D1.2 Benchmark with wave tank data from MARIN

[Version 1.0]

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Document History

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1. Overview

The report presents the benchmarking of the computational fluid dynamics (CFD) numerical setup of OpenFoam with the wave tank experiments carried out by MARIN. This experimental validation is published in the MDPI energies journal titled *"OC6 Phase Ia: CFD Simulations of the Free-Decay Motion of the DeepCwind Semisubmersible"* [1] and can be found at https://www.mdpi.com/1996-1073/15/1/389. In this document, a summary of the findings is presented. For more technical details, the journal paper would provide further insights.

2. Abstract

Offshore wind energy has great potential as it remains largely untapped. Fixed-bottom wind turbines have grown tremendously due to their competitive energy cost. However, floating wind systems are still considerably more expensive, and these costs must be reduced to be commercially feasible. Floating support structures contribute to almost 30% of the floating wind turbine's total levelised cost of energy (LCOE). Proper substructure design depends on the correct estimation of ultimate and fatigue loads. In this regard, it is essential to accurately predict hydrodynamic loads for optimisation.

This report is based on the OC6 (Offshore Code Comparison Collaboration, Continued, with Correlation, and unCertainty) project, part of the International Energy Agency Wind Task 30 framework. The OC6 project focused on verifying and validating CFD models for a semisubmersible platform. Several institutions took part in submitting the CFD results, and STEP4WIND actively contributed to the CFD results.

The numerical setup is based on the wave basin tests carried out by MARIN. Three different load cases (LC) were considered: calm-water free-decay motions in surge, heave, and pitch. Both the experiment and CFD simulations were performed at a 1:50 scale. The motion periods, linear and quadratic damping coefficients, and equivalent linear damping ratios were estimated from the experimental and numerical floater motion time series and are used as validation metrics. The results showed some differences between experimental and CFD surge decay motion, while the other degrees of motion exhibited no such behaviour. In general, CFD results and experiments showed good agreement, and the CFD can be further used to tune model coefficients.

3. Objectives

This report aims to validate the numerical framework proposed to understand the non-linear hydrodynamics of the floating offshore substructure and improve the mid-fidelity models by tuning the hydrodynamic damping coefficients needed by these models. All the experimental tests and numerical modelling are performed on an OC5-DeepCwind Semisubmerible type substructure. The objectives addressed in this work are listed below.

- CFD setup for the semisubmersible
- Wave tank experiments performed in MARIN
- Verification of the CFD results from different solvers
- Validation of the CFD setup against experimental results

4. Conclusions

The CFD model for the “DeepCwind” semisubmersible was set up and validated, laying the foundation for the entire PhD work. The conclusions for individual work are listed below.

- Established a baseline mesh for CFD modelling and conducted a grid-independent study
- Validated and verified the numerical CFD model developed in OpenFoam using wave basin test results
- Estimated the modelling uncertainties and numerical errors associated with modelling choices (like turbulence model, numerical schemes, and so on)

The benchmarked CFD model can be used to further study different load cases and improve engineering models utilising the available understanding of the subject.

References

[1] Wang L, Robertson A, Jonkman J, Kim J, Shen Z-R, Koop A, Borràs Nadal A, Shi W, Zeng X, Ransley E, et al. OC6 Phase Ia: CFD Simulations of the Free-Decay Motion of the DeepCwind Semisubmersible. *Energies*. 2022; 15(1):389. https://doi.org/10.3390/en15010389