Influence of narrow gap wave resonance on a dual-floater system with WECs and breakwaters

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Introduction

The high construction cost and low extraction performance of the Wave Energy Converters (WECs) reduce the economic competitiveness of the wave energy, which constrains the development of the commercial-scale wave power operations. Combining WECs with the breakwater can provide an effective solution to make the wave energy economically competitive and promote the development of WECs and floating breakwaters. One of the widely studied integrated WEC-breakwater system is Oscillating-Buoy (OB) type WECs integrated with floating breakwaters, which mainly includes the single-floater integrated system and the dual-floater hybrid system.

The existence of the gap between two floaters of the dual-floater hybrid system is one of main differences comparing with the single-floater integrated system. The wave response amplitude in the gap between two structures can reach the maximum under certain wave frequency, which is called narrow gap wave resonance. The wave resonance in the gap of the dual-floater hybrid system can significantly affect the performance of the WEC. Thus, it is essential to study the influence of the gap wave resonance on the performance of the hybrid system.

Numerical Model

A two-dimensional numerical wave flume was established using the Star-CCM+ software to simulate wave interaction with a hybrid system consisting of a floating breakwater and an oscillating-buoy type WEC, as shown in Fig. 1.

The breakwater was assumed to be fixed because the motion of the breakwater was relatively small compared to the WEC. The WEC can only move in z direction independently, and the mooring system of the hybrid system was not considered.

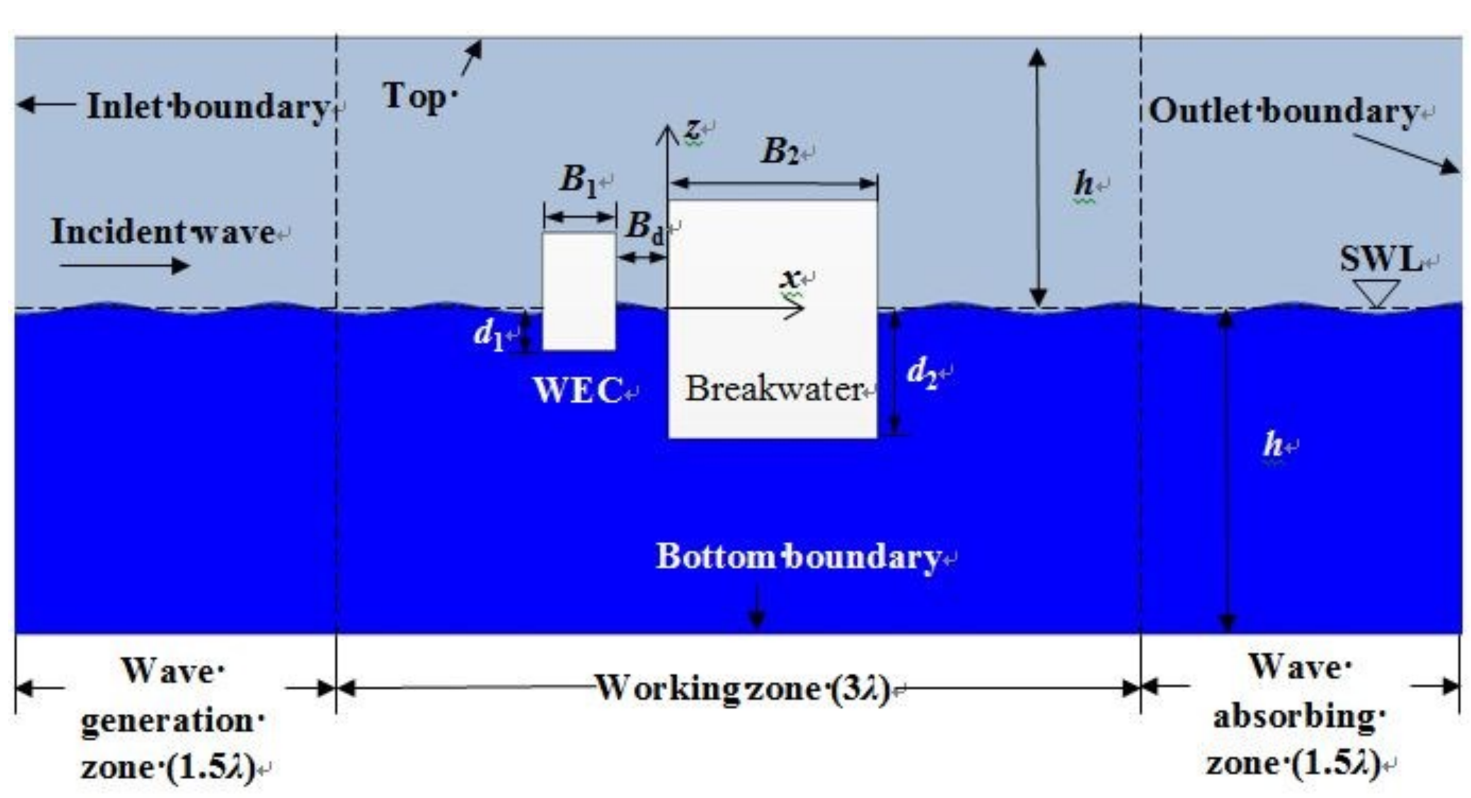
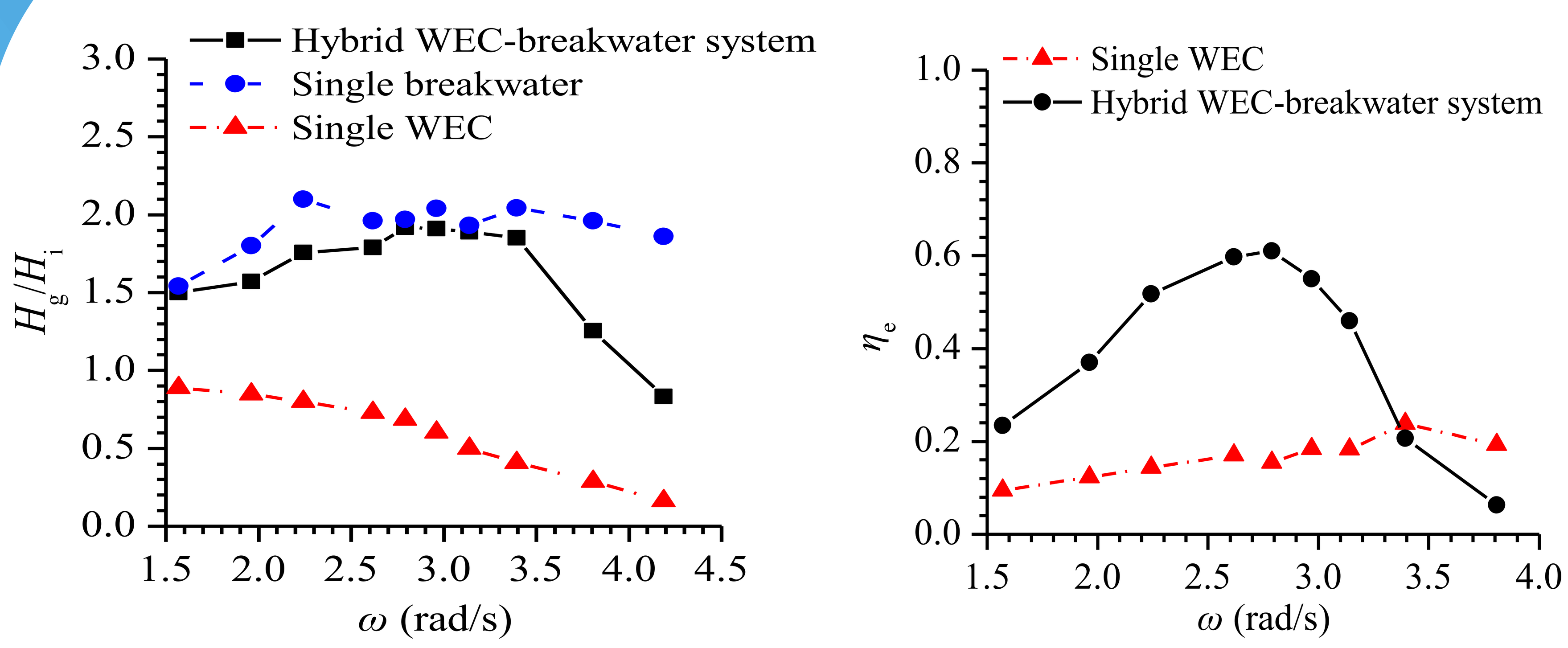


Fig. 1 A diagram of the two-dimensional numerical wave tank model

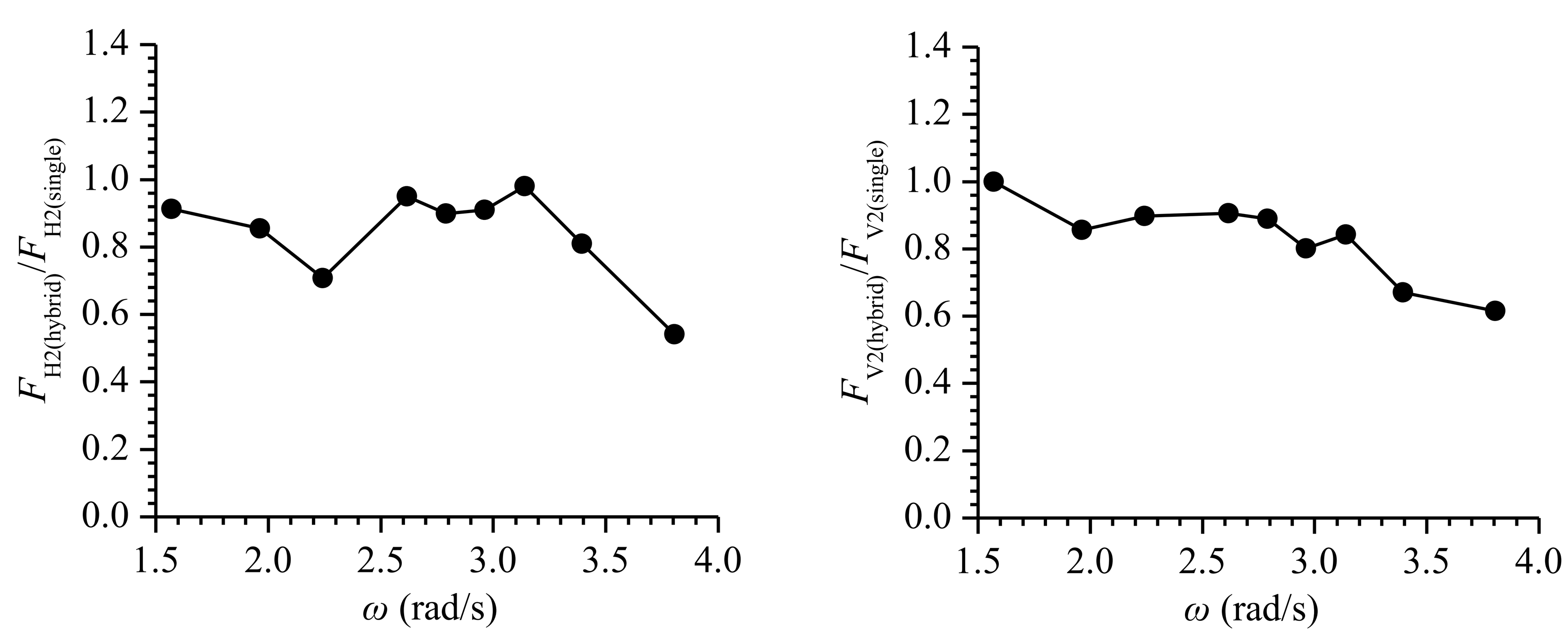
(λ: wave length)

Results



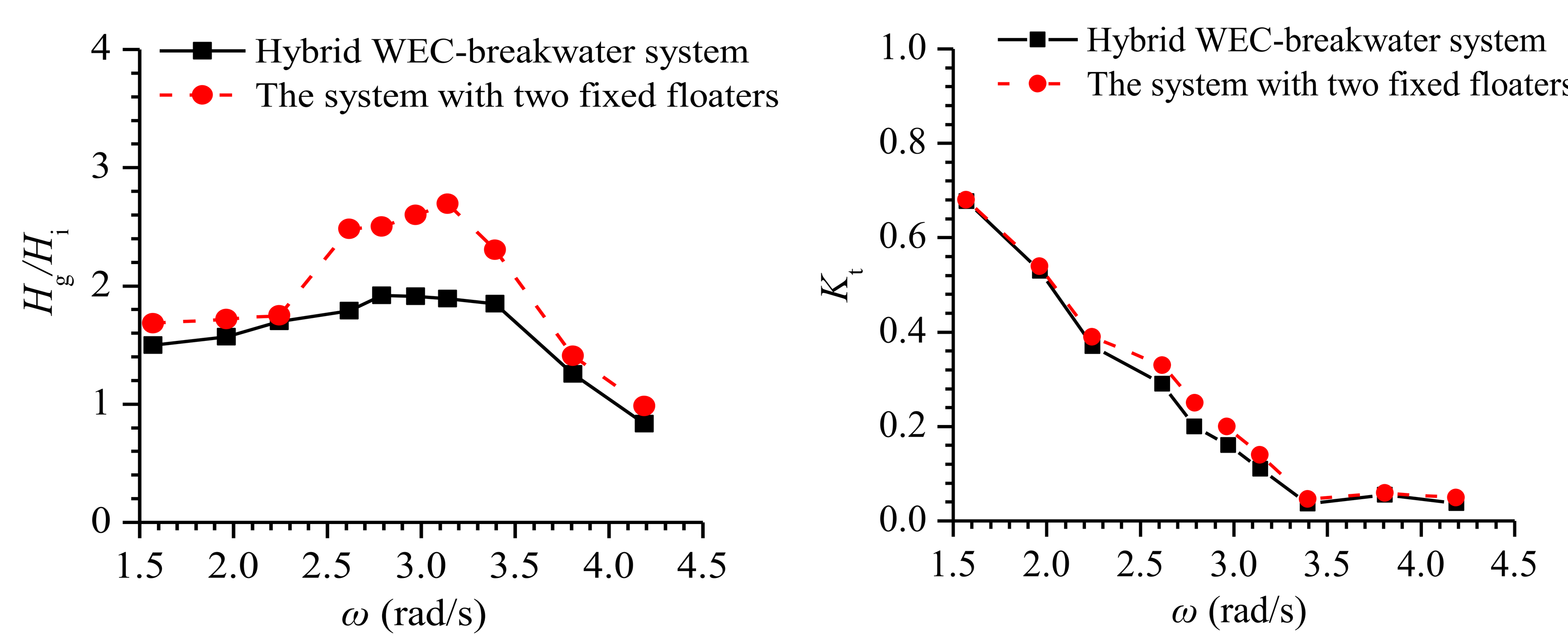
(a) Wave elevations in the gap (b) Conversion efficiency

Fig. 2 Variations of H_g/H_i and η_e, versus ω for different models



(a) Horizontal force (b) Vertical force

Fig. 3 Comparison of vertical and horizontal forces on the single breakwater and the breakwater of the hybrid system



(a) Wave elevations in the gap (b) Transmission coefficient

Fig. 4 Variations of H_g/H_i and K_t versus ω for different models

Conclusion

(1) Comparing to the single WEC, the wave resonance in the WEC-breakwater gap causes conversion efficiency of the hybrid system with a symmetric WEC significantly increasing. The forces on the breakwater of the hybrid system are smaller than those of the single breakwater.

(2) The motion of the WEC leads to the decrease of the wave elevations and resonance frequency in the WEC-breakwater gap and the forces on the breakwater of the hybrid system in the whole frequency region.

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