Gas Hydrate Plugging Conceptual Mechanistic Model During Transient Shut-in/Restart Operation in Fully Dispersed Systems

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The rapid formation of gas hydrates is one of the primary issues that affects offshore oil and gas production. In most cases, the system condition during continuous steady-state production will be kept out of the hydrate equilibrium region. It is the scheduled extended as well as unplanned shut-ins and restarts of the production system that lead to gas hydrate blockage concerns. Over the past decade, hydrate predictive tools have been developed and coupled with a dynamic multiphase flow simulator based on a set of steady-state conceptual pictures that describe the physical phenomena of gas hydrate formation. However, the transient shut-in/restart operations are not yet included in the conceptual pictures for the fully-dispersed system. Since the produced crude oil typically forms an emulsion of water in oil, fully-dispersed transient conceptual pictures are essential for modeling hydrate slurry transportation. This work presents a series of conceptual pictures for the dispersed water-in-crude oil system undergoing cold restart. Direct observations and results from bottle tests, rheometer, micromechanical force apparatus, and rocking cell studies support the mechanisms outlined in the conceptual pictures. A yield stress model to determine the minimum differential pressure to restart the flow will also be presented. The model behaviors will be demonstrated to suggest which conditions can be safe or potentially lead to plugs during field restarts.