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CRYSTALLIZATION OF METHANE HYDRATES FROM AN EMULSION IN A FLOWLOOP: EXPERIMENTS IN A GAS-LIQUID-LIQUID SYSTEM WITH A GAS-LIFT

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1. Introduction
- Offshore systems operate at low temperature and high pressure which favor conditions for gas hydrate formation and agglomeration.
- Gas hydrate is a serious issue in flow assurance; it may cause many troubles, especially, plugging in oil and gas pipelines.
- The previous work (Melchuna 2016, [1]) allowed to construct a preliminary model of understanding of the crystallization under flow.

![Diagram of subsea pipelines](image)

Figure 1 – Subsea pipelines [6].

2. Objective
- Science: understand the mechanisms of methane hydrate crystallization, agglomeration together with slurry transport and deposition in oil and gas pipelines at high water cut with a gas-lift.
- Industry: understand the properties and role of commercial additives (anti-agglomerants - AA-LDHs) in dispersing hydrate particles to prevent plugging in offshore pipelines.

3. Materials and Methods
 Experimental procedure and apparatus
- Emulsions formed by water (with and without salt) and oil (Kerdane®) are charged into the flow loop with and without anti-agglomerants (AA-LDHs).
- The system is cooled down until 4-5°C and pressurized up to 75 bar by the injection of methane for gas hydrate formation, agglomeration and deposition study.
- Flowrate: 150-400 L/h; water volume fraction (80-100%); dosage of AA-LDH: 0; 0.01; 0.05; 0.1; and 2.0% salt: 0 and 30g per liter of water.
- Probes used: Particle Video Microscope (PVM, [4]); Focus Beam Reflectance Measurement (FBRM, [5]); Attenuated Total Reflection (ATR, [7]); pressure drop, flowrate and density measurement.

![Diagram of FBRM and ATR probes](image)

Figure 2 – Topological model of crystallization under flow [1].

![Diagram of flowloop photos and schemas](image)

Figure 3 – Archimede flowloop photos and schemas [1-2-3].

4. Experimental Results

![Graph of temperature, flowrate, and density](image)

Figure 4 – Typical temperature (T7), flowrate and density profile during a crystallization experiment for mixture of 80%WC at 400L/h and 85%LV.

![Graph of pressure drop and gas-lift](image)

Figure 5 – Typical pressure drop (in horizontal line), pressure drop in the separator (PD4) and pressure profile during a crystallization experiment for mixture of 80%WC at 400L/h and 85%LV.

![Graph of FBRM chord counts](image)

Figure 7 – FBRM chord counts as function of hydrate volume for experiment of 80%WC at 400L/h and 85%LV.

5. Conclusions & Perspectives
The FBRM probe enables to monitor the crystallization by following the size of droplets, particles and agglomerates with chord length distribution measurements during time.

Different morphologies of hydrate particles during crystallization were observed with PVM.

Hydrate deposition on the pipe wall was observed with the FBRM, the PVM and the density measurements.

Future work will be modelling of gas hydrate formation, agglomeration, deposition and plugging combined with flow pattern.

6. References