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Laboratory modelling of resonant wave-current interaction in the vicinity wind farm masts

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In the nearest future, by 2020, about 4% of electricity in Europe will be supplied by sea stations operating from renewable sources: ocean thermal energy, wave and tidal energy, wind farms. By now the wind stations located in the coastal zone, provide the most part of electricity in different European countries. Meanwhile, effects of wind farms on the environment are not sufficiently studied.

We report results of laboratory simulations aimed at investigation of hydrodynamic fields arising in the vicinity of wind farm masts under the action of currents and surface waves. The main attention is paid to modeling the resonance effects when the amplitude of velocity pulsations in the vicinity of the masts under the joint action of currents and harmonic waves demonstrate significant growth. This resonance can lead to an increase in Reynolds stress on the bottom, intensification of sediment transport and sound generation.

The experiments are performed in the 17 meters hydrodynamical channel of laboratory Morphodynamique Continentale et Côtière UMR CNRS 6143. Mast are modeled by vertical cylinder placed in a steady flow. Behind the cylinder turbulent Karman vortex street occurs. Results are obtained in interval of Reynolds numbers Re=10^3 – 10^4(Re=Ud/v, where U is the velocity of the flow, d is diameter of the cylinder, ν is cinematic viscosity). Harmonic surface waves of small amplitude propagating upstream are excited by computer controlled wave maker. In the absence of surface waves, turbulent Karman street with averaged frequency f is observed. It is revealed experimentally that harmonic surface waves with a frequencies closed to $2f$ can synchronize vortex shedding and increase the amplitude of velocity fluctuations in the wake of the cylinder. Map of regimes is found on the parameter plane amplitude of the surface wave - wave frequency. In order to distinguish the synchronization regimes, we defined phase of oscillations using the Hilbert transform technique.

We investigate effect of hydrodynamic turbulence on synchronization of hydrodynamic wake by surface waves. To change the level of turbulence we used honeycombs. Measuring the velocity upstream the cylinder, we found that under our experimental conditions honeycombs can reduce the level of hydrodynamic turbulence in two times. It is found that intensity of turbulence determines the amplitude threshold of synchronization in the wake behind cylinder.

The physical mechanisms of synchronization, its impact to the Reynolds stress and the possibility of such a resonance in the vicinity of masts located in the coastal zone are discussed.

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