Numerical Hydrodynamic Analysis of Bottom-Hinged Surge-Type Wave Energy Converters with Flat and Curved Flap Geometries

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Abstract:

A numerical investigation was carried out on bottom-hinged surge-type wave energy converters with flat and curved flap geometries to quantify the effect of leading-face curvature on the hydrodynamic response under the fully submerged condition at a model scale of 1:5. Three configurations were compared: a flat flap and two curved flaps of focal length 0.20 m and 0.30 m, with the concave face oriented into the incident waves. A three-dimensional Rhino model of each configuration was created and analysed in ANSYS AQWA R2 using the boundary element method (BEM), yielding the added mass, radiation damping, wave-excitation moment and response amplitude operator, complemented by time-domain surge-response simulations. Relative to the flat flap, curvature lowers all three coefficients: for the 0.20 m flap, the added mass, radiation damping and excitation decrease by 7.3%, 8.9% and 5.4%, and for the 0.30 m flap by 4.7%, 5.3% and 3.1%. The resonant peak is lowered without being shifted: the flat flap resonates at 3.21 s, the 0.30 m flap at 3.25 s and the 0.20 m flap at 3.28 s, with peak RAO reduced by 2.6% and 4.6%, respectively. In the time domain, the near-resonant response (T= 3.0 s) builds up to a sustained steady amplitude of about ±3.5° for the flat flap and marginally less for the curved flaps, whereas the off-resonance response (T= 4.0 s) is markedly smaller for all three configurations.Curvature thus emerges as a controllable design parameter that trims the resonant peak while reducing radiation damping,a combination that favours power-take-off impedance matching.

Keywords:

Added mass, boundary element method, curvature, radiation damping, response amplitude operator, time-domain response, wave energy converter, wave excitation moment.