Reliability-Based Geometry Optimization of a Heaving Point-Absorber with PTO Reliability Objectives

Caitlyn E. Clark*[1], Anna Garcia-Teruel[2], Bryony DuPont[1], and David Forehand[2]

[1] *Oregon State University, Corvallis, OR, USA*
[2] *The University of Edinburgh, Edinburgh, Scotland*
[*] *Corresponding Author: clarkc@oregonstate.edu*

Abstract

As the wave energy industry progresses towards commercialization, research and development efforts to characterize and improve reliability of wave energy converters (WECs) have increased. Issues with reliability and survivability of WEC designs have previously led to setbacks for WEC development and implementation. Moreover, component or system failure rates directly affect capital costs, operational costs, and power production. Therefore, designing WECs to withstand highly energetic wave conditions without over-engineering them is critical to overcoming industrial and development challenges and enabling their implementation.

Despite the importance of considering reliability in WEC design, it is often considered secondary to power production. Maximizing power production across sea states can increase revenue potential, but also loads and costs. Thus, power production and component reliability should be considered simultaneously throughout the WEC design process. Particularly in device geometry design, there is an opportunity to reduce structural and PTO loads [1]. Ensuring that WECs perform as they were designed for their intended lifespan, while decreasing levelized costs of energy, is integral to improving their feasibility.

In previous work, WEC hull geometries have been optimized for cost and power production, where costs varied with device size [2]. Reliability-based design optimization of hull geometries has not yet been explored, but would allow for hull geometries with advantageous reliability scores to be prioritized, balancing cost, power production, and reliability objectives. However, to develop this optimization method, we first need to develop analysis methods that relate environmental loads the WEC experiences to its reliability, as well as evaluate the sensitivity of its reliability to varying hull geometries. In this study, we explore the relationship between WEC floater geometry and Power Take-Off (PTO) reliability, focusing on developing a reliability assessment method to evaluate PTO failure.

To complete this analysis, we leverage previous work that generates WEC hull geometries and performs hydrodynamic analysis, from which power production and PTO forces for each geometry can be obtained [2, 3]. From this PTO force time series, we then use Rainflow Counting and appropriate S-N Curves to count the number of fatigue cycles and relate it to Damage Equivalent Load metrics. The flexible definition of the WEC hull geometry allows us to evaluate and compare several hull shapes and their resulting PTO damage. This study will provide insight about how hull geometries affect PTO damage, and enable future work incorporating this reliability assessment method within a geometry optimization process.

References

[1] Coe, R., et al., A Survey of WEC Reliability, Survival and Design Practices, Energies, 2017.

[2] McCabe, A., et al., Optimizing the shape of a surge-and-pitch wave energy collector using a genetic algorithm, Renew. Energy, 2010.

[3] Garcia-Teruel, A., and Forehand, D. Smith J., Optimal wave energy converter geometry for different modes of motion 3rd Int. Conf. on Renewable Energies Offshore, 2018.