XI International Conference on Computational Methods in Marine Engineering

Genetic Algorithms for the Control Co-Design of Permanent Magnet Synchronous Generators for Wave Energy Converters

Matthew Onslow[1,*], and Adam Stock[2]

[1] Centre for Doctoral Training in Wind and Marine Energy Systems and Structures, Electronic and Electrical Engineering Department, University of Strathclyde, Glasgow, G1 1XQ, United Kingdom.

[2] Institute of Mechanical, Process and Energy Engineering, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, United Kingdom.

[*] Corresponding Author: matthew.onslow@strath.ac.uk

ABSTRACT

The design of controllers for a wave energy converter (WEC) will often prioritise mechanical power output, neglecting the dynamics and efficiencies of the drive train; this can result in the WEC consuming electrical power despite extracting mechanical power from the seas (Stock, 2024). This work details the design of a model for the co-optimisation of the geometry of a permanent magnet synchronous generator (PMSG) and the power-generation control strategy, for a heaving point absorber operating across a range of sea states.

The geometry of the PMSG is defined by a set of genes (number of pole pairs, rotor radius, etc.) that are optimised via a genetic algorithm with a cost function defined by the average electrical power outputted divided by the monetary material cost of the generator (a proxy for total cost). A flow chart showing the operation of the optimisation is shown in Figure 1. Importantly, for each PMSG design created, the optimal control strategy (maximum electrical power) for each sea state is found. As such, the PMSG designs are optimised alongside their control strategies, rather than being designed for a predefined control method that does not account for differences in PMSG design. An example of a WEC PMSG design is shown in Figure 2. Computational efficiency is ensured by using a lumped parameter model of the PMSG, derived from work by P. Krause *et al.*, with the WEC drive train model based on work by C. Ströfer *et al.*

Using the outputs from the genetic algorithm PMSG design optimisation, the impacts of WEC buoy shape, site choice, and control strategy on optimal PMSG design are discussed.

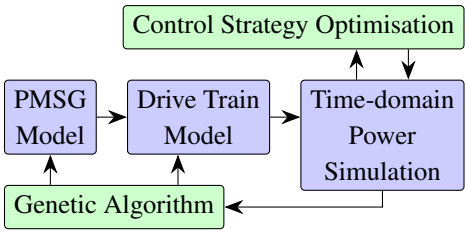

Figure 1: Flow chart of the operation of the optimiser.

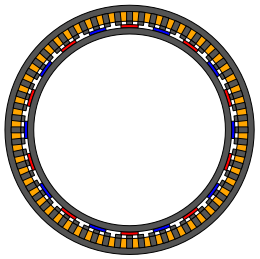

Figure 2: Example of an optimised PMSG.

References

A. Stock, 'Accounting for power take-off efficiency in optimal velocity tracking control of wave energy converters', Ocean Engineering, 2024. doi: 10.1016/j.oceaneng.2024.119191

P. Krause *et al.*, 'Analysis of Electric Machinery and Drive Systems', 3rd edition, Chapter 15, John Wiley & Sons, Inc., 2013, doi: 10.1002/9781118524336.ch15

C. Ströfer *et al.*, 'Control Co-Design of Power Take-Off Systems for Wave Energy Converters Using WecOptTool', in IEEE Transactions on Sustainable Energy, 2023, doi: 10.1109/TSTE.2023.3272868.