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Experimental study of the duct-effects of the tidal current turbines in multi-row-staggered layout

Yaling Chen[1], **Binliang Lin**[2], and Jinxi Guo[2]
[1]College of Earth and Environmental Sciences, Lanzhou University, Lanzhou 730000, China (chenyaling@lzu.edu.cn)
[2]State Key Laboratory of Hydro-science and Engineering, Tsinghua University, Beijing 100084, China

Tidal turbine array was optimized to increase the power production in order to improve the commercial competitivity of tidal current energy with other forms of energy generation. Due to duct-effects, the power performance of turbines in the staggered layout was better than that of the aligned layout. However, shear layer with enhanced turbulence occurred between the duct zone and isolated wake zone downstream, which had influence on the performance stability and increased the fatigue failure of tidal turbines. The study conducted a series of laboratory experiments to investigate the duct-effects of tidal turbines located in multi-row array with staggered layout. The turbine rotor was represented by porous disc. The flow thrust and time-varying velocity were measured using micro strain gauge and acoustic doppler velometer, respectively. Results showed that the flow was accelerated between turbines with the increment around 20% behind the first row, while the duct-effects were weakened as distance increased downstream. The shear-induced turbulence was enlarged by the duct-effect when it diffused mainly towards individual wake zone at the initial stage. As the turbulence filled the whole individual wake zones, it diffused rapidly to lateral sides and jointed together, and the turbulence intensity across the array wake was significantly higher than that of the free flow. Correspondingly, the performance of turbine rotor located downstream was improved limitedly by the duct-effects, and the stability was reduced clearly. It indicated that the advantage of the duct-effect induced in the staggered layout was limited in the near wake as the lateral interval between two turbine centres was 2 times of rotor diameter.

Keywords**:** Turbine rotor array; Staggered layout; Duct-effects; Turbine performance; Shear-induced turbulence