Kinetic modelling of methane hydrate formation and agglomeration with and without anti-agglomerants from emulsion in pipelines

Trung-Kien Pham, Aline Melchuna, Ana Cameirao, Jean-Michel Herri, Pierre Duchet-Suchaux, Philippe Glenat

Kinetic modelling of methane hydrate formation and agglomeration with and without anti-agglomerants from emulsion in pipelines

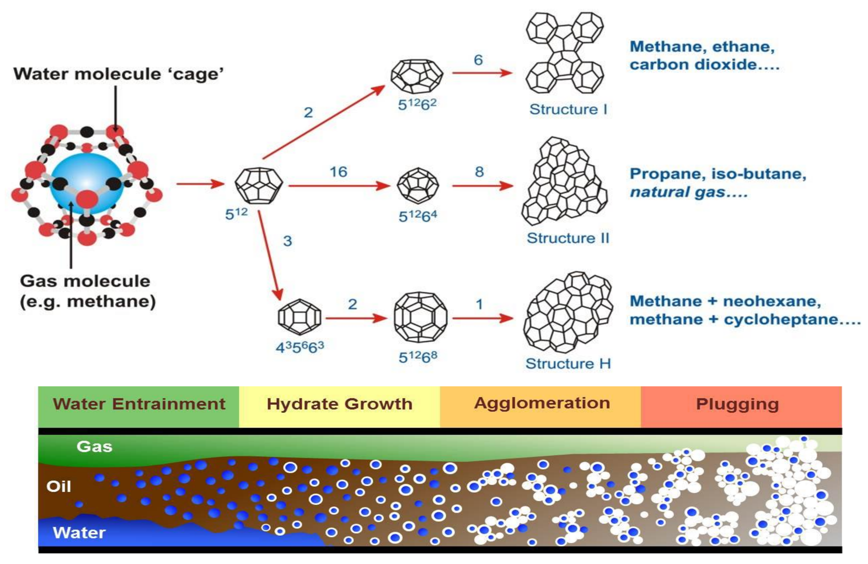
Trung-Kien PHAM*[a,d], Aline MELCHUNA[a], Ana CAMEIRAO[a], Jean-Michel HERRI[a], Pierre Duchet-SUCHAUX[c], Philippe GLENAT[b]

[a]Gas Hydrate Dynamics Centre, Ecole Nationale Supérieure des Mines de Saint-Etienne, 158 Cours Fauriel, Saint-Etienne 42023, France
[b]TOTAL S.A., CSTJF, Avenue Larribau, Pau Cédex 64018, France
[c]TOTAL S.A., 2 place Jean Millier La Défense, 6 92400 Courbevoie, France
[d]Hanoi University of Mining and Geology, Duc Thang - Tu Liem - Ha Noi, Vietnam

(*) kien.pham-trung@emse.fr

Introduction

- Offshore systems mainly containing crude oil, natural gas and water operate at low temperature and high pressure which favour 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 pipeline.

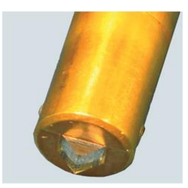


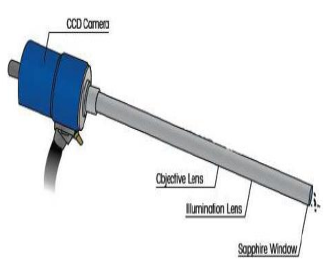
Objective

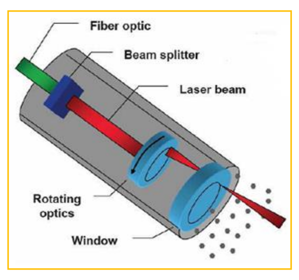
- Intend to develop a kinetic model to predict gas hydrate formation, agglomeration and plugging in flowlines based on the experimental data obtained from Archimede Flowloop from the work of Mendes-Melchuna (2015).
- A preliminary study of the emulsion formation and behaviour will contribute to a better understanding of the hydrates formation and agglomeration.

Experimental Method

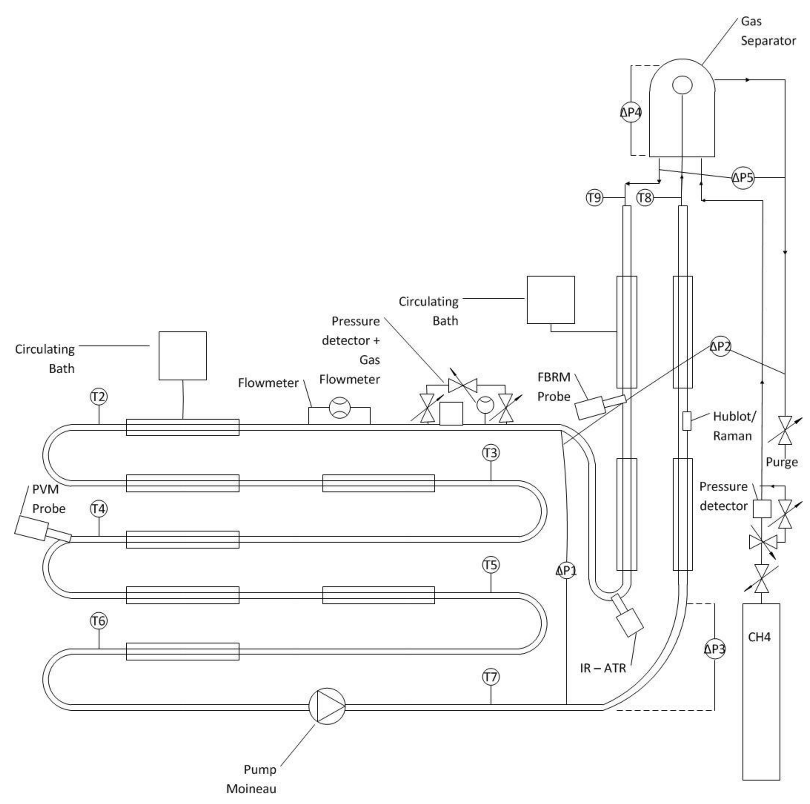
- Emulsions formed by water and oil (Kerdane®) are charged into flow loop with and without anti- agglomerants (AAs-LDHI) to study rheology.
- The system is cooled down 4-5°C and pressed up to 80 bar by the injection of methane for gas hydrate formation and agglomeration study.
- Probes used: Particle Video Microscope (PVM), Focus Beam Reflectance Measurement (FBRM) and Attenuated Total Reflection – Infrared (ATR-FTIR)







Experimental Apparatus (Archimede Flowloop)



Mean Droplet Size Model

Schema for Developing Mean Droplet Size Model

Develop mean droplet size model (d_p) from model of Turner (2009) and Boxall (2011)

↓

Experimental data: velocity (v), dispersed phase cut (dpc), viscosity of continuous phase (μ), interfacial tension between oil and water (σ)

↓

$d_p = A*(v)^B*(dpc)^C*(\mu)^D*(\sigma)^E$

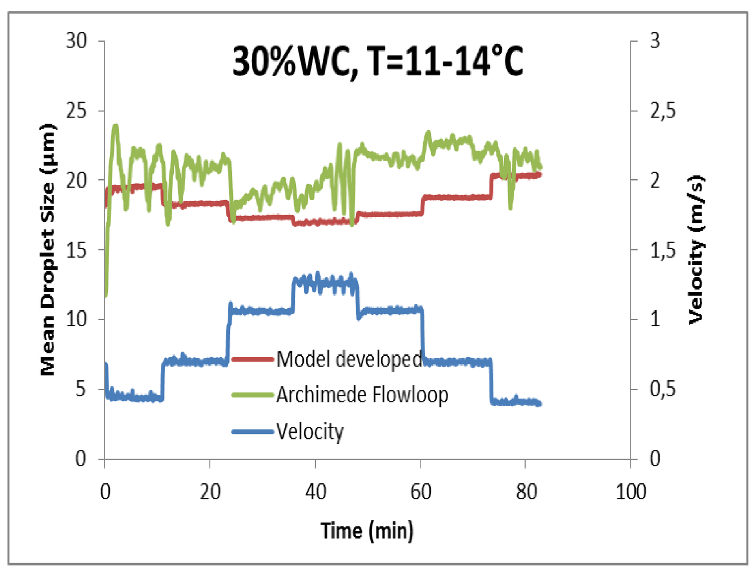
↓

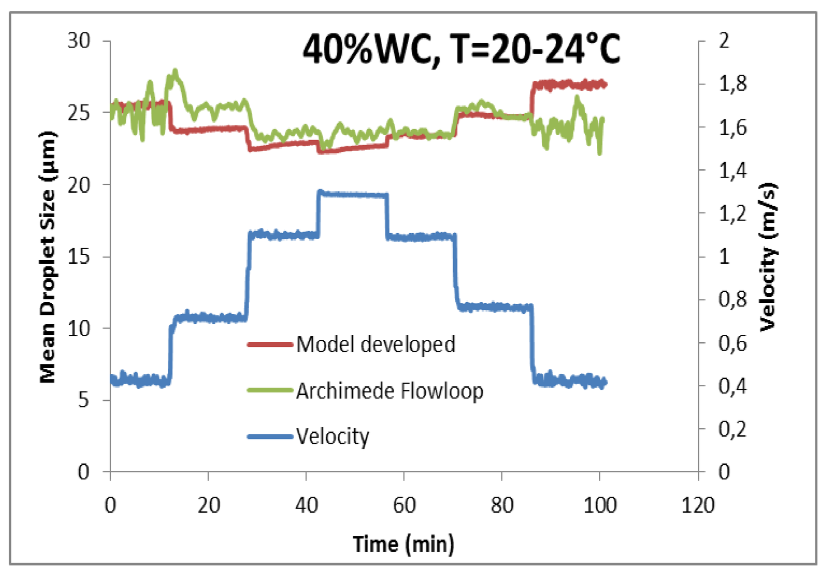
Regressed d_p (A, B, C, D, E) from Archimede Flowloop experimental data

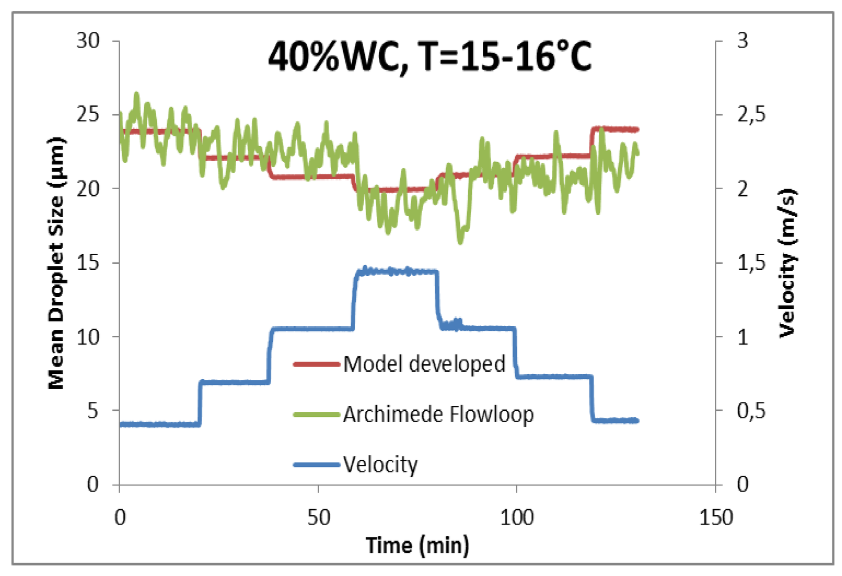
↓

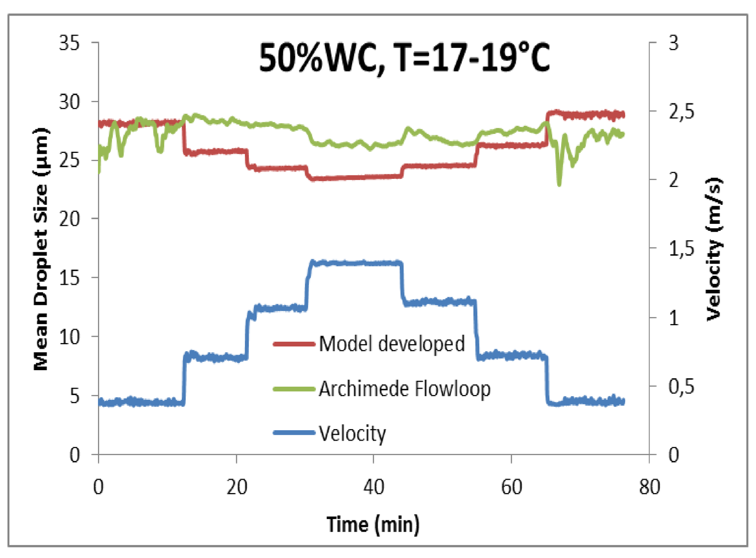
$d_p = (100/6)*(v)^{-0.15}*(dpc)^{0.526}*(\mu)^{-0.5}*(\sigma)^{3/5}$

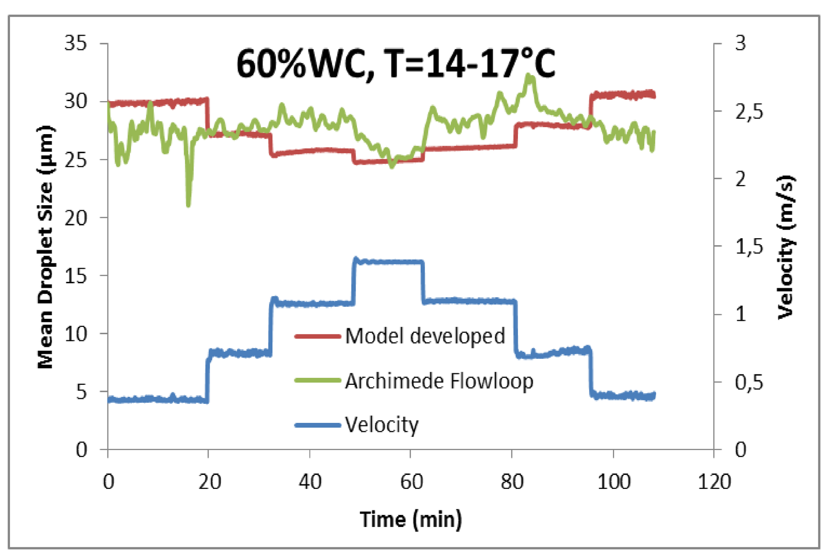
Initial results for mean droplet size model developed from Archimede Flowloop data

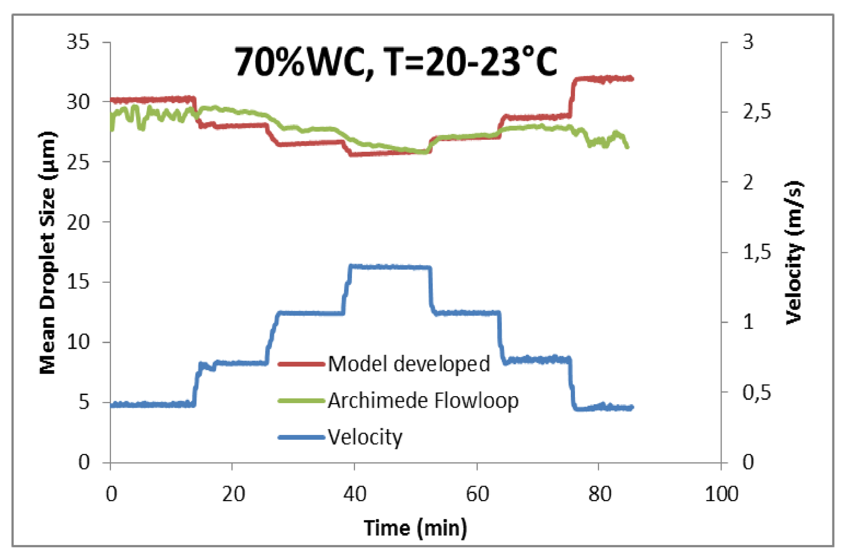


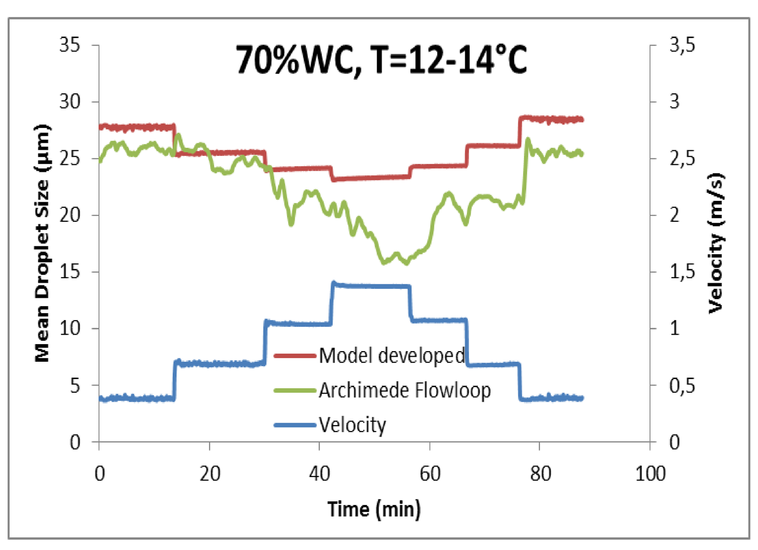


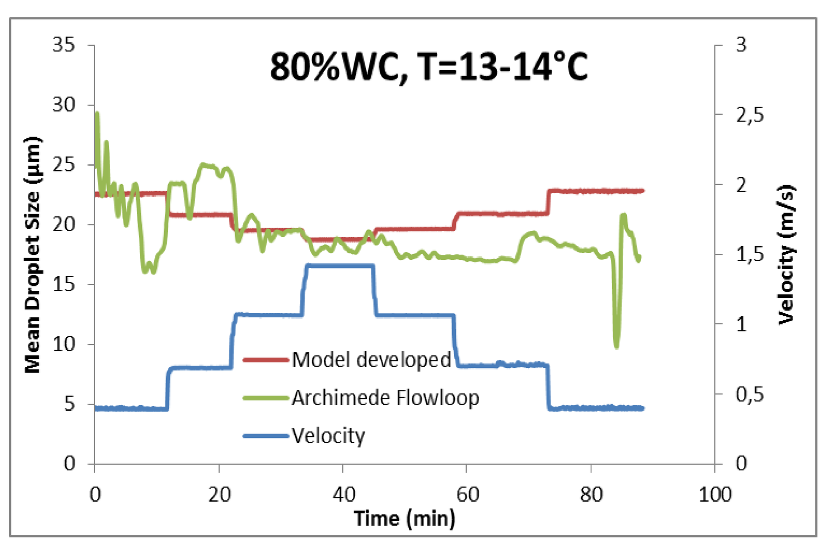


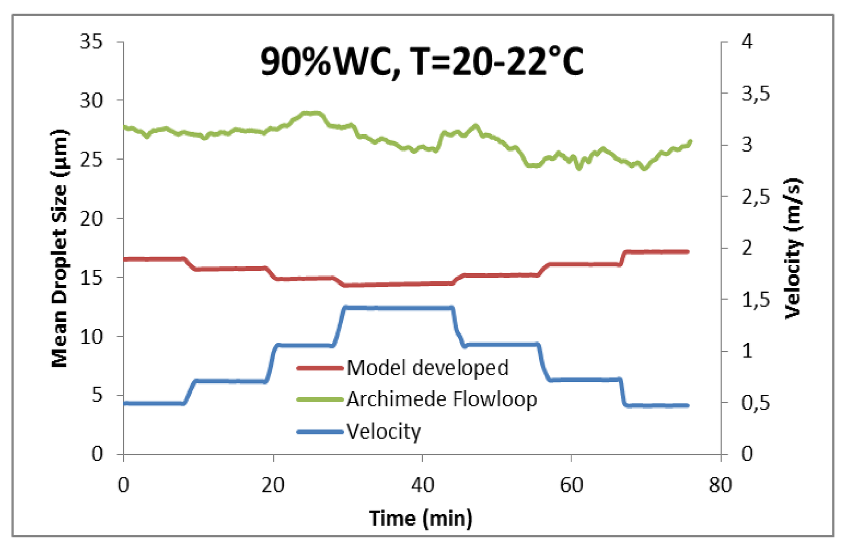












Conclusions & Perspectives

- Mean droplet size of emulsion is a key factor for kinetics of gas hydrate formation and agglomeration in oil and gas pipelines.
- This mean droplet diameter model will be further studied to better match with higher water cut and in the presence of AAs-LDHI using dimensionless parameters (Reynolds and Weber numbers).
- Future work will focus on developing model of gas hydrate formation and agglomeration in flowlines.

References:

Aline MELCHUNA, Ana CAMEIRAO, Jean-Michel HERRI, 2015, Topological modeling of methane hydrate crystallization from an emulsion with small to very high water cut, Fluid Phase Equilibria (submitted)
Anklam, M.R., York, J.D., Helmerich, L., Firoozabadi, A., 2008, Effects of antiagglomerants on the interactions between hydrate particles. AIChE Journal
Camargo, R., Palermo, T., 2002, Rheological properties of hydrate suspensions in an asphaltenic crude oil. In: Proceedings of the 4th International Conference of Gas Hydrates, Yokohama, Japan, pp. 880–885.
D.J. Turner, K.T. Miller, E.D. Sloan, 2009, Direct conversion of water droplets to methane hydrate in crude oil, Chemical Engineering Science, Volume 64, Issue 23, Pages 5066-5072
John A. Boxall,Carolyn A. Koh,E. Dendy Sloan, Amadeu K. Sum, and David T. Wu, 2012, Droplet Size Scaling of Water-in-Oil Emulsions under Turbulent Flow, Langmuir, 28, 104–110
Luis E. Zerpa, E. Dendy Sloan, Amadeu K. Sum, Carolyn A. Koh, 2012, Overview of CSMHyK: A transient hydrate formation model. Journal of Petroleum Science and Engineering, Volumes 98–99, Pages 122-129

Acknowledgment