Dynamic response and power performance of a hybrid system combing an offshore wind platform and wave energy converters

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Introduction

Offshore wind energy has been rapidly developing in recent years due to the fact that wind is stronger and steadier at the sea than on the land, and the availability of space for wind farm installation. Wave energy is one of the most promising renewable energy resources because of its high energy density, predictability, and wide-spread availability, which similarly has a much higher power density in deep water regions. Deep water offshore deployment of wind and wave energy is only at an early stage of development due to the challenges of high design, installation, operation, and maintenance costs. The combined exploitation of offshore wind power and ocean wave energy has been proposed as one way of helping to reduce cost.

There are multiple benefits of the hybrid system of a floating offshore wind energy and Wave Energy Converters (WECs). Firstly, it can reduce the overall project cost by sharing the mooring system, power infrastructure, and other components of the wind farm. Secondly, wave energy production may compensate for the intermittency of offshore wind, i.e., the hybrid system can reduce the hours of zero production compared with a stand-alone wind turbine, as ocean waves tend to persist even after the wind dies away. In addition, an efficient layout of WECs can modify the local wave climate, providing a sheltered environment for operation and maintenance, which will effectively protect the offshore wind platform from heavy wave loads during storm conditions.

Material & Methods

The multi-constraint coupled motion model of the floating platform, WECs and mooring system is established based on Newton-Euler equation. The mooring force of the numerical model is transformed into the equivalent stiffness matrix in frequency domain by the static catenary theory. The radius and draft size of WECs with different $2r/d$ are designed according to the specific marine environment using a dimensionless method. The variation of platform motion and mooring force with the added wave energy converters with different diameter to draft ratio $2r/d$ is analyzed. The effects of the platform motion on the hydrodynamic performance and wave power of WECs are also studied.

Fig. 1 Hybrid system

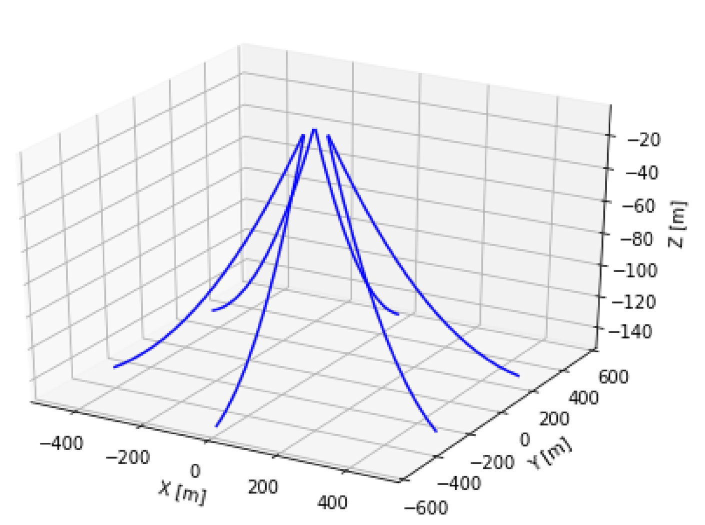

Fig. 2 Mooring lines

Table 1 Parameters of different layouts of WECs

Number of WECs	r [m]	d [m]	L_1 [m]	L_2 [m]
6	5.39	3.37	21.57	17.42
6	4.73	3.64	18.91	18.75
9	3.22	4.29	10.68	12.18
12	2.35	4.71	7.81	8.67
15	1.96	4.91	6.52	8.65

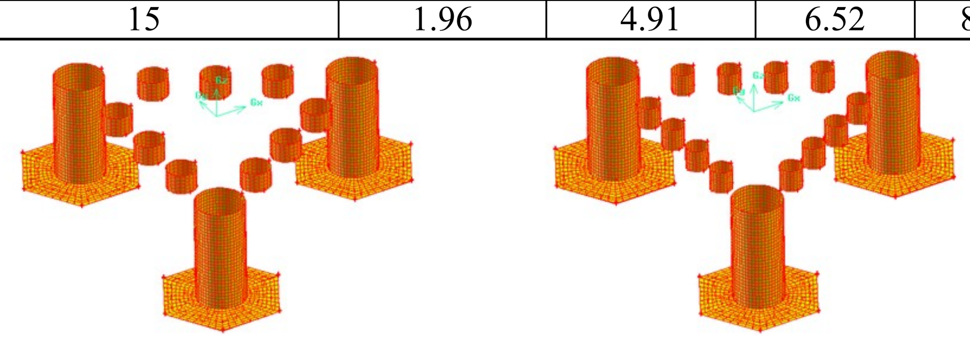

Fig.3 Mesh of the hybrid system for two different layouts of WECs.

Results

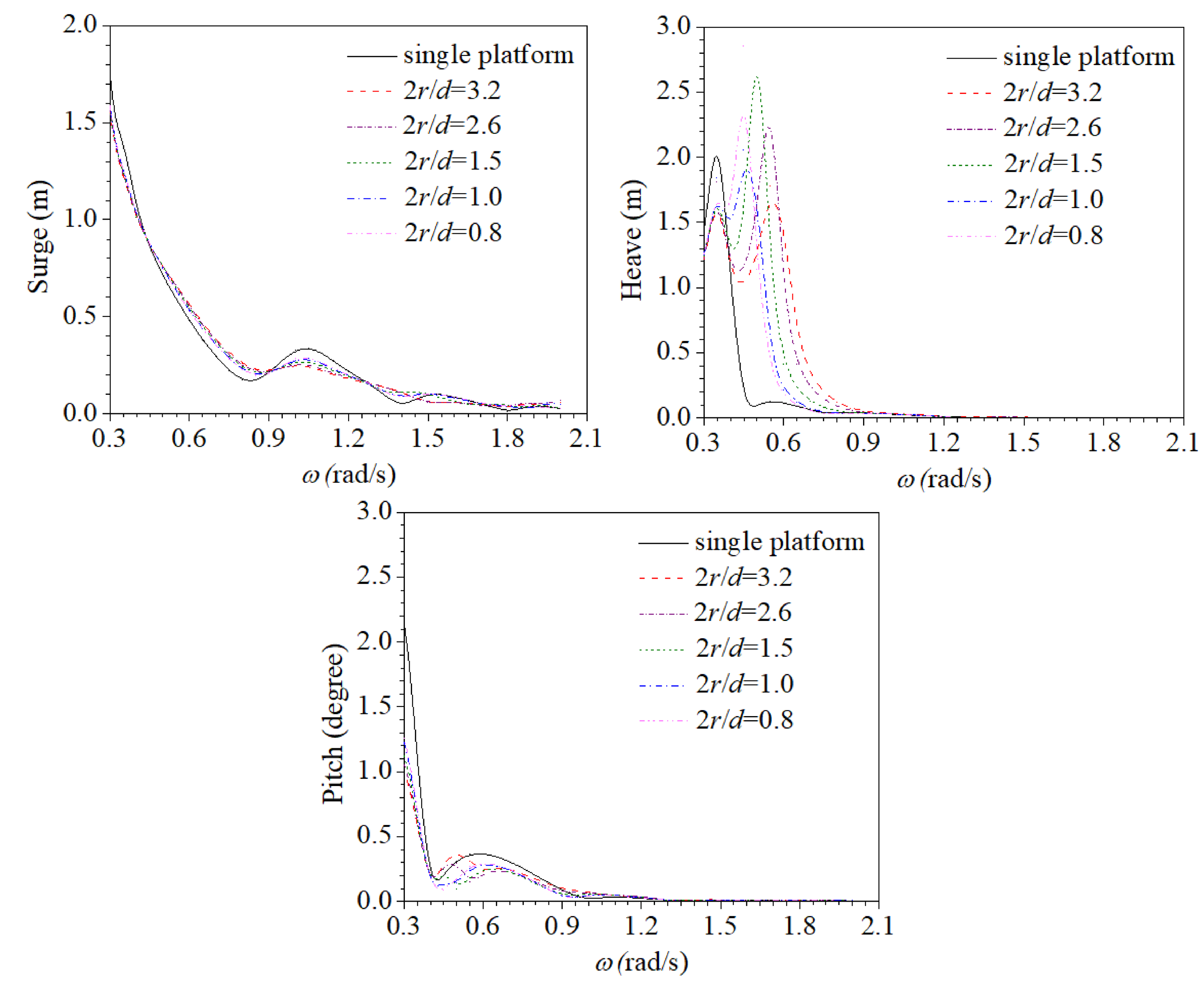

Fig. 4 Motion response of Windfloat platform versus ω with different 2*r*/*d*

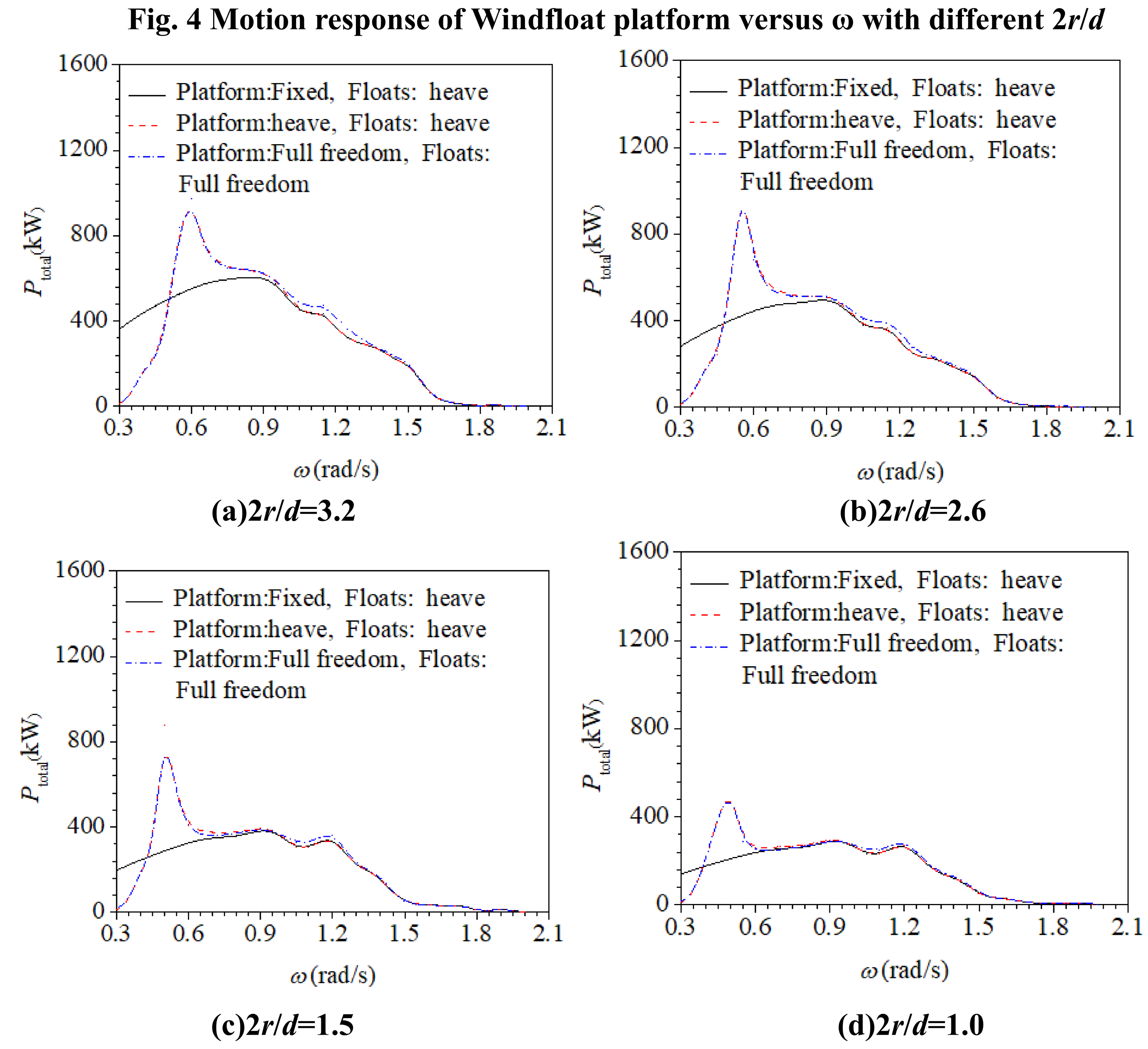

Fig. 5 Wave power with the fixed、heave motion and full freedom platform of different layout.

Conclusion

Fig.4 shows that after the wave energy converters are added, the surge motion of the platform do not change much. The heave motion of the platform generally increases, and the peak of the heave motion shifts to a larger frequency as $2r/d$ increases. The pitch motion of the platform decreases under almost all frequencies, especially in the low frequencies where the pitch motion is already large and the decrease of the pitch motion increases as $2r/d$ increases. After considering the motion of the platform, the wave power generally increases within the range of 0.5rad/s-2.0rad/s. The above phenomenon shows that the combination of the floating wind platform and the wave energy converters greatly improves the safety of the floating wind platform in the case of large waves compared with the single floating platform.