

Modeling Gas Hydrate Growth Kinetics in Water-in-Oil Emulsion for Offshore Petroleum Production Applications

BASSANI Carlos^{a,b*}, CAMEIRÃO Ana^a, MORALES Rigoberto^b, HERRI Jean-Michel^a

^aPEG/SPIN, École de Mines de Saint Etienne

158 cours Fauriel, CS 62362, F-42023, Saint Etienne, France

^bMultiphase Flow Research Center, Federal University of Technology - Paraná

Deputado Heitor Alencar Furtado 5000, Bloco N, CEP 81280-340, Curitiba, Brazil

Abstract

The high pressure and low temperature conditions commonly found in offshore oil & gas production scenarios (Fig.1a) favor the formation of gas hydrates, which may block the production pipeline causing several revenue losses. Gas hydrates are crystals formed by the imprisonment of gas molecules (e.g., light hydrocarbons) in a cage of hydrogen-bonded water molecules (Fig.1b). The multiphase flow inside the pipelines (composed by oil, gas, sand and water with salt) determines the interfacial surfaces between the phases (e.g., oil & gas, oil & water, Fig.1c), which by their turn are essential to predict the order of magnitude of each competing phenomena on the hydrate growth kinetics. The present study couples gas absorption by the bulk, gas diffusion and water permeability through the hydrate shell with the phenomena of particle core pressurization and crystal integration processes either in the inner and outer particle surface (Fig.1d) for predicting gas hydrate growth in water-in-oil emulsions. The model results in three ODE's for the inner and outer growth radius and for the bulk gas concentration. The initial size of the hydrate particles come from the radius of the water droplets, estimated via the turbulence vs. surface energy criterion of Hinze. Preliminary implementations show that the model captures the mass transfer limitation due to the hydrate shell growth, which is represented by the asymptotic trend of the amount of gas consumed over time (Fig.1e). Future work shall be done in order to couple the present model with pressure and temperature predictions over the production pipeline (from multiphase flow calculations), to measure the necessary closure parameters of the model (e.g., constant of proportionality of the crystal integration process, gas diffusion and absorption coefficients, etc.) and to validate the model against experimental data.

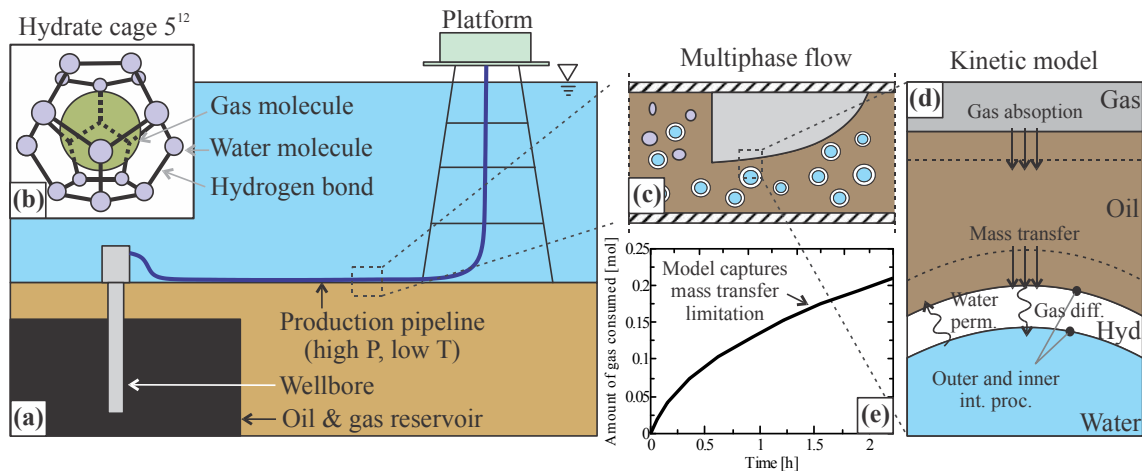


Figure 1. Graphical abstract. (a) Offshore oil & gas production pipeline. (b) Depiction of gas hydrate cage. (c) Multiphase flow determines interfacial surfaces between the phases. (d) Phenomena modeled in the present study for gas hydrate growth kinetics. (e) The model captures mass transfer limitation due to the hydrate shell growth (asymptotic trend in the gas consumption during hydrate formation).

* Corresponding author : carlos.lange-bassani@emse.fr