Effect of the Size and Location of Variable Geometry Modules on Wave Energy Converter Hydrodynamics

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Abstract

The National Renewable Energy Laboratory (NREL) research team has been exploring the optimum sizing and placement of variable geometry modules to create favorable changes in wave energy converter (WEC) hydrodynamics [1]. NREL's research has shown that a large reduction in loads can be achieved by modulating a small section of the surface area on the absorber body. For this work a submerged plate has been chosen to represent the WEC absorber body. The variable geometry modules are shown as controllable irises in Figure 1.

The variable A_r will denote the ratio between the surface area, given by the

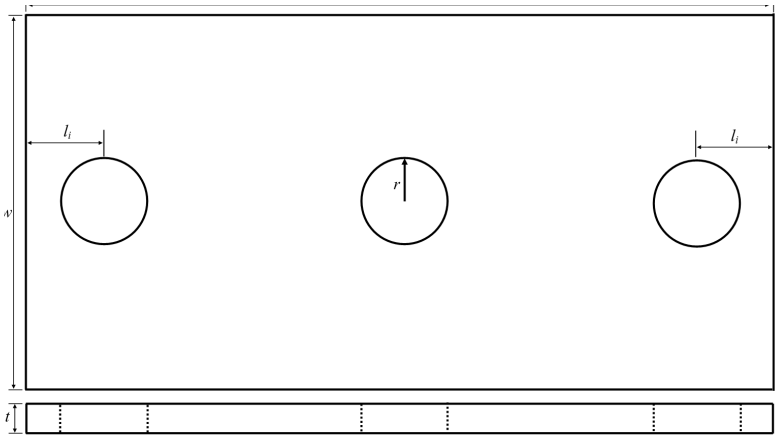
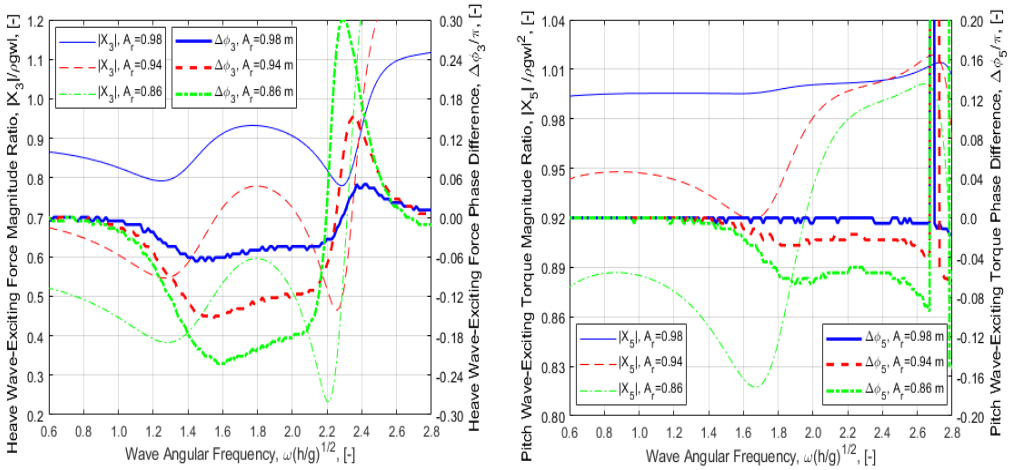


Figure 1: Top down view of the submerged plate with controllable irises.

primary dimensions, and the surface area remaining after removing the area of the irises when opened. The area ratio is described by:

$$A_r = 1 - \frac{\pi n r_i^2}{wl} \tag{1}$$

where n is the number of irises open, r_i is the radius of the irises, w is the width of the plate, and l is the length of the plate.



(a) Heave Wave-Exciting Force (b) Pitch Wave-Exciting Torque

Figure 2: Wave-Exciting Force and Torque Magnitude Ratio and Phase Difference Against Versus Wave Angular Frequency. Water depth, h, has been set at 20 m and can be used to scale the incident wave angular frequency.

As observed from Figure 2(a), when opening just the center iris, $n = 1$, there is a nonlinear reduction in the heave-wave exciting force. When A_r and r_i are equal to 0.86 and 3 m respectively, there is a 60% reduction in the heave wave-exciting force magnitude while the phase lag increases causing the heave wave-exciting force to peak later. This is an interesting discovery as results demonstrate that a large variable geometry module is unnecessary to achieve significant load shedding properties. For the heave degree of freedom, the percentage reduction in wave exciting-force exceeds the percentage reduction in surface area. In contrast, the pitch wave-exciting torque does not have load shedding magnitude as in heave, see Figure 2(b). The pitch wave-exciting torque appears to have an approximate linear relationship with the reduced surface area. This highlights the additional complexity of design VGWECs with multiple degrees of freedom.

Acknowledgements

The Alliance for Sustainable Energy, LLC (Alliance) is the manager and operator of the National Renewable Energy Laboratory (NREL). NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. This work was authored by the Alliance and supported by the U. S. Department of Energy under Contract No. DE-AC36-08GO28308. Funding was provided by the U.S. Department of Energy Wind Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the U.S. Department of Energy or the U.S. government. The U.S. government retains, and the publisher, by accepting the article for publication, acknowledges that the U.S. government retains a

References

[1] Kelley, M., and Tom, N. "Development of the Second Generation Oscillating Surge Wave Energy Converter with Variable Geometry." In Proceedings of the 27th International Ocean and Polar Engineering Conference, ISOPE 2017.