Nonlinear Iterative Force Correction Procedure for Turbulent Flow Interacting with 3D Oscillating and Floating Structures

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ABSTRACT

Vortex-Induced Motion (VIM) of semi-submersible floating structure has recently emerged as an important issue in offshore and ocean engineering, mainly with the development of deep draft semi-submersibles. The geometry of the semi-submersible platforms implies a more complex VIM phenomenon than that identified for single cylindrical structures such as spars and mono-columns offshore structures. The vortex shedding from each column and thus the wake interference increases the complexity of VIM of semi-submersible platforms for different current headings in harsh ultra-deepwater environments.

In this paper, we present a stable partitioned iterative scheme for solving incompressible turbulent flow interacting with oscillating low-mass ratio structures. The scheme uses the so called nonlinear iterative force correction formulation based on the Arbitrary Lagrangian-Eulerian approach with continuous Petrov-Galerkin procedure. Although loosely-coupled partitioned schemes are often popular choices for simulating FSI problems, these schemes may suffer from inherent instability at low structure to fluid mass-density ratios. We show that our second-order scheme is stable for low mass density ratio m* and hence is able to handle strong added-mass effects. The numerical stability and robustness of the scheme is assessed with the aid of three-dimensional freely vibrating 3D structures interacting with turbulent flows. Complex vortex-induced motion of offshore floating semi-submersible structure is simulated at mass ratio $m^*\approx1.0$.

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