Nortek Vector ADV

- 2 additional sensor units, based around 9DoF motion sensors
  - 3 axis accelerometer
  - 3 axis gyro
  - 3 axis magnetometer

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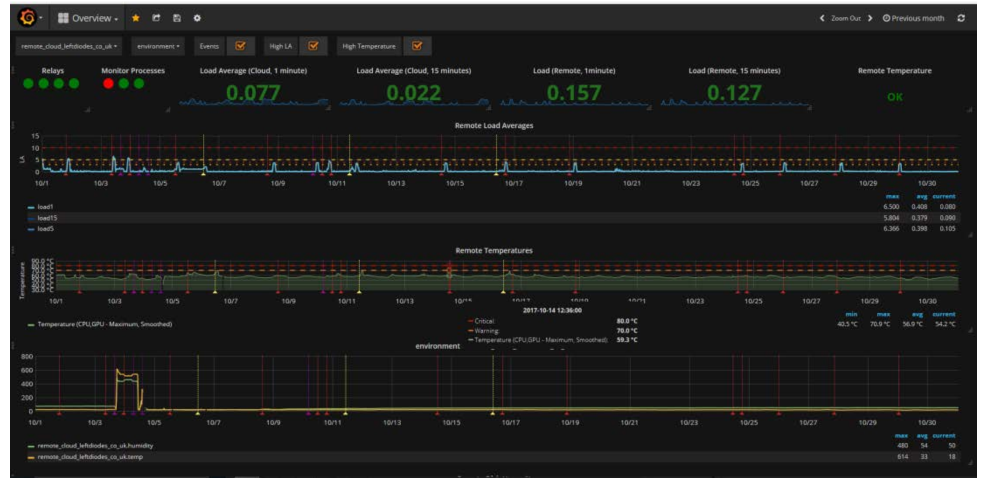
Monitoring Software

- Remote access and monitoring software has been set up
- Gives information about state of logging equipment
  - Is it running?
  - Most recent values for some parameters
  - Error messages
- “Is the box on fire or full of water yet?”
- Remote (automated!) data download to minimise risk of data loss



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Numerical model approach

- Couple Swansea's existing BEMT model (turbine) with rigid body model (platform)
- Aim to predict loads on the device under given flow conditions
  - Inputs for the fatigue modelling → prediction of component and system life → design and operational strategy guidelines
- Produce generic floating platform BEMT model
  - Open access to academic research groups

Numerical method – progress

- Document existing MATLAB version of BEMT code
- Reimplement in C++
- Test + revalidate
- Develop rigid body platform model
- Integrate with BEMT model
- Document, test and validate
- Data from measurement campaign used to validate the model

Recent BEMT model development

- Existing BEMT model predicts rotor performance in a range of operating conditions
  - Waves, turbulence
- Knowledge about impact of turbulence is critical for tidal turbine developers
- But sometimes the full turbulent data is not known
- Can it be created from existing data?
  - Investigated by Togneri et al[1], presented at EWTEC 2017
- Implemented two synthetic turbulence methods
  - Synthetic eddy method matches second order statistics (TKE density, Reynolds stress)
  - Sandia method uses von-Kármán spectra to generate velocity time series at specified points

[1]Togneri et al, Comparison of synthetic turbulence approaches for two numerical tidal turbine models, EWTEC 2017

Recent BEMT model development

- Attempt to replicate experimental conditions in IFREMER flume
- Flume measurements show spatially uniform turbulence
  - Turbulence intensity $I_\infty = 3\%$ and 15%
  - Anisotropy $\sigma_u{:}\,\sigma_v{:}\,\sigma_w = 1{:}\,0.75{:}\,0.56$
- Synthetic models adequately recover I_∞ and anisotropy ratios

	I_∞	$\sigma_u : \sigma_v : \sigma_w$
Target	3%	$1 : 0.75 : 0.56$
SEM	$2.97 \pm 0.03\%$	$1 \pm 0.01 : 0.749 \pm 0.008 : 0.557 \pm 0.008$
Sandia	$3.00 \pm 0.05\%$	$1 \pm 0.01 : 0.747 \pm 0.010 : 0.557 \pm 0.005$
Target	15%	$1 : 0.75 : 0.56$
SEM	$14.8 \pm 0.1\%$	$1 \pm 0.03 : 0.750 \pm 0.012 : 0.558 \pm 0.013$
Sandia	$15.1 \pm 0.2\%$	$1 \pm 0.02 : 0.744 \pm 0.013 : 0.553 \pm 0.012$

Recent BEMT model development

- IFREMER test turbine – 0.7m diameter, NACA 63418 profile, TSR=2.5
- Power coefficient approx 25% below experimental data
  - Possibly due to blockage effects
- Thrust predictions with Sandia model close to observations, but SEM significantly lower
- Standard deviation of results directly proportional to turbulence intensity

Case	C_P	C_T
SEM 3%	0.210 ± 0.004	0.428 ± 0.006
SEM 15%	0.197 ± 0.019	0.434 ± 0.032
Sandia 3%	0.187 ± 0.003	0.590 ± 0.009
Sandia 15%	0.190 ± 0.014	0.599 ± 0.047

Recent BEMT model development

- Preliminary work
  - Indicates synthetic turbulence methods can adequately recover turbulence intensity and anisotropic ratios
  - Shows encouraging results for using synthetic turbulence models with BEMT but further work needed
- Potentially useful technique for modelling loads on FTEC (and other) rotors when full turbulence data is not known

Rigid body model

- Model needs to represent rigid body motion and hydrodynamic loading
- Floating offshore wind turbine models exist
  - Hydrodynamic analyses in frequency or time domain
- Investigate if these can be used as a basis for FTEC rigid body model
- Develop and couple with BEMT
- Validate…

Design and strategy guide

- Validated model will be used to calculate loads on generic FTEC device
  - Range of environmental data (supplied by EMEC)
- Fatigue model will be developed
  - Collaboration with Black & Veatch
  - Enabling prediction of component and system life
- Lead to a strategy guide providing guidelines for improving FTEC device reliability and survivability

Summary and immediate priorities

- Summary
  - Strategy for data collection has been developed and implemented
  - Numerical model development is underway
- Next steps
  - Collect and process data from PLAT-I deployment
  - Continue to test BEMT model in new implementation
  - Develop rigid body model and couple with BEMT