Scale Effects in Tidal Current Device

Patricia Okorie; Dr Alan Owen

Work stream 1: Numerical and physical convergence

Introduction

It is important to investigate scale effects in Tidal Current Device (TCD) model testing, especially with the recent realisation that Computational Fluid Dynamics (CFD) could be an alternative to physical modelling and the emerging tidal current energy technology. Scale effects are the differences between the prototype and model response resulting from the inability to simulate all relevant forces in the model. Scale effects in physical modelling are analogous to decreased accuracy in numerical modelling when complex physical processes are represented by a simplified mathematical formulation (1).

The k-epsilon Turbulence Model (TM) is isotropic and it is commonly used due to its computational economy and ease of application. It produces reasonable results in some applications (2). However, it is inadequate for tidal current flow where anisotropy is significant (3). The k-epsilon TM treats eddies of different sizes as the same while Large Eddy Simulation (LES) requires a flow field with large scale turbulent structures. LES has been found suitable to study unsteady loads on structures (4).

Aim - To determine the suitability of predicting prototype response from results obtained by using k - epsilon turbulence model, in testing a small scale tidal current device.

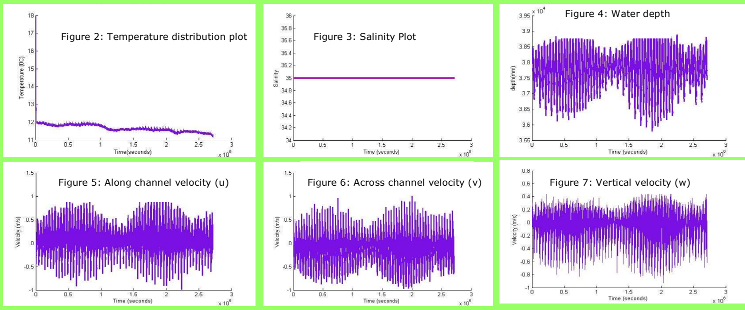
Methods

▪Analysis of ADCP data to visualise the flow field parameters.

Figure 1 : A 4-beam ACDP

ADCP deployed at the seabed of a tidal current site of average depth of 38m, for 31 days. Sampling frequency of 2 Hz.

Results



Figures 2-7 : Tidal current flow field parameters

▪Test a generic virtual scale support structure using the k-epsilon model.

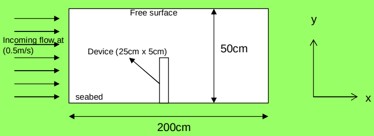


Figure 8 : 2- Dimensional computational domain

Results

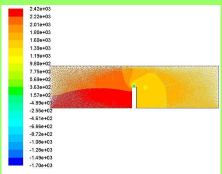


Figure 9 : Contours of static pressure

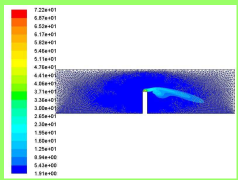


Figure 10 : contours of turbulence intensity (T.I).

Evident from figure 9 is a lower pressure downstream of device which induces a high pressure drag (5).

Figure 10 shows an increase in T.I in the wake of the device.

Discussion/Conclusion.

▪Tidal current velocity fluctuate in three dimensions. In addition, the temperature and salinity plots suggest a turbulence model without a buoyancy factor.

▪Using a realizable k-epsilon TM with a turbulent intensity (T.I) and viscosity ratio specification of 5% and 10 respectively, the contours of static pressure indicates a pressure gradient due to flow over a bluff body which induces a drag force. The T.I is highest at the top of the device and decreases downstream of device.

▪Predicted drag force is dominated by pressure force and is approximately 111N.

Further Work

▪Test a geometrically similar prototype using the LES method.
▪Validate results.
▪Qualify and quantify scale effects.

References

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(5) Hoerner SF. Fluid-dynamic drag: *practical information on aerodynamic drag and hydrodynamic resistance.* Brick Town New Jersey: 1965.

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