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Evaluation of Sloshing in Process Equipment for Floating Cryogenic Application

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Abstract : A variety of process equipment having flow in and out is widely used in industrial land-based cryogenic facilities. In some of this equipment, such as vapor-liquid separator, a liquid level is established during the steady operation. As the implementation of such industrial processes extends to off-shore floating facilities, it is important to investigate the effect of sea motion on the process equipment partially filled with liquid. One important aspect to consider is the occurrence of sloshing therein. The flow characteristics are different from the classical study of sloshing, where the fluid is enclosed inside a vessel (e.g., storage tank) with no flow in or out. Liquid inside process equipment continuously flows in and out of the system. To understand this key difference, a Computational Fluid Dynamics (CFD) model is developed to simulate the liquid motion inside a partially filled cylinder with and without continuous flow in and out. For a partially filled vertical cylinder without any continuous flow in and out, the CFD model is found to be able to capture the well-known sloshing behavior documented in the literature. For the cylinder with a continuous steady flow in and out, the CFD simulation results demonstrate that the continuous flow suppresses sloshing. Given typical cryogenic fluid has very low viscosity, an analysis based on potential flow theory is developed to explain why flow into and out of the cylinder changes the natural frequency of the system and thereby suppresses sloshing. This analysis further validates the CFD results.

Keywords : computational fluid dynamics, CFD, cryogenic process equipment, off-shore floating processes, sloshing
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