New depths of knowledge

Dr Martin Smedstad Foss explains how a long-term collaborative project between scientists and industry in Norway is aiming to assuage concerns over flow assurance within the petroleum industry

Firstly, could you explain the Multiphase Flow Assurance Centre (FACE) and what it sets out to achieve?

FACE is a collaborative research project and network between the Institute for Energy Technology (IFE), SINTEF and the Natural Science University (NTNU) on one side, and the Research Council of Norway and six industry partners (Statoil, Shell, FMCtechnologies, GE Oil & Gas, CD-adapco and SPTgroup) on the other. The goal is to develop next generation multiphase flow models and laboratory data by combining fluid mechanics and colloid (surface) chemistry.

From where did the idea to bring together IFE, SINTEF and NTNU stem? How do the specialities of each institution differ?

The idea stems from the need to combine the strengths of the Norwegian Flow Assurance cluster which is behind ~90 per cent of the software market in multiphase flow modelling. We aim to do this through the software codes OLGA and LEDAFLow.

Multiphase modelling in the shape of OLGA was invented at IFE in 1980 and developed in collaboration with SINTEF from 1984-93. Thereafter, the development was done in collaboration between IFE and SPTgroup. In 2011 SINTEF launched the competing code LEDAFLow. The software development was closely followed by the oil companies present on the Norwegian continental shelf and the results were directly applied in large field developments. The OLGA tool is today the de facto industry standard.

What are complex fluids and what broad challenges do they pose to industry?

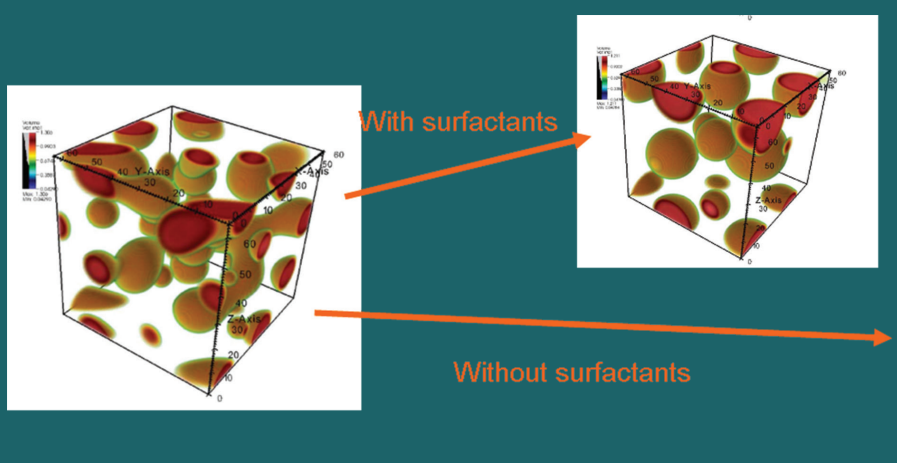
Complex fluids, as defined in FACE, are fluids that may undergo large compositional changes during pipe transport. The changes are largely caused by reduced temperatures and pressures which may result in formation of crystals such as waxes or hydrates, or the precipitation of various components of the crude oil, such as asphalthenes. In FACE we have a particular focus on the presence of surfactants. These are made up of a multitude of large molecules that have affinity to both oil and water, much like ordinary soap. This dual affinity means that the molecules tend to sit on the interface between oil and water and in this way they may stabilise the oil-water mixture (emulsion), which may have a severe impact on both pipe transport and subsequent separation of oil and water. To put it bluntly, we are trying to avoid generating 'mayonnaise' in our pipelines.

One core aspect of FACE is the development of generic methods to describe complex fluid systems in models that can be incorporated into scalable and robust multiphase flow assurance tools. Why is this needed and how will it benefit industry?

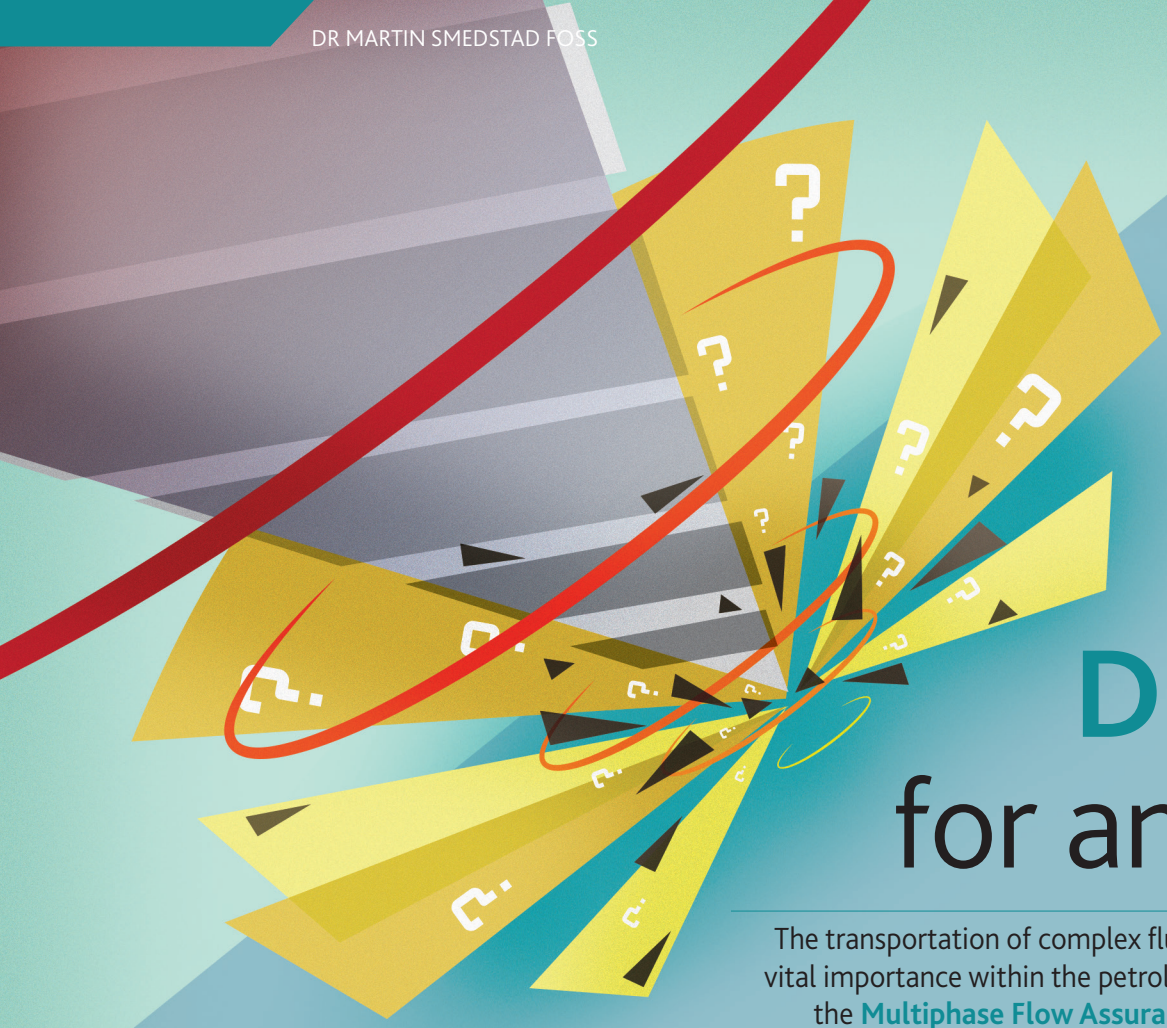
One of the major challenges the industry has is that most of the models developed were tested against small-scale laboratory experiments with limited similarity to real crude oil systems. The consequence was that models had limited credibility until tuned to real production systems because they did not scale well. One of the products of our research is a new model fluid system that mimics the behaviour of a given crude oil. This greatly increases the applicability of small-scale experiments and will hopefully help close the gap between academic research and industrial needs.

FACE has also focused on three further subprojects: Suspensions, Multiphase Transport and Separation. Could you summarise what each sets out to address and the progress that has been made?

To a large degree, all the subprojects were focused on improving available laboratory data through the use of more realistic model fluids. The Suspensions project was aimed at improving our modelling of particle transport in liquids; we developed a new model for interaction of particles and fluid. The Multiphase Transport project is focused on transport of liquids in pipes and has a particular focus on more viscous oils, as this was identified as a gap in the technology. The Separation project is focused on research towards a new approach to modelling the separation process of oil and water. Additionally, all of the subprojects have a goal of contributing to the education of candidates in the industry. In total, FACE will produce 16 PhDs and postdoctoral researchers in the period 2007-14.



The images show how a model developed in FACE simulates the effect of surfactant on the stability and coalescence of emulsions. The presence of surfactant on the interface stabilises the emulsion and hinders coalescence.



Drilling for answers

The transportation of complex fluids such as crude oil is of vital importance within the petroleum industry. In Norway, the **Multiphase Flow Assurance Innovation Centre** is working to better prevent flow assurance problems

THE TRANSPORT OF complex well fluids from oil fields can be a precarious business. Decreases in temperature and pressure within the pipes can lead to compositional changes in these fluids, which can cause major problems. Until now, research in this area has been based on small-scale laboratory experiments that do not translate well to real systems. Furthermore, simulations of multiphase transportation of oil and gas have only been well validated for gas condensate and light oil/gas systems. This is partly due to a lack of data and partly due to the challenges of modelling complex fluid systems. The petroleum industry urgently needs more studies to acquire data, and develop and test new, more accurate models for the description of viscous gas-oil-water systems. This will facilitate the creation and implementation of new production solutions for oil fields with complex well fluids.

COLLABORATING ON COMPLEX FLUIDS

In Norway, scientists and industrial partners have teamed up to address this demand. The Multiphase Flow Assurance Centre (FACE) is a long-term collaboration between three academic partners – the Institute for Energy Technology (IFE), SINTEF and the Norwegian Technical and Natural Science University (NTNU) – together with six partners from the petroleum industry and the Research Council of Norway. Industry support is provided by Statoil, Shell Technology Norway, SPTgroup (a Schlumberger company), CD-adapco, FMCtechnologies and GE Oil&Gas.

FACE is a Centre for Research-based Innovation (CRI) and is developing models and other tools that can be used to help understand, predict and prevent a range of flow assurance problems. The overall goal of the Centre is to develop generic methods to describe complex fluid systems within tools that can be incorporated into scalable and robust multiphase flow assurance models, which will be invaluable to the petroleum industry. Centre Manager Dr Martin Smedstad Foss explains: "The advantage of this collaborative initiative is that we are merging the resources of a small nation to meet future needs. In particular, public funding has been scarce for petroleum research, which has resulted in fierce competition among research groups. FACE provides a neutral playing field for research on common challenges".

SUSPENSIONS, SEPARATION AND TRANSPORT

Within the centre, the FACE Academy carries out basic research in areas such as crude oil characterisation, rheology, the development of reference fluids, emulsion modelling and multiphase flow. Most recently, focus has centred around three subprojects: Suspensions, Separation and Multiphase Transport.

The Suspensions project aimed to improve the prediction of particle transport and understand the effect that the presence of particles has in the oil and water phases in pipelines. In this regard, the team has carried out experiments and modelling activities with particle properties similar to those of sand in oil pipelines. The main objective was to significantly improve understanding of particle transport in pipelines and its effects on the carrier phase; the models produced as a result of the project have been applied directly in industrial settings.

The purpose of the Separation project was to reveal and establish a fundamental understanding of basic mechanisms and phenomena governing multiphase separation,

Tech corner

The host institutions IFE and SINTEF have a broad range of instrumentation available to FACE researchers, including:

- Broad beam gamma densitometer
- Traversing gamma densitometer
- X-ray tomography system with high-time resolution, available for instantaneous measurement of cross sectional fluid distribution in two- and three-phase flows
- Conductance probes for detecting whether the pipe wall is oil- or water-wetted
- Combined particle image velocimetry and laser induced fluorescence to enable measurement of velocity profiles in the liquids

including phase dispersion processes. The project focused on developing a description and basic understanding of the multiphase system in pipelines and separation equipment, with an emphasis on complex fluids that are difficult to separate, such as heavy crude. This new basic understanding will be used to improve existing – and develop new – separation processes. The Separation project also dealt with the benchmarking of measurement techniques for all the projects, with the final objective to qualify and develop techniques that would be used in experimental activities within the other projects.

In terms of the Multiphase Transport project, the group has carried out experiments and modelling to better understand multiphase transport processes of viscous oils and the underlying micro/meso-scale phenomena that influence macro-scale flow assurance problems. This included areas such as the dispersion of gas bubbles and water drops into viscous oil, the influence of viscosity and surfactants on flow patterns, and the formation and stability of emulsions and other dispersed flows. The experiments and modelling efforts will result in better understanding of phase distribution, and pressure drop and flow regime transitions in gas/liquid flow with viscous oil. FACE is currently gathering large amounts of more relevant laboratory data for use in tuning and validating multiphase flow models.

REFERENCE FLUIDS AND INSTRUMENTATION

In contrast to previous studies, FACE has successfully produced a realistic model oil for experimental use. The Centre's reference fluids have the same dynamic and equilibrium interfacial tension, as well as the same stability as crude oil emulsions. The initiative has also been able to successfully mimic pressure drop and emulsion properties. Moreover, the FACE reference fluids can be tailor-made; a field-specific fluid can be created from a small well sample and used throughout the field design process. This means that realistic experiments can now be conducted in university laboratories, where previously the only alternative was the use of real fluids in specialised certified flow facilities, which are few in number and notoriously expensive to operate.

ACADEMIC RESEARCH AND APPLICATIONS BEYOND NORWAY

As a CRI, FACE's combination of high-level academic research and innovative technological applications is key. The Centre's success has been demonstrated through its doctoral degree programmes, scientific publications, papers in recognised international conferences and attraction of outstanding researchers.

Furthermore, as well as strengthening the link between basic and applied research, the FACE Academy is supporting the development of the next generation of complex well oil fluid researchers: "In particular, a large emphasis has been placed on aggregating two branches of science – fluid mechanics and colloid chemistry – that do not normally join forces," Foss enthuses. The FACE Academy has established a new university course on rheology as a consequence of the research being conducted at the centre.

Finally, FACE's reach extends well beyond Norway. Foss adds: "As the history of the multiphase flow modelling software OLGA shows, technology developed in Norway does not know any borders and is applied in all corners of the petroleum world. One of the FACE partners, SPTgroup, owns and develops the OLGA code and this means that there is a short path from research to market".

INTELLIGENCE

FACE

MULTIPHASE FLOW ASSURANCE CENTRE

OBJECTIVES

To deliver world-class applied and fundamental research and education focused on production, transportation and separation of complex well fluids.

KEY COLLABORATORS

University of Oslo, Norway

University of Toulouse, France

City University of New York, USA

Newcastle University, UK

FUNDING

SINTEF, Norway

Institute for Energy Technology (IFE), Norway

Norwegian University of Science and Technology (NTNU)

Research Council of Norway

Statoil, Norway

Shell Technology Norway

CD-adapco, Norway

SPTgroup (a Schlumberger company)

FMCtechnologies

GE Oil&Gas

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