FACTS

SINTEF Petroleum Research

Hydrate slurry fundamentals

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Hydrate slurry technology development and transport fundamentals

SINTEF has more than two decades of experience with gas hydrates in flowing systems, in particular with gas hydrate slurries, as e.g. in the efforts (with various industrial partners) on the "SATURN Cold Flow" technology since the turn of the century.

Our understanding of the phenomena involved in these processes has evolved steadily from the start, and we have recently presented our own "state-of-the-art" in Lund et. al*, which also serves as the basis for a number of new approaches to further study and technology development.

This allow us to develop tools and understanding for better resource use, more efficient problem-solving, and more environmentally friendly oil and gas production.

Burning gas hydrates.

*Lund, A., Hjarbo, K.W., Wolden, M., Høiland, S., Skjetne, P., Straume, E.O., and Larsen, R.:
Cold Flow – towards a fundamental understanding, OFCS 2010, Geilo, Norway, March 14-17, 2010

Hydrate slurry fundamentals

Fundamental flow loop experiments is an activity with detailed studies of hydrate particle slurries in a realistic high-pressure flowing system.

Fundamental particle studies will be performed with advanced techniques for microscopic study of individual particles, e.g. micro-mechanical force measurements (MMF).

Hydrate slurry melting is an issue for both transport and processing of slurries, and shall be studied under both stagnant and flowing conditions.

Hydrate slurry crystal growth is important to understand and control in order to achieve optimal results for slurry systems.

Hydrate slurry separation is a technique which may be important both subsea and for topsides processing. Water in solid (hydrate) form may be easier to separate out than reversing the hydrate formation process by melting back to the "original" composition.

Wettability in relation to hydrate slurry behaviour is an experimental study to develop an understanding of how hydrate plugging tendency and slurry behaviour is affected by hydrate wettability and plugging index.

Gas drying by gas hydrates – HyDry, is a powerful, new subsea or topsides adaptation of SINTEFs Cold Flow technology, where gas hydrates are used to dry a produced gas stream to allow problem-free transport, without slurry transport issues. Patent pending.

Modeling of hydrate slurry fundamentals is going to be an important tool for all who encounter hydrate slurries, whether as a problem or as a transport philosophy.

Our connected matrix of experimental investigations and state-of-the-art equipment will ensure the best possible data for this modeling.

General "Cold Flow" investigations of technologies, ideas, and implementations from other sources (oil and gas companies, engineering companies, other research institutions, universities, etc.) can be carried out for independent verification and additional data gathering purposes in our state-of-the-art realistic flow equipment (cell, flow wheels, flow loops), and interpreted from a comprehensive viewpoint and not just as single points of technology.

Activity	**Duration** (months)	**Deliverables**	**Approx. cost**
Fundamental flow loop experiments	12+	Data for modeling	kUSD 300
Fundamental particle studies	12+	Data, basic understanding	kUSD 300
Hydrate slurry melting	9	Data, modeling, operating procedures	kUSD 150
Hydrate slurry crystal growth	12	Data, models	kUSD 150
Hydrate slurry separation	9	Operating procedures	kUSD 150 to 300
Wettability in relation to hydrate slurry behaviour	12+	Data, basic understanding	JIP - Ticket cost: kUSD 200+
Gas drying by gas hydrates - HyDry	9	Proof of concept	kUSD 400
Modeling of hydrate slurry fundamentals	12	Modeling tools	kUSD 150
General "Cold Flow" investigations	12+	Independent verification of technologies	TBD

Several of these activities may be run in parallel.

Our facilities

- An explosion proof laboratory where HSE is top priority, enabling experiments on real crude oils and natural gas at real conditions (high pressure, full temperature-control).
- A 50 m long temperature-controlled 1" real crude loop with max pressure 100 bar.
- Temperature-controlled real crude wheel flow simulators with pressure up till 1000 bar.
- An oil chemistry laboratory.

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