

Rheological Perspective on Hydrate Agglomeration Tendency in Crude Oils at Different Thermodynamic Conditions

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Clathrate hydrates are non-stoichiometric inclusion compounds that form equilibrium structures based upon thermodynamic pressure and temperature conditions. Gas hydrates are composed of hydrogen bonded water cages with guest gas molecules (e.g., methane, ethane) contained within the structure. Generally, low temperature and high pressure are required to form hydrates in situ, with the most common equilibrium structure in the oil and gas industry being sII which can house larger gas molecules (e.g., propane) in its $5^{12}6^4$ cage network. The ability of crude oils to disperse hydrates formed during transportation is of foremost importance during design and implementation of oil treatment and transportation facilities. The dispersion tendency of oils is highly dependent on the thermodynamic conditions present in a certain oil/gas/water system. In this work, high pressure rheological slurry flow experiments were carried out to determine the sII hydrate dispersion behavior in a crude oil at different pressure and temperature conditions (subcoolings). The ability to keep shear rate as a controlled variable allows for in-depth analysis of crude oil/hydrate interactions from a non-Newtonian fluid mechanical perspective. It is thought that in an emulsified system, subcooling affects nucleation time, initial formation rate, and overall agglomeration rate due to annealing tendency of the hydrates at different conditions. Slurry viscosity vs. time data were analyzed to elucidate the impact of subcooling on the potential hydrate agglomeration mechanisms that play a role in the overall hydrate transportability profile of crude oils.