The 23rd Offshore Symposium

Feb 14, 2018 | Houston, TX

Prediction of Propeller-induced Hull Pressure Fluctuation and Marine Turbine Performance via a Potential-based Method: Study of the Influence of Different Wake Alignment Schemes

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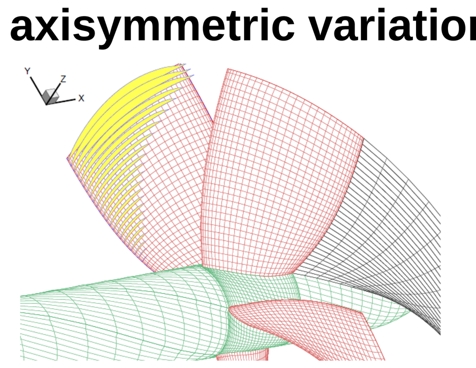
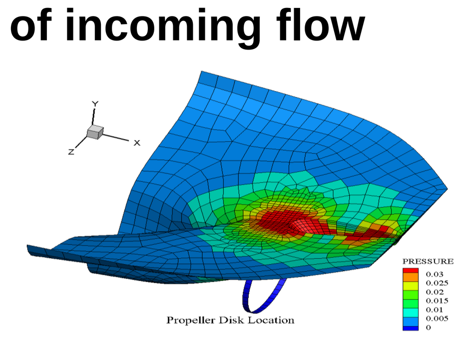
Introduction and Methodologies

In recent years, the onboard comfort of crew and passengers has become more and more crucial in the maritime industry. The propeller-induced hull pressure fluctuation is one of the main sources of vibration on ship. To evaluate the hull pressure, several methods developed in our group are incorporated:

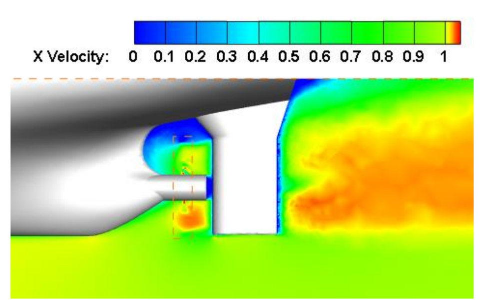
- PROPCAV: boundary element code to predict unsteady propeller performance and cavitation behavior
- HULLFPP: boundary element code to predict propeller-induced hull pressure fluctuation
- BEM/RANS: hybrid BEM/RANS code used to evaluate the non-axisymmetric variation of incoming flow



PROPCAV

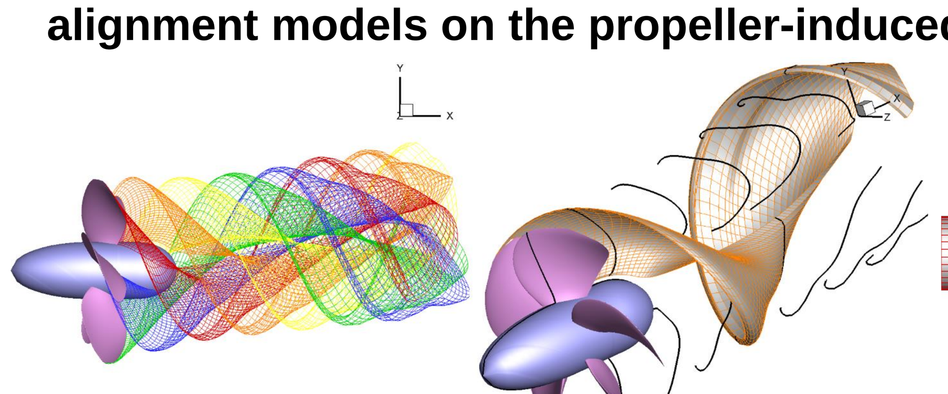


HULLFPP

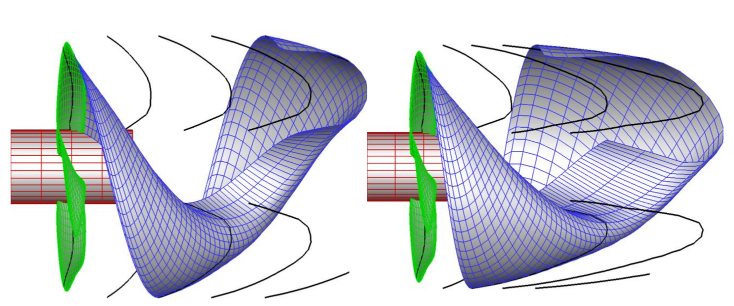


BEM/RANS

When evaluating the hull pressure due to the propeller and its wake, a proper wake alignment model improves the numerical accuracy of the predicted pressure field in non-cavitating situations. Two different wake alignment model, i.e., PSF-2 and Unsteady Wake Alignment Model are applied to cavitating situation to investigate the influence of different wake alignment models on the propeller-induced hull pressure.



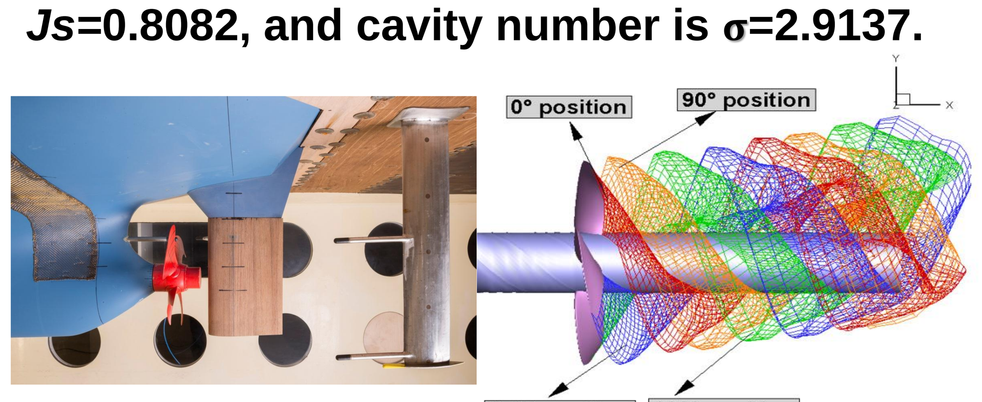
Unsteady Wake Alignment



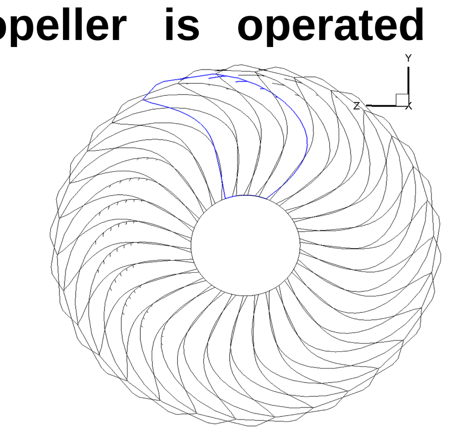
PSF-2 Alignment Model

Sample Run: Propeller-Hull Interaction

With fully aligned wake from the unsteady wetted run, cavity calculation is performed at each time step to predict the cavity patterns on the blade surface in unsteady state. SPSS P2772 propeller is operated with Js=0.8082, and cavity number is σ=2.9137.



The geometric arrangement in the experiment and fully aligned unsteady wake from PROPCAV

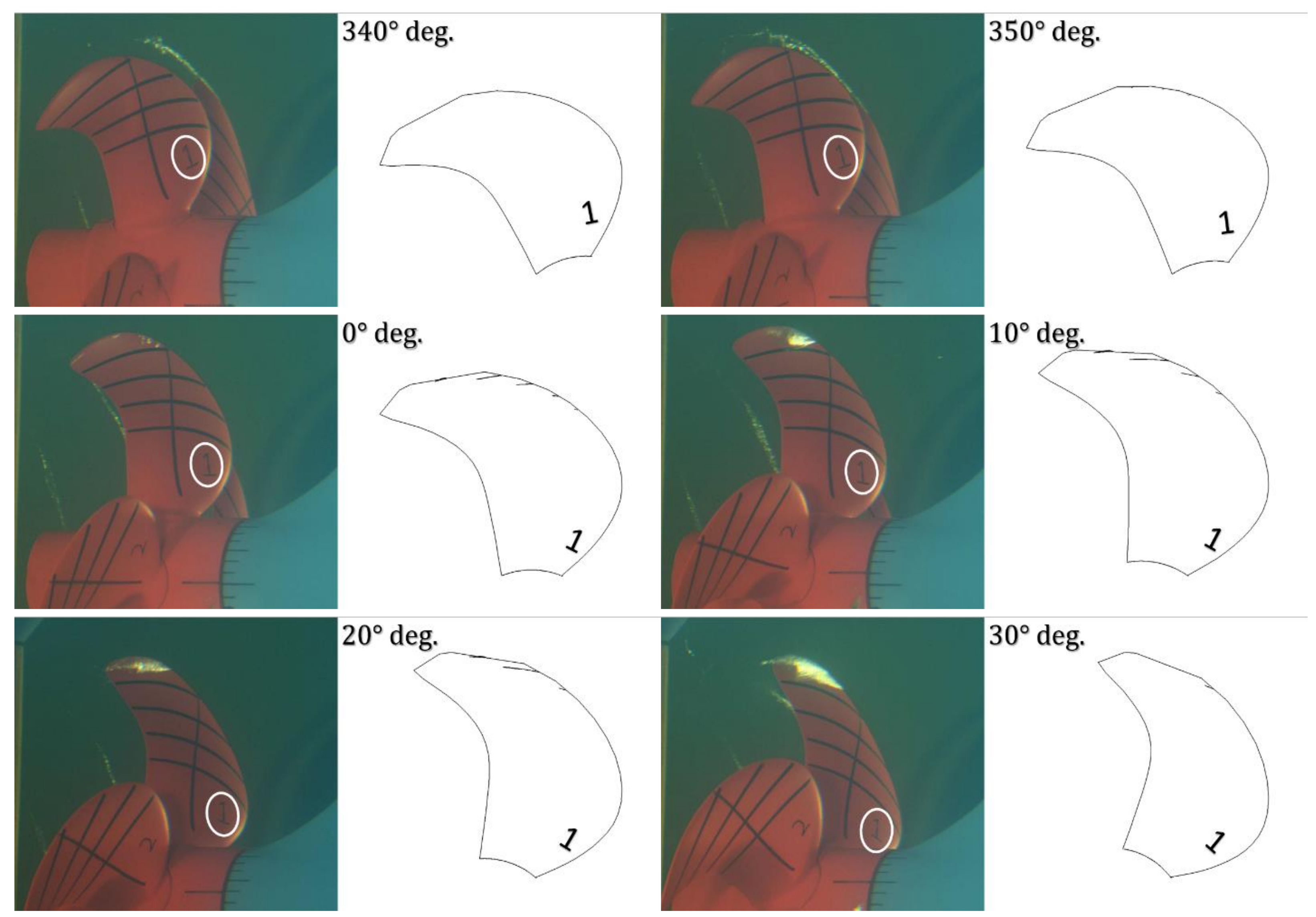


The projected blade geometry with the predicted cavity patterns at various angular positions.

Sample Run: Propeller-Hull Interaction

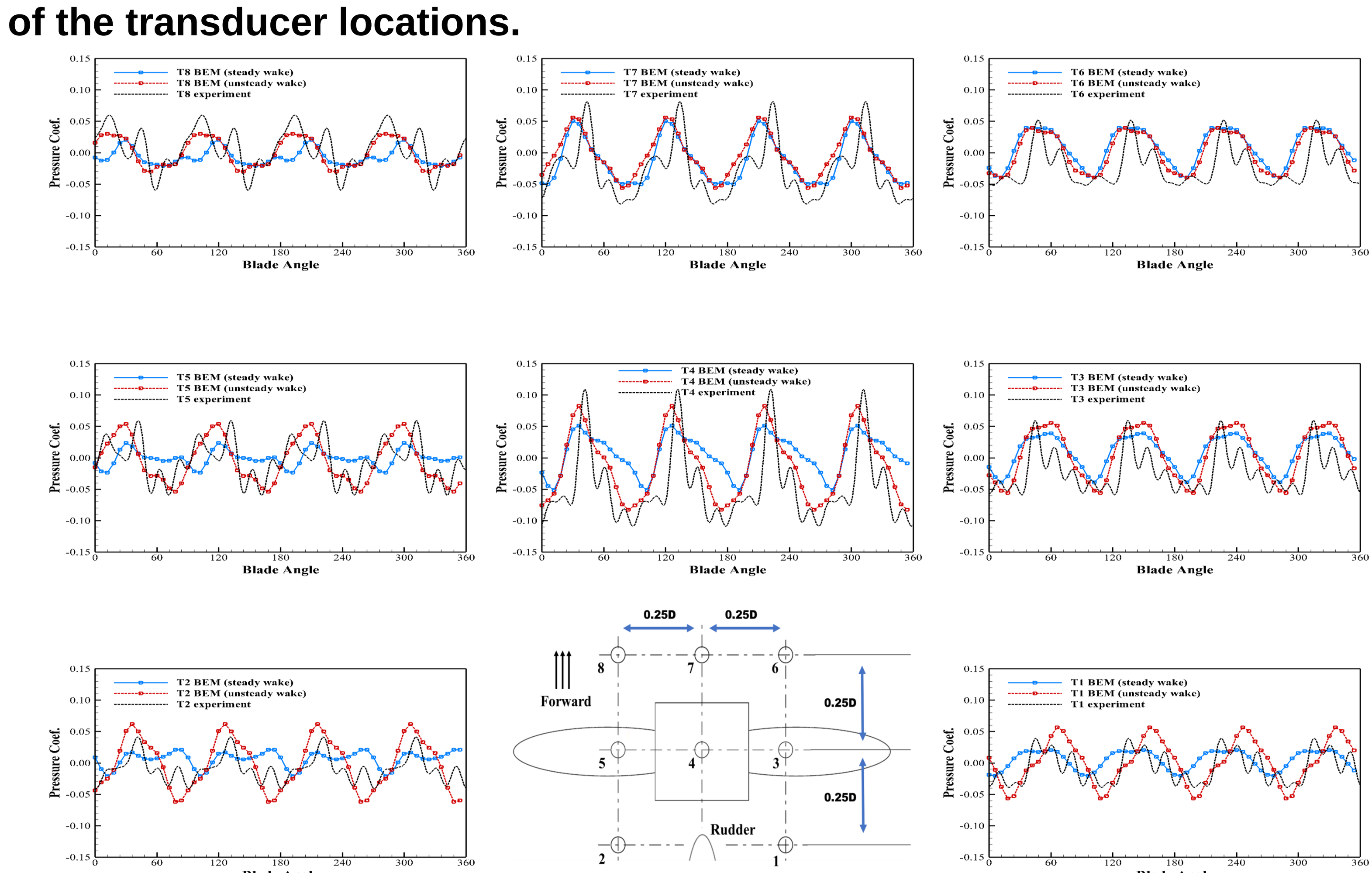
Photographs taken during the experiments are shown below for comparison with the results from PROPCAV at several angular positions.

As shown, both PROPCAV and the experiments detect a very small amount of sheet cavity on blade surface.

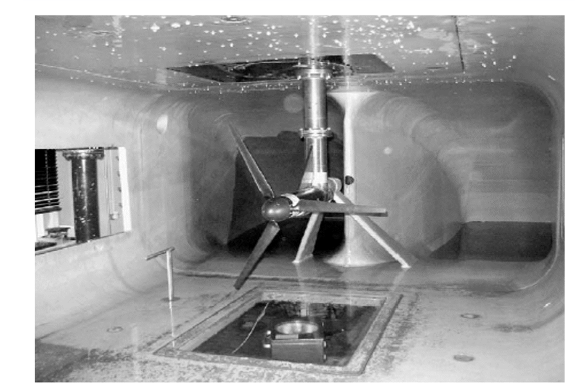


Sample Run: Propeller-Hull Interaction

Pressure history predicted by HULLFPP is compared to the experimental measurement. As show, HULLFPP can predict the peak amplitude on most of the transducer locations.



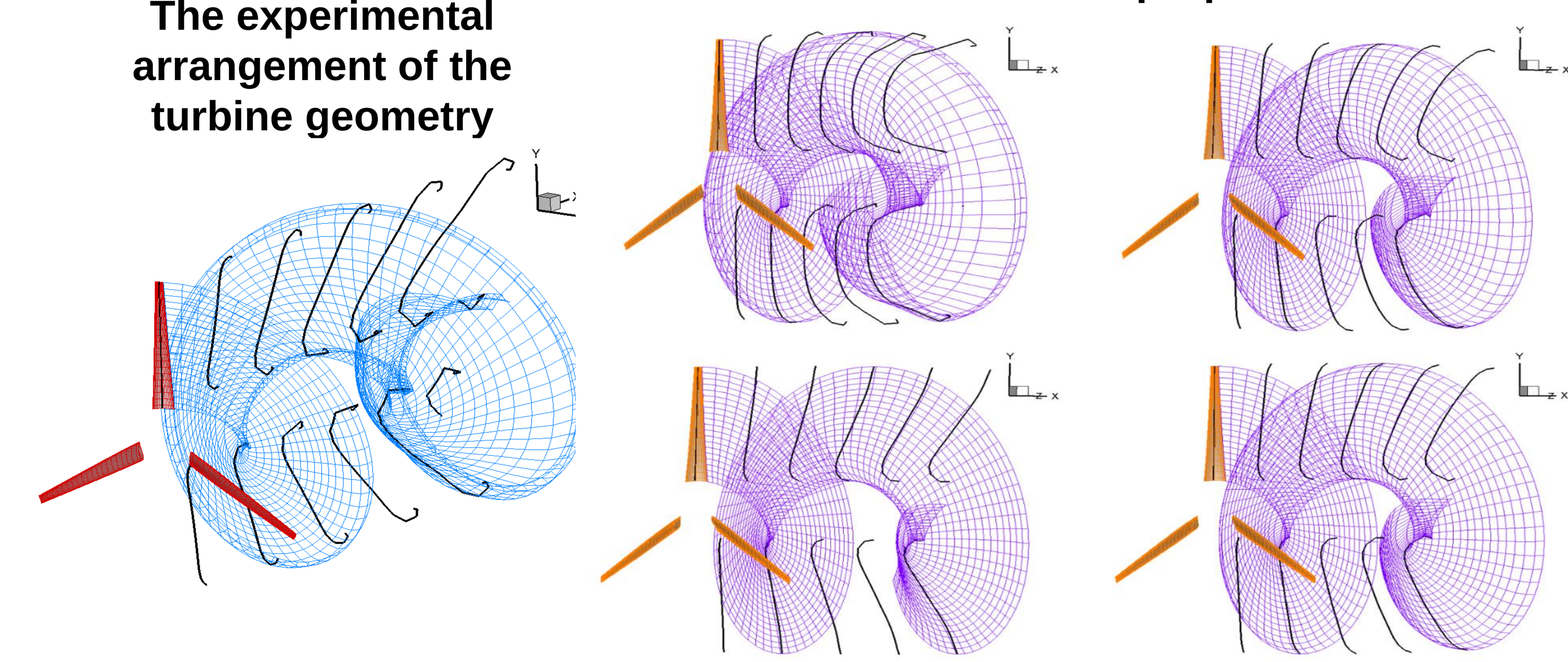
Sample Run: Marine Turbine



The experimental arrangement of the turbine geometry

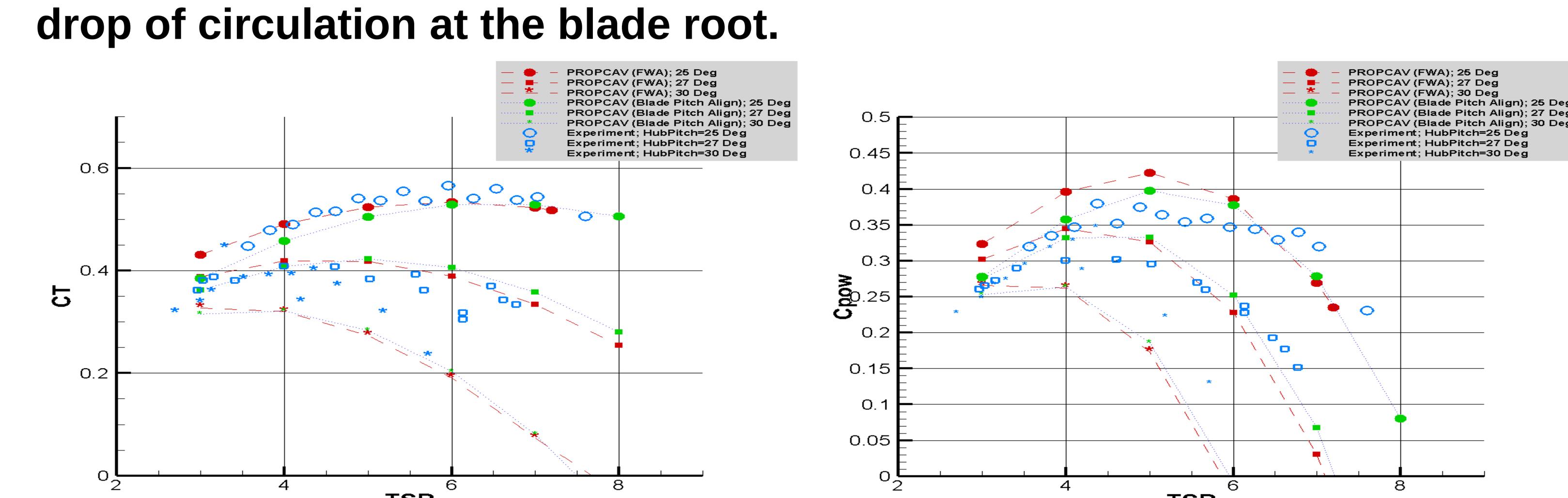
The predicted turbine performance from PROPCAV and full-blown RANS simulations are compared to the experiment, which was conducted by (Bahaj et el. 2007).

Full Wake Alignment (FWA) is also applied to marine turbine to align its wake based on he local flow as in the case of propeller.



Turbine geometry with fully aligned wake from PROPCAV using FWA. Four different hub pitch angles. i.e., 20°, 25°, 27°, and 30° are assumed.

The roll-up in the wake from blade tip is in the opposite direction to the propeller case. It is because the circulation on the blade is negative in turbine case. The hub is not included, since a gap between the hub and each blade root, as shown in the real geometry will lead to a significant drop of circulation at the blade root.



Comparison of thrust coefficient and power coefficient between BEM/FWA and the experiments.

Conclusions and Future Work

- In the case non-uniform inflow is assumed around the hub, the hub effect on the wake panels should also be considered. Since the penetration of the wake panels into the hub happen downstream
- In the near future, developed tip vortex cavitation model onto the current unsteady wake alignment model needs to be included.
- In the case of non-zero yaw angle, unsteady wake alignment model needs to be applied to turbine wake.