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RANS and LES modeling of hydrate slurry flow in pipelines

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Gas hydrates are ice-like and nonstoichiometric crystalline mixtures, consisting of a frame work of water cages occupied by gas molecules such as methane and ethane. In the oil and gas transport system, the presence and accumulation of gas hydrates when encounters high pressure and low temperature conditions can cause blockage of flowlines. Preventing the formation of hydrates by injecting thermodynamic inhibitors is very costly. Recently there has been a growing interest in shifting hydrates prevention to more economic paradigm of hydrates risk management, which allows directly transport hydrates slurries while avoiding plugs in the pipelines. Understanding the hydrate-containing flow characteristics is important to efficiently manage and transport hydrate slurries. The latter can be achieved using CFD to simulate slurry flow and gather ample information on the multiphase system under various operation conditions. This study shows a CFD simulation of hydrates slurry flow in a three- dimensional pipeline using Eulerian-Eulerian multiphase model. Both RANS and LES approaches were used to capture the turbulence. A user defined function (UDF) of hydrates shear viscosity derived from a correlation of experimental data was developed and integrated into the software. The numerical results on pressure gradients at different inlet velocities and different hydrates volume fractions were compared with the experimental data. Very good agreements have been achieved. After the model validation, the distributions of hydrates velocity magnitude and hydrates volume fraction together with the hydrates velocity vectors were extracted from the simulations and presented through six different cross-sections of the pipeline. In addition, the effects of hydrate velocity and hydrate volume fractions on flow characteristics were explored. This study not only demonstrates the usability of Eulerian-Eulerian method for the simulation of hydrates slurry flow, but also provides valuable hydrate laden flow properties in pipelines that might help redesign them for better flow assurance.

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