Développement d'une interface de traitement des données pour un procédé de cristallisation en écoulement

Parties prenantes

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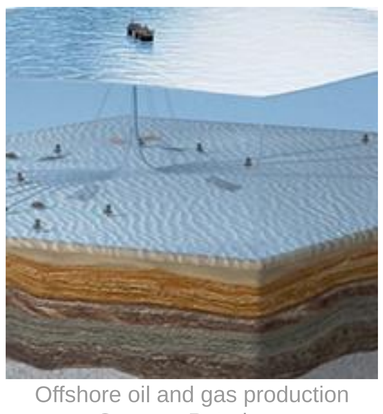
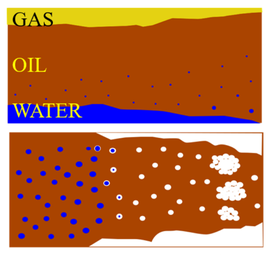


Offshore oil and gas production
Source : Petrobras



Multiphase flow with and without crystalization
Source : Authors

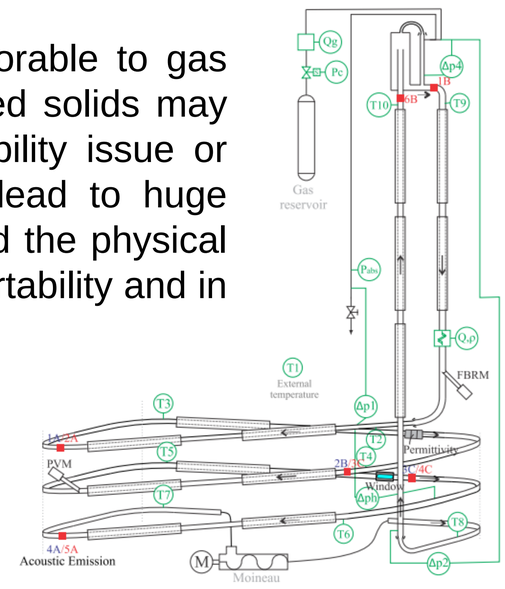
Industrial Context

Multiphase flow in oil & gas production

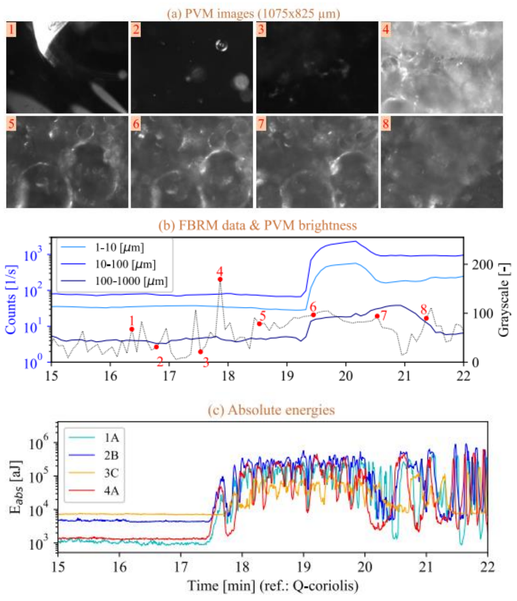
► **Operational conditions** Crude oil, sea water and natural gas flowing together into the production facilities under medium to high pressures (> 35 bar) and low temperatures (~ 4 °C).

► **Flow assurance** The thermodynamic condition is favorable to gas hydrates and wax crystals nucleation. Those nucleated solids may grow, agglomerate and deposit, causing a transportability issue or even completely blocking the pipeline, which may lead to huge financial losses. Therefore, it is important to understand the physical and chemical aspects that might interfere in the transportability and in the plugging mechanism.

► **Pilot scale flow-loop** Archimedes flow-loop is a 56 meter long flow loop with vertical section (20 meters long and 15.7 mm of inner diameter) and a horizontal (slightly downward) section (36 meters long and 10.2 inner diameter).



Archimedes flow-loop
Source : Almeida 2020



Cross data analysis
Source : Almeida 2020

Multi-instrument pilot scale flow-loop

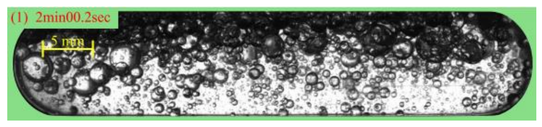
Crystallization under flowing conditions

► **Multi-instrument data measurement** Currently, there are 127 measurements in the system.

► **Data acquisition** Data acquired from different software in different computers are gathered in a unified data processing app.

Sensor	Information	Interpretation
Coriolis	Flowrate and density	The flow rate and the density, correlated with pressure drop and other signals might give some information whether the particles are suspended in the bulk phase or they've deposited in the pipeline. Also, it is essential to determinate the flow regime.
Differential Pressure probes	Pressure drop	Indicates the transition from a single-phase flow (liquid) to a multiphase flow (solid + liquid). Also, important input to calculate the viscosity.
Temperature probes	Temperature	It's an important parameter to check both the paraffin crystallization (WAT) and the paraffin deposition (thermal insulation).
FBRM	Chords counts and chords lengths	It helps to detect the presence of crystals as well as their sizes. Also, it gives information about how the sizes changes overtime.
PVM	Images	It helps to identify the size of crystals and droplets in the bulk. Also, the image's brightness is correlated to amount of crystals formed.
Permittivity probe	Permitivitty at the wall	Along with different sensors, as he high-speed camera and the Coriolis it helps to detect the flow pattern and the continuous phase.
Acoustic emission	Absolute energy	It is a very precise detection of hydrates particles.
High-speed camera	Images	It helps identifying the presence of solid particles and the flow pattern. In addition, it gives information whether the emulsion is stable or shear stabilized.

Sensors and its measurements
Source: Authors



High-speed camere image for a test with 80 % water-cut and AA.
Source : Almeida 2020

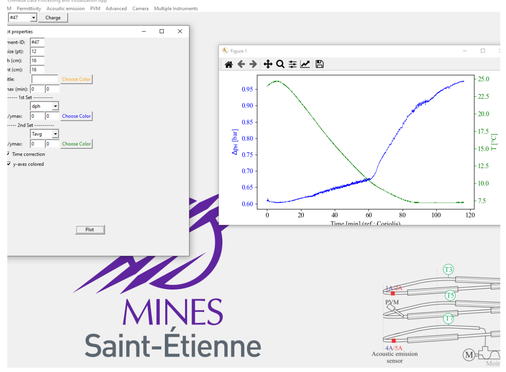
Experimental data and its analysis

Unified data processing app

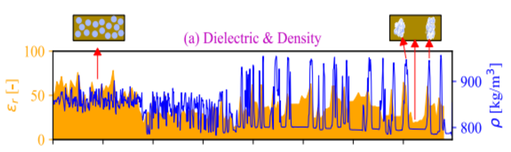
► **Data treatment** A app was in-house developed, using Python language, specifically for the Archimedes flow loop in order to gather all the experimental data in the same interface and synchronize in relation to the main acquisition system.

► **Data analysis** It allows to conduct a joint analysis considering the chemical and hydrodynamical information from each experiment and also comparing among different experiments within the app.

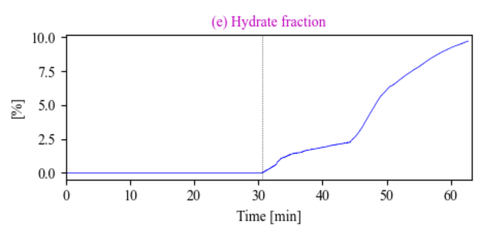
► **Hydrate modeling** Beyond the experimental information, the app contains a hydrate fraction calculation procedure built in based on some measured variables.



Visual interface
Source : Almeida 2020



Dielectric measurement compared with density
Source : Almeida 2020



Hydrate fraction over time
Source: Authors

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