Calibrating drag coefficients with numerical optimization

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Introduction

For the simulation of the coupled dynamic response of floating offshore wind turbines, it is crucial to calibrate the hydrodynamic damping with experimental data. The aim of this work is to find a set of hydrodynamic drag coefficients (C_D) for the semi-submersible platform (shown in Figure 1) which provides suitable results for an irregular sea state [1] . It is common to calibrate C_D with decay tests. However, applying these C_D values for an irregular waves leads to misprediction of the motions.

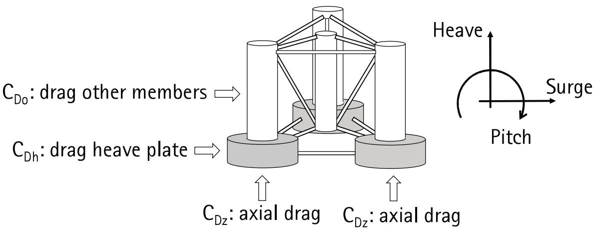

Figure 1: The semi-submersible platform including the drag coefficient distribution and directions

Objective

- Identify a set of drag coefficients for irregular wave cases
- Find an effective tuning method applicable for all load cases

Method: Numerical optimization

Benefits

- Calibration of multiple drag coefficients at the same time
- Consideration of several degrees of freedom

Optimization scheme

- Design variables: drag coefficients C_{Dh}, C_{Do}, C_{Dz} (see Figure 1)
- Minimizing the residual banded spectral power (ϵ) between experiment and simulation
- Multi-objective optimization considering heave and surge (ϵ_1) and pitch (ϵ_2)

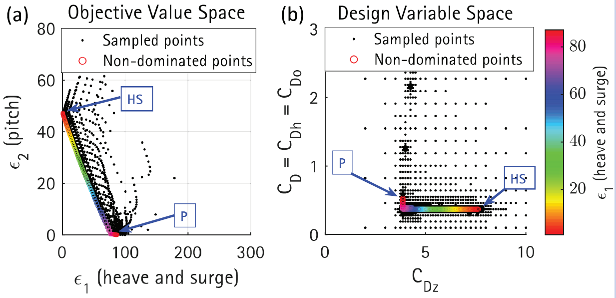

Figure 2: Pareto front (a) and Design Variable Space (b)

Results

- Optimal C_{Dh} is much smaller for irregular waves than for decay tests
- C_{Do} is larger for irregular waves, because model underestimates fluid velocity near the free surface
- Not possible to find good solution for C_{Dz} that matches both heave and pitch responses well
- Pareto front (Figure 2a) shows discrepancy between optimal C_D solutions for heave and surge (HS) and pitch (P)
- Optimal C_{Dz} for pitch is smaller by a factor of 2 compared to optimal C_{Dz} for heave as indicated by the location of the optimal solutions in the design variable space (Figure 2b)
- Most relevant results summarized in Figure 3

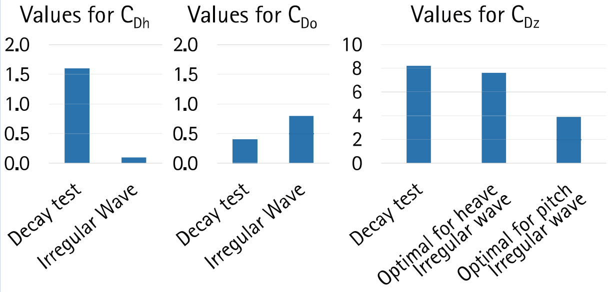

Figure 3: Resulting drag coefficients

Conclusions and future Work

- Major improvements in response to irregular waves when tuning to that load case, compared to tuning using decay load case
- Pitch and heave cannot be both represented well with this model, since both mainly rely on the axial drag
- Further improvement for representation of drag or overall hydrodynamic model necessary
- Velocity dependence of drag should be regarded
- Tilt angle of structure might need consideration

References

[1] Robertson A, Bachynski E, Gueydon S, Wendt F and Schünemann P 2020. Total experimental uncertainty in hydrodynamic testing of a semi-submersible wind turbine, considering numerical propagation of systematic uncertainty. Ocean Engineering

Acknowledgements

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