

Supporting Information

for

Gas Hydrates Sloughing as Observed and Quantified from Multiphase Flow Conditions

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1. Procedure for Porosity Calculations

The porosity of hydrates reported in this thesis is defined as the void volume fraction of the apparent total volume of hydrates. Based on this definition the hydrate porosity ($\varepsilon_{hydrate}$) could be estimated from the volume of hydrate phase present in the system ($V_{hydrate}$), which was calculated according to the procedures presented in our previous paper¹, and the apparent total volume of hydrate (V_{total}), which was estimated from visual observation:

$$\varepsilon_{hydrate} = 1 - \frac{V_{hydrate}}{V_{total}} \quad (3.1)$$

The apparent total volume of the hydrate deposits at the upper surface and bedded hydrates in the bulk was estimated based on images captured from the video recordings and known dimensions of the cell and cell windows. A program was developed using the software MATLAB[®] ² to calculate the apparent total volume of hydrate (V_{total}). The program first calculated the 2D area covered with hydrates viewed in the window of the cell. (Figure S1) and extrapolated the extent of the hydrates to the whole of the cell following the 3D cylindrical shape of the cell.

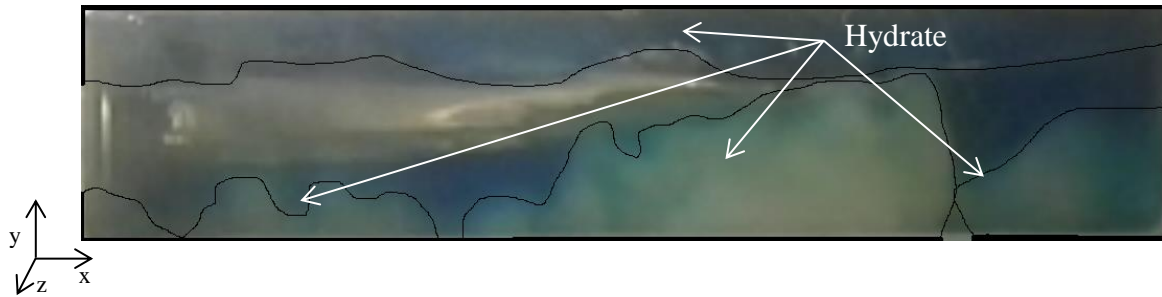


Figure S1. Image captured from the video recorded from an experiment.

There will be uncertainties in the calculations of hydrate volume in the part of the cell that is not monitored through the window. Considering deposit extending to the full length of the cell as maximum volume and deposit only covering the part of the cell cooled by the cooling of the upper wall, a simplified geometry, demonstrated in Figure S2, was developed for the volume calculations. The maximum hydrate volume and porosity can be calculated assuming the extent of the deposit is 285 mm, and the minimum hydrate volume and porosity can be calculated assuming the extent of the deposit is 175 mm.

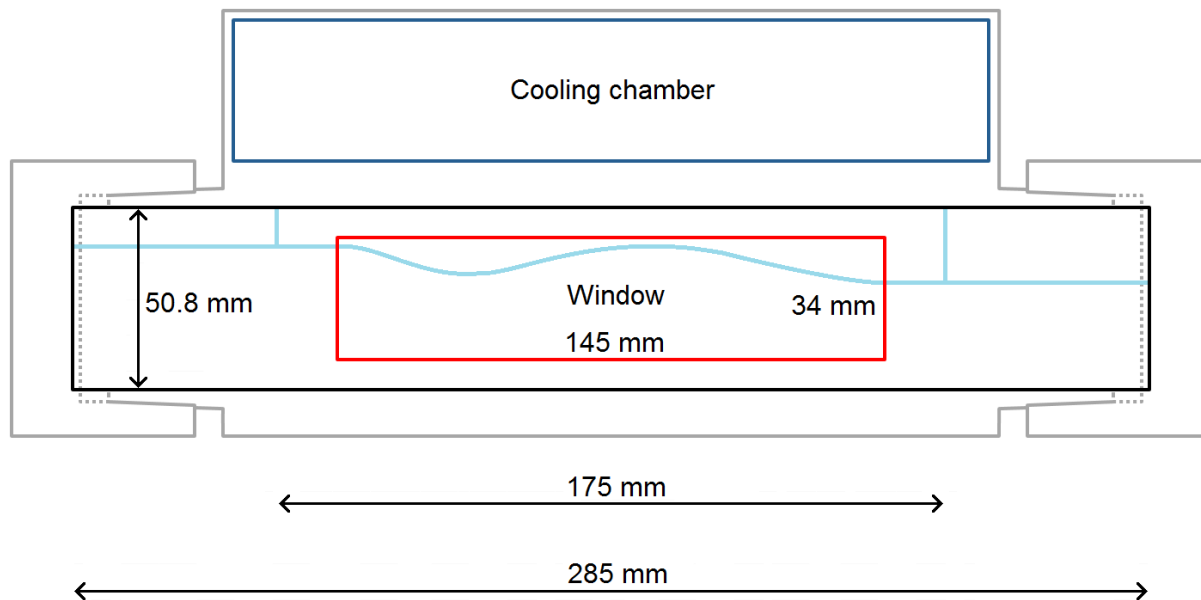


Figure S2. Simplified geometry with maximum and minimum extent of hydrates (light blue lines) extrapolated from the window (red rectangle).

2. Edited videos from the experiments

A video is available to demonstrate the hydrate sloughing phenomena. The video is composed of short snippets showing the dynamics of the sloughing phenomena observed in experiments with gas mixture, 70% liquid loading, 60% water cut, and the three tested oil compositions.

References

- (1) Straume, E. O.; Kakitani, C.; Merino-Garcia, D.; Morales, R. E. M., and Sum, A. K. Experimental Study of the Formation and Deposition of Gas Hydrates in Non-Emulsifying Oil and Condensate Systems. *Chemical Engineering Science* 2016, 155, 111-126.
- (2) MathWorks. (2009, February 12). MATLAB Version 7.8.0.347 (R2009a). Natick, MA, USA: The MathWorks Inc.