Study of Hydrate Formation Behavior in Shut-In and Restart Conditions

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Gas hydrates are crystalline structures formed by water and gas molecules at high pressure and/or low temperature. Hydrate plug formation is one of the most severe concerns in flow assurance for the oil and gas industry, especially in transient operation, such as shut-in and restart conditions. Many variables can influence the dynamics of hydrate formation in transient conditions, such as water cut, memory effect, viscosity of the oil phase, pressure, subcooling, emulsion stability, and shear/mixing at restart. This work is focused on studying the behavior of hydrate formation in transient conditions. Experiments are performed at constant pressure, in a high pressure cell coupled in a rheometer using a custom-designed impeller in order to quantify the hydrate slurry apparent viscosity associated with the hydrate fraction. A three-phase system is used in the experiments: mineral oil or crude oil as oil phase, deionized water as aqueous phase, and natural gas mixture as gas phase. The effect on hydrate formation and restart are studied with respect to antiagglomerants, rotational speed, and subcooling. It is observed that the increase of the rotational speed can break the hydrate particles, and a decrease in the rotational speed does not recover the hydrate particle size as before the increase in the rotational speed. In addition, the results show that the pressure and subcooling can influence the hydrate crystal morphology. These results contribute to understand and identify conditions for hydrate plug formation or flowable conditions for the restart.