FACE
Annual Status Report 2009

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Executive Summary

The report covers the period January-December 2009. The FACE centre is a Centre for Research driven Innovation (CRI), a collaboration between the research partners NTNU, SINTEF and IFE.

The funding partners in 2009 have been: The Norwegian Research Council, Statoil ASA, ConocoPhillips Scandinavia A/S, Vetco Gray Scandinavia AS, SPT Group AS, FMC, CD-adapco, Shell Technology Norway AS.

The scientific work in the centre has had a good progress leading to many good results. The work has formed a basis for the work in the next three year period 2010-2012. Plans for that next three year period have been drafted and will be finalized and approved after a new iteration in 2010.

The international cooperation in FACE was strengthened, particularly by introducing two international experts in the FACE Reference Group.

In this document, we describe quite briefly the main purpose of the centre, some headlines of the scientific work and some aspects of how the centre is working internally and towards the outside. For a more detailed progress reports, we refer to proceedings of our FACE workshops, and to the bi-annual progress reports. For more details on the scientific plans, we refer to the current document on the 2010-2012 FACE plans.

Funding was transferred from 2007 and 2008 as described in the annual report for 2008. The delayed work was performed in 2009, and the centre is then on the original track.

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1 Introduction

This is the annual report to the Norwegian Research Council for FACE (Flow Assurance Centre). The report covers 2009, i.e. the second full year of FACE work, following the short startup period in 2007. The FACE centre is a Centre for Research driven Innovation (CRI), a collaboration between the research partners NTNU, SINTEF and IFE.

The funding partners in 2009 have been: The Norwegian Research Council, Statoil ASA, ConocoPhillips Scandinavia A/S, Vetco Gray Scandinavia AS, SPT Group AS, FMC, CD-adapco, Shell Technology Norway AS.

The scientific work in the centre has had good progress. The work follows the planned FACE working chain: designing and synthesizing Reference Fluids mimicking true crude oils characterized during the first period of the FACE work. Model hydrate particles and model fluids for suspensions have also been established. Then experiments are carried out with the Reference or model fluids. In parallel, models on small length scales are developed and then compared to the experimental results. In the suspension project, this process has developed to the furthest extent. Publication through journals and conferences has started, and the PhD program has gained momentum and is under good control.

In parallel, a process of developing plans for the next three year period has been carried out, including defining the remaining PhDs/postdocs planned for the centre.

In this document, we describe quite briefly the main purpose of the centre and some headlines of the scientific work in 2009. The appendices contain the costs and the FACE staff. For a more detailed progress report, we refer to presentations from our FACE workshops, and to the bi-annual progress reports. For more details on the scientific plans, we also refer to the current documents on the 2010-2012 FACE plans. All these documents are available for FACE partners in the FACE e-room, an internal web site in the centre.

2 FACE main strategy: vision and values, KPIs and targets

The FACE KPIs (Key performance indicators or success factors), vision and values were developed in 2008. In addition, we also identified targets inside the innovation areas, and also targets for the rest of the three year period 2007-2009. These building blocks form the base for the FACE centre, and they will be briefly described here.

The FACE vision:

Combining Surface and Colloid Chemistry with Fluid Mechanics to solve Flow Assurance problems

It expresses the multidisciplinary aspect of the centre, and the challenging balance between academic research and industrial application.

As our most important, we have chosen these three current FACE values: Long term Science, Ambitious, and Industrially relevant.

In a presentation at the NRC in 2007, we received signals on the criteria that will be used for evaluating the CRI centers. From these, the FACE Board and Management have produced a list of KPIs that we believe will give a substantially realistic picture of how the centre is performing as compared to the intentions from all the partners. The list of FACE KPIs:

1. Scientific results
2. PhDs, Masters, postdocs
3. Journal papers
4. Conference papers
5. Number of Partners
6. IPR
7. International cooperation
8. Industrial partners' evaluation
9. Involvement of industrial partners
10. Scientific cooperation across institute lines

Some of these are straightforward to measure. Some of the KPIs are not easy to measure, but still all the more important for evaluating the centre performance. Therefore, we are currently developing a strategy for measuring the KPIs. Following this, we will set goals for each KPI inside the subprojects of FACE.

The targets of the scientific work in FACE are addressed in a dynamic document. There, the current FACE innovation areas are described:

- Model fluids and reference fluids able to reproduce experimentally the behavior of actual crude oils
- Improved tools for design of fluid transport systems with surface active components and emulsions.
- Improved tools for design of flow systems including solids, hydrates and waxes
- Improved tools for design of viscous fluids transport systems
- Improved separator design for water/oil separation

Furthermore, the overall FACE targets are identified:

- Develop macro models that can incorporate micro/meso effects
- Educate PhDs, postdocs and Masters
- Establish the status and gaps on relevant scientific topics
- Design, synthesize and characterize model fluids to study suspension behaviour
- Characterize crude oil samples from the industrial partners
- Design and characterize Reference fluids, based on the crude oil characterizations, to study emulsion and crude oil behavior
- Establish new understanding of micro/meso phenomena leading to flow assurance problems by performing well designed experiment campaigns
- Develop new models on the meso-scale to describe these phenomena

- Initiate a Forum for Flow Assurance for the FACE partners

In addition to these, more detailed targets for the three year period 2007-2009 were formed. They serve as a starting point and direction pointers for the remaining FACE work. The plans for 2010-2012 will show a more narrow scope, selecting fewer end targets based on the initial work 2007-2009.

3 FACE: Organization

The FACE organization is described in the document "Governance structure" following the consortium agreement. The FACE organization is depicted in the figure below.

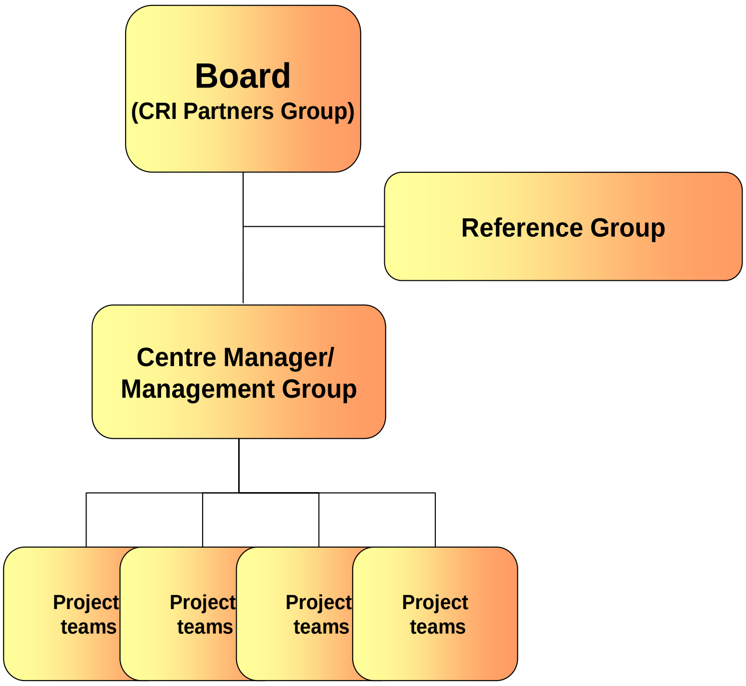

Figure 1: FACE governance structure

To overcome some of the leadership challenges in this virtual centre with three independent organizations, FACE has defined a leader group consisting of personnel that hold executive line management positions in the three research institutions. This CRI Partners Group forms a subgroup of the Board with special responsibility for the supervisory control of leadership and operational management of the Centre. Effectively, this group shall support the centre manager when operation of the centre requires decisions in the CRI partner line organizations, and when internal disagreement in the Centre Management Group calls for decisions at a higher level. At present, this group consists of Dag Thomassen from IFE (Host institution), Kjell Arne Jacobsen from SINTEF and Bjørn Hafskjold from NTNU. However, there has not been significant activity in the group in 2009, as the centre work has progressed in the expected manner, as described in the Governance Structure document.

The following individuals have been filling the roles of the FACE centre in 2009:

FACE 2009

FACE Board	
Representative	**Company**
Simon Lo	CD-Adapco
Ole Lindefjeld	ConocoPhillips
Keld Nielsen	ENI
Rune Fantoft, then Andreas Hannisdal	FMC
Dan Friedeman	GE Vetco Gray
Dag Thomassen	IFE
Tor-Petter Johnsen	NRC, Observer
Bjørn Hafskjold	NTNU
Kjell Arne Jacobsen	Sintef
Davoud Tayebi	Shell
Jørn Sikkerbøl	SPT Group
Per Gerhard Grini	Statoil, Chair

FACE Reference Group	
Representative	**Company**
Simon Lo	CD-Adapco
Kris Bansal	ConocoPhillips, Chair
Alberto di Lullo	ENI
Lars Grønnæss then Andreas Hannisdal	FMC
Johan Kristian Sveen	GE Vetco Gray
Jan Nossen	IFE
Tor-Petter Johnsen	NRC, Observer
Sigurd Skogestad	NTNU
Jon Harald Kaspersen	Sintef
Gert van Spronsen	Shell
Lars Hovden	SPT Group
Einar Eng Johnsen	Statoil
Hans Kuipers	Univ. Twente
Sanjoy Banerjee	City university NY

FACE Project leaders	
Roar Skartlien, IFE	P1: Modelling
Johan Sjøblom, NTNU	P2: Fluids
Paal Skjetne, SINTEF	P3: Separation
Tor Erling Unander, SINTEF	P4: Experiments
Erik J. Holm, IFE	P5: Make FACE a centre
Christian Brekken, SINTEF	P7: Viscous oil (2008 only planning stage, project starting 2009)

FACE Centre Manager
Erik J. Holm, IFE

4 The scientific work

The FACE scientific work is now also organized and coordinated according to the FACE innovation areas described in section 2, in addition to the structure of the projects. A new project structure will result from 2010. There are also strong interrelations between the innovation areas. This must be kept in mind when reading the project progress reporting. Some of the links are clearly stated in the descriptions. For some topics, the discussions and developing of plans has taken longer time than for others. Below, we mention two particular examples.

The Separation project in FACE spent much time in 2008 defining the scope and contents of the activities in close discussions with the industrial partners. This work was continued in the first part of 2009, and conclusions were made. In addition, these conclusions were materialized in the 2010-2012 planning process, reaching very concrete steps towards the objectives and targets.

The Viscous oil work in FACE started in 2009 instead of later after industry prioritization. It proved that – as in the Separation work - a similar type of process for identifying gaps, prioritization, FACE scope and FACE working methods is needed here. This resulted in several difficult discussions and changes in the plans during the year.

The scientific work and progress in the projects is described in the next chapters.

5 Project 1 – Flow Assurance Modelling

Suspensions:

A generic model for dispersions and suspensions has been developed. Suspensions that may be modelled range from hydrates, wax, and sand, in different flow regimes. The model focuses on the behaviour of model particles (i.e., particles that emulate to a large degree the behaviour of hydrates, wax or sand, and to some extent fluid droplets) in turbulent channel flow using water or oil. The exchange of information between experiments and modelling is essential for the model development, and to understand the underlying physics. There are four main activities related to suspension modelling:

1. **Two-way coupling in turbulent suspensions and dispersions.** The main focus has been on a description where both the particles and the fluid are represented by Eulerian Reynolds stress models. The coupling between the two phases is explicitly accounted for, including the effects of frictional drag and the so-called added mass. The kinetic theory of suspensions has been adopted to construct the needed closure relations. The experimental activities at IFE have been central in the development of the model. A conference paper and a report have been produced from this work.

2. **Cross sectional flow assurance models**. The objective for this work has been to integrate rheology models into a description of fluid and particle behavior that is general enough to account for the transition to dense suspensions in near pipe wall regions. A literature review on settling particles has been produced and has aided the improvement of the model results. The model is currently being tested against FACE experimental results.

3. **PhD project "PDF kinetic approach for particles near a wall or interface in inhomogeneous turbulence, with density ratio of particles to carrier flow of order unity".** The PhD candidate is Andrew Bragg at the University of Newcastle with Dr. David Swailes as main advisor, and R. Skartlien at IFE as second advisor. Bragg develops closure models for particle transport in turbulent flow. The kinetic theory developed at the University of Newcastle is invoked, and this is tested against the simulation tool TransAT by ASCOMP. In particular, Bragg focuses on the development and testing of the model to describe particles near a wall or close to an interface in inhomogeneous turbulence. A conference paper was accepted based on the work of done by the PhD student and collaboration with FACE researchers.

4. **In-kind contributions**. TransAT software has been made available to FACE researchers as part of an in-kind contribution from ASCOMP, Inc, Zurich. The software is used to carry out detailed Euler-Lagrange simulations in order to fine-tune the TDM closures, as well as to understand the dynamics seen in the suspension experiments.

Fluid modelling

A significant accomplishment has been the development of a simulation tool to study the effect of surfactant on the interface between oil and water. Thanks to an implementation of parallel computing, the code is now able to handle large scale computations that address emulsion flow and emulsion coalescence stability in the presence of surfactant. This code can be used to directly address the main vision of FACE: To combine interfacial chemistry with fluid dynamics.

We have had a fruitful cooperation between NTNU, SINTEF and IFE, in which the simulation tool was tested against benchmark experiments. It was demonstrated that the model captures important aspects of oil/water flow with surfactant.

Numerical simulations using the related phase-field method have been used to study droplet dynamics with focus on electro-coalescence, used in separators.

We have generated two journal papers and one conference paper on this work. A publication on jet/filament stability in the presence of surfactant in planned, where we use simple reference fluids.

6 Project 2 – Fluids and Characterization

At the Ugelstad Laboratory the following persons have been employed to work in FACE in 2009:

-Johan Sjöblom (Project manager, part time)

-Sébastien Simon (Postdoc, part time)

-Asal Amiri (PhD student, 100%, project 2.1)

-Serkan Kelesoglu (PhD student, 100 %, project 2.2)

- Mehdi Benmekhbi (PhD student, started in October 2009, project Interfacial rheology)

In addition Yanru Fan (Postdoc, 100%) has worked in the separation project.

The main accomplishments obtained in 2009 are the followings:

6.1 Project 2.1.: Design and characterization of model fluids

The goal of this project is to study rheological properties and stability of hydrophilic silica suspensions. In 2009 the effect of adding polar high viscosity solvent (glycerol) to the mentioned suspensions was studied, and a surprising flow behaviour “shear induced gelation” was obtained and described by influence of salinity and particle packing. The effect of temperature on this gelation was also studied.

Moreover a model to measure the rheology of settling suspensions has been developed and tested with monodisperse particles in collaboration with IFE. This work is currently completed for gently polydisperse suspensions with settling trend.

6.2 Project 2.2.: Design and characterization of reference fluids

The purpose of this study is to prepare reference fluids for crude oil emulsions. Reference fluids aim to mimic the bulk (viscosity, rheology, density, stability, flow behaviour in a pipeline etc.) and interfacial (dynamic and static interfacial tension against water) properties of real crude oils and their emulsions.

In the beginning of 2009, a reference fluid for Heidrun crude oil and its emulsions had been prepared, and their properties have been compared with the actual crude oils. The flow tests were carried out using the flow loop at StatoilHydro's R&D Centre in Trondheim. Experimental results indicate that the reference fluid successfully mimics the flow properties of the Heidrun oil and its emulsions; in particular the pressure drop, interfacial tension, droplet size and viscosity are correctly matched.

In the middle of the 2009, the influence of the pH of the aqueous phase on the flow properties of Heidrun crude oil and its emulsions has been investigated using rheometer and test loop bench in StatoilHydro. Experimental results indicate that pH of the aqueous phase affects the pressure drop and viscosity for Heidrun crude oil emulsions.

In the last period of the 2009, the preparation of a reference fluid for Grane oil (a heavier oil than Heidrun) has started. For this purpose, silicone oils were used. Experimental results indicate that silicone oils are not suitable to prepare a reference fluid for Grane crude oil. Consequently, other oils have to be considered. We are currently in contact with a manufacturer to find suitable oil for our purpose.

6.3 Project 2.3 Flow characterization

PhD student Jose Plasencia started at the EPT laboratory (NTNU) in summer 2009. His project consists of investigating diameter scaling of oil-water flows and the possibility of determining flow model parameters directly from small scale characterization methods using reference fluids. His activities in 2009 consisted in:

- Training and preparation of the flow loop (instrumentation, data acquisition, and new smaller test section – 16 mm internal diameter) at the Multiphase Flow Laboratory at EPT-NTNU.
- An evaluation of the capacity of the multiphase flow loop (EPT/NTNU) has been done. Preparation is in progress in order to be able to handle stable emulsions (reference fluid). New low shear pumps and a new tank will be implemented.
- The acquisition of Gamma densitometers at the multiphase laboratory (EPT/NTNU) is being coordinated with Tor Erling Unander (SINTEF). A prototype of this instrument was developed at SINTEF in the initial stages of FACE.
- Experiments on the investigation of pipe diameter influence in dispersed oil-water flows have started using the oil Marcol 52 in pipes with internal diameters of 16, 32 and 60 mm.

6.4

FACE academy: Interfacial rheology

PhD student Mehdi Benmekhbi started at the Ugelstad laboratory (NTNU) in October 2009. His project consists in investigating rheological properties of molecular films spread at interfaces using a new commercially available device: The interfacial shear rheometer (ISR) is developed by KSV (Finland). Experimental work is done in parallel with a modelling activity, conducted by IFE and based on the Lattice Boltzmann approach. The obtained data will serve to establish a model for the behaviour of real emulsion systems. His activities in 2009 consisted in:

- Training and preparation of the interfacial shear rheometer in Ugelstad laboratory
- Study of viscoelastic properties of a model surfactant (myristic acid) film at the air - water interface using the ISR. Investigation on the effect of the subphase pH on the film’s properties have started.

7 Project 3 – Separation

Shell has contributed its phenomenological frame work for separation modelling of separation vessels and wash tanks. Statoil has suggested using a CFD based approach which builds on the Hartland model for batch settling and extending this to include flowing conditions by applying CFD. Both these frameworks were put forward in a workshop held to involve and develop the industrial focus on separation in the centre.

This activity is organized into four sub-projects:

- *Mechanisms and phenomena* - in this activity in-kind datasets from industry were used to illustrate and identify important mechanisms and phenomena within separation. The main conclusion from the review has been that it is very difficult to make anything but very vague qualitative statements based on such data sets. In order to be able to make better qualitative statements or quantitative statements it is important that data sets go through a rigorous documentation and quality assurance process. Empirical relations can be established for test systems but would have poor predictive power if employed for another system. Thus, data must be of very high quality in order to be able to isolate and understand specific effects. Based on this there is now general agreement in the project that detailed and well documented controlled experiments is needed to understand the fundamental mechanisms of separation. A significant accomplishment for improving understanding of separation would be if improved measurements could be made of the evolution of the droplet size distribution. This is identified as one of the major challenges the centre will have to work with in the next three year period.
- *In kind data and models from partners* – **(a)** two data sets were provided; separation data from a high pressure flow loop, and separation data from a batch settler system. The first facility uses recombined crude oils, whereas the latter facility can use live crude oils sampled from oil fields. The data has been analyzed and the findings reported in separate reports. **(b)** Two of the major oil companies have contributed input towards establishing a framework for separation modelling: a phenomenological framework for engineering applications and ideas for a CFD based framework. Both these frameworks were

put forward in a workshop held to involve and develop the industrial focus on separation in the centre.

- *Droplet breakup and coalescence* – in 2009 this activity has been primarily focused on developing a modelling framework for coalescence. This was based on industry input in a separate modelling workshop in February. In March a workshop on interfacial rheology was arranged with world leading experts in the field. This provided a much needed overview of interfacial rheology both from a phenomenological, physical, experimental and computational point of view for the whole centre. The multiscale nature of coalescence phenomena requires a multiscale approach to modelling as well. Thus a review of DPD methodologies for representation of surfactant dynamics at interfaces and coarse graining methodologies was performed. Industry is hesitant in adopting such methodologies due to the large investments and complexity both phenomenological and theoretically. The main contribution from this activity in 2009 has been the development of a FEM based phase field method for studies of coalescence. The method has been validated against experimental and numerical data in literature and to our knowledge represents the first model to successfully model alternating current electro-coalescence. Once FACE starts producing its own high quality experimental data this framework will prove an invaluable and powerful tool for understanding basic coalescence phenomena. The model has also been extended to include the effect of surfactants.
- *Optimal destabilization of crude oil emulsions* **-** The goal of this postdoc study has been to perform an in-depth analysis of the destabilisation mechanism of emulsions encountered during oil production by de-emulsifiers. The first part focused on testing de-emulsification properties of a series of model surfactants (polyoxyethylene nonylphenol) as a function of their hydrophilic-lipophilic balance (HLB). Bottle tests and interfacial tension measurements showed that among the tested chemicals, those with intermediate hydrophilic-lipophilic balance were most efficient. Two different experimental techniques were used: **(a)** Langmuir film studies of asphaltene films at the oil/water and air/water interface coupled with Brewster Angle Microscopy. Results show that asphaltenes form domains at the air/water interface. The domain morphology is largely dictated by the initial concentration of the asphaltene solution, the total mass, and the dynamics of nanoaggregate and resulting cluster formation. The role of surfactant is largely to compete with and displace the asphaltenes at the interface, as well as to disperse the asphaltenes. **(b)** The interfacial shear rheology of an asphaltene film at a toluene-heptane/brine interface was investigated. Results show that asphaltenes form a gel-like structure at the interface. The gel formation exhibits slow kinetic and in the tested systems, no equilibrium was reached even after 20 hours. In addition, when a nonionic surfactant coexists with asphaltenes in the bulk phase, only a viscous interface was found, which may be attributed to surfactants displacing asphaltenes at the interface and inhibiting asphaltene cluster formation in the bulk phase.

A new three year plan for separation has been successfully developed in close collaboration with industry and the scientific advisors to FACE (Prof. S. Banerjee – CUNY and Prof. J. A. M. Kuipers – Twente/Eindhoven). Two publications have been accepted in international journals, one conference paper has been accepted for ICMF

2010 and one publication is under preparation for a leading international journal on multiphase flow.

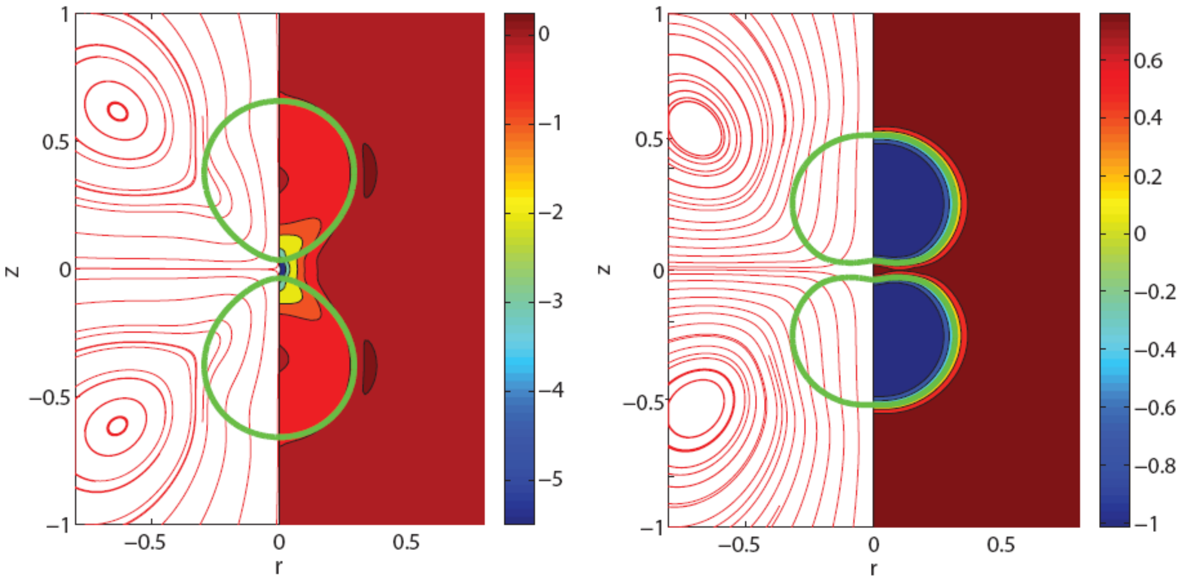

Figure: Streamlines and pressure contours for two droplets in an electrical field at two different viscosity ratios; left 1:100 right 100:1. (*Y. Lin et al . in press*)

8 Project 4 – Flow assurance Experiments

8.1 Suspension experiments

The main goals of the suspensions experiment are to study the effects of particles on the carrier fluid by using advanced experimental techniques in order to improve our knowledge of the two-way coupling phenomenon (particle-fluid interaction) and provide benchmark data set for the modelling project.

The main accomplishments achieved during 2009 include:

- A modern Time-Resolved Particle Image Velocimetry / Particle Tracking Velocimetry (TR-PIV/PTV) system was installed at IFE's laboratories.
- The first experimental campaign on dilute suspension flow experiments has been completed.
- Processing of dilute suspension experimental data is ongoing and preliminary results show interesting trends of the flow characteristics. Results are being used to test the suspension models.
- Reports and literature reviews on dilute suspension flow have been completed. Several papers have been submitted and accepted in international conferences and journals.

This project also includes a PhD on improving PIV measurements of suspension flow in pipes. The student was recruited during the fall of 2009 and is coursing his PhD at the University of Oslo.

The work planned for 2010 includes the expansion of the experimental matrix to cover oil based dilute suspensions in channel and pipe flow geometry. Experiments will include the use of monodisperse particles with different sizes and densities.

8.2 Hydrates experiments

The goal of this task was to develop model particles with tailored properties for use in multiphase flow experiments. Properties of interest to tune for specific applications include particle density, interfacial properties and particle size. The particles must also be resistant to the conditions during flow experiments, where they are stirred and sheared in contact with water as well as aliphatic hydrocarbons.

In the project we have mainly concentrated on hydrate-like particles. Therefore the particles should have properties similar to those of real hydrates. We have therefore aimed at a density lower than that of water, a hydrophilic surface of the particles and aggregating and non-aggregating behaviour respectively.

A process for the production of particles with tuneable density has been developed. The particle surface has been manipulated in order to obtain the desirable interaction of the particles with the solvent (hydrophilic) and with each other (aggregating-non-aggregating). It has been demonstrated that the particle surface can be substituted by different chemical groups to obtain different properties (hydrophobic, ionized etc). In order to make the particles more easily detected by optical techniques during multiphase flow experiments, a dye was encapsulated inside the particles.

8.3 Oil/water experiments

The Oil/water experiments were designed to produce results that contribute to the understanding of the effects of surfactants on droplet and bubble entrainment in multiphase pipe flow. This work includes studies to obtain information about critical surface active components in crude oils. The experimental campaign also added to the understanding of the effect of flow rates and surfactant concentrations on the stability and breakup of liquid-liquid interfaces. The experimental results are also part of the effort to develop simplified mathematical models for droplet and bubble entrainment rates in the presence of surfactants.

This activity has provided experimental data to the liquid-liquid modelling activity, which relates both to liquid jet experiments and tilted channel experiments. The activity has also developed VOF simulation capacity for oil-water flow through internal FACE activity and by involving CD Adapco. The reference fluid technology developed at NTNU has been developed and tested in cooperation with this activity. This activity has not come as far as planned. The assumed simple experiments that were initially started to 1) get a quick start and 2) provide experimental data to the basic modelling effort has turned out to require significant resources. At present, there has not been room for more experiments.

9 Project 7 – Viscous oil

FACE started an activity on viscous oil modelling in 2009. This was done earlier than planned because this was clearly prioritized by the industrial FACE partners. One of the goals is to reveal which closure relations need improvement and which new closure relations need to be included to improve the existing macro modelling tools (OLGA/LEDA). Statoil gave FACE access to a literature study on viscous oil as an in kind contribution. This literature study shows to a large degree that the closure relations that need improvement to tackle viscous oil are identified by the scientific community.

FACE is currently working on identifying the flow phenomena that need better models. This part is done in close cooperation with the industrial partners, also using the expertise of retired Statoil expert Per Fuchs, now working as a private consultant for FACE on science and QA. We are also reviewing existing literature and relevant available data sets. FACE is also working on defining what new experimental data is needed to validate and to develop the new or improved models.

In summary, we have identified several gaps in our knowledge concerning multiphase transport of viscous oil, both in experimental data and commercially available models. The challenge is now to focus the activity in FACE towards experimental and modelling efforts related to one or a few specific flow phenomena. The work in the current viscous oil project will be merged into the 2010-12 plan for Oil-Water Transport. There is a potential for new in-kind contributions in this area (for example VO experimental data and VO modelling gap analyses).

We have concluded that there is a need for new data on systems with oil viscosity >50cP. In general, there is a large number of specific modelling issues that should be pursued (11 specific issues are listed). In FACE, there is a need to prioritize one or a few modelling issues and to relate this to subsequent experimental activities. The work to identify focus areas for the viscous oil modelling is an ongoing process, but an expert group has issued a document with recommendations for the viscous oil work. In addition to these expert group recommendations and gap analysis on viscous oil has been conducted to identify areas where the currently available data is scarce. The expert group recommendations identify and prioritize flow phenomena in the viscous oil flow work. In addition to these efforts a selection and comparison of appropriate data sets with OLGA has been done.

The work on establishing a multiphase flow database is still ongoing. The data sets we will select include experiments with viscous oils and data from numerical simulations of systems with viscous oils. Relevant data sources are listed in the FACE literature study and the gap analysis done as part of the viscous oil project. The sources include PhD theses, reports and journal articles.

One PhD (2009-2012) and one postdoc has been hired as part of the viscous oil effort. These positions are meant to strengthen the efforts on viscous oil further. The PhD student is currently running experiments to investigate the pipe diameter influence on oil-water dispersed flows. Screening tests using real crude oils will commence in 2010. The study will focus on inversion point phenomena, and a characterization of the different crudes will contribute to the development of new reference fluids in the FACE project. A conference paper has been submitted to the ICMF 2010 conference by the PhD student.

10 Project 5 – Make FACE a centre

A major part of the centre integration work in 2009 has been a quite long, iterative process of developing the new three year plan for 2010-2012. Regular status, Reference Group and Board meetings have been held. The status meeting in November was commented to be “the best FACE meeting ever” by the industrial partners, due to good results and high quality presentations. This was an important inspiration for the FACE staff.

A scientific course on interface rheology with three invited external experts was a main highlight in the education of the FACE staff and partners in 2009. The workshop was commented as being very successful.

FACE workshops, meetings 2009

- 23.-24.March, Oslo: FACE Interface Rheology course
- 25.-26.March, Oslo: FACE Workshop/Status meeting
- 27.March, Oslo: FACE Reference Group meeting
- 27.-28. April, Trondheim: Internal seminar for FACE staff, brainstorming and initiation of process for plans 2010-2012
- 4.June, Kjeller: FACE Board meeting
- 2.-3.Nov, Trondheim: FACE status meeting
- 4.Nov, Trondheim: FACE Reference Group meeting
- 9.Dec, Trondheim: FACE Board meeting
- In addition: Centre Management Group meetings when needed. Some on video, some in person.

Partner status: ENI notified that they will leave FACE from 2010 after a total evaluation of all their research activities. Discussions have been held and information exchanged with a handful of potential partners without resulting in any concrete new partnerships.

Planning 2010-2012 started by industrial input after the large March technical FACE meeting. An internal seminar at the end of April generated a lot of potential ideas. The tight budgets forced us to be selective in the scope of the three year plan. In order to get an intermediate response from the industry before outlining concrete plans, a strategy note was submitted. Based on feedback on the strategy note, on the FACE overall strategy, on obtained knowledge, and also based on meetings with the two FACE external experts, a concrete set of plans were drafted. The Reference Group responded partly in the 4. November RG meeting and in emails prior to and after the meeting. Based on this input, yet another version of these plans is currently being developed. In every iteration, the Centre Management Group is obliged to agree on consolidated plans. This process and collecting industry input takes time in our complex centre. Some differences in opinion inside the CMG are the reason for the delay in this late stage of the process. This is expected to be resolved immediately. This is absolutely necessary in order to get started on the 2010 work; hence a rapid closing of the planning process is a strong request from the FACE Board. It is the hope of everyone involved that we are soon converging to a finished set of plans for 2010-2012, taking us towards the FACE vision and targets. It must also be remembered that as agreed, we are a dynamic centre, and such a three year plan will be revised every autumn based on what we have learned.

The NRC carried out their annual "Site visit" to FACE at Tiller in May. They were presented with the latest developments in FACE, FACE seen from the industry, the successful work of the FACE PhD student on Reference Fluids, the opportunities of FACE seen from SINTEF and an introduction to the EPT lab. The Tiller laboratories were also presented by a tour. The NRC expressed that FACE seems to be in good shape, and expressed that this is important in order to be prepared for the evaluation autumn 2010.

In the remaining part of this section, we will mainly give a brief outline of the progress in terms of the FACE KPIs number 2-10. KPI no. 1: Scientific results are the topic for the rest of the document.

KPI No. 2: PhDs, postdocs and Masters. 3 PhDs and one postdoc were hired from 2007. During 2009, a significant part of the remaining plan for PhDs and postdocs was defined and hired. A postdoc is coming to the EPT lab in December, a PhD is coming to the Ugelstad lab in January and the PhD on LBM – where the candidate dropped out before start-up autumn 2009, is currently being slightly redefined, and a new candidate is being sought. As requested by the FACE Management one of the FACE partners, FMC, suggests to put in a PhD as their in-kind from 2009. The suggestion is currently being evaluated by the Reference Group. In total, we will then have defined and hired 11 PhDs/postdocs not long into 2010. The current ambition is 15. The remaining 4 PhD/postdocs are taken into the work plan for 2010-2012. No master students have been dedicated to FACE yet, and this should be a focus in the next three year period. A master student did some modelling work for FACE summer 2009.

KPI No. 3: **Journal Papers.** 2 papers are published in international journals. Approximately 5 are either sent or about to be sent to the Reference Group for review.

KPI No. 4: Conference papers. 5 abstracts have been sent to the Reference Group for 2010 conferences.

KPI No. 5: Number of partners. 11 partners are currently FACE members. ENI pulls out from January 2010. The FACE management has had discussions with 6 potential partners and been in contact with a few others without a positive result. Two potential partners are very seriously considering joining FACE from 2010. One of them has asked to review the contract, which is usually a very good sign.

KPI No. 6: IPR. The patenting process for the first generation of Reference Fluids will start as soon as the contract change on patenting is finalized. At present we lack one signature: GE Vetco Gray.

KPI No. 7: International cooperation

- Sanjoy Banerjee, CUNY: international expert in the FACE Reference Group
- Prof. J. A. M. Kuipers, Univ. Twente: international expert in the FACE Reference Group
- University of Newcastle hosting a PhD on particles in turbulent fluid
- Cooperation with Ascomp (Switzerland) on suspensions
- Interface Rheology course for FACE staff in March 2009
- Paul Meakin, INL, consultant on modelling
- 5 partners outside Norway
- Research network from the partners.

KPI No. 8: Industrial partners' evaluation. See comment in KPI 9. In the internal FACE evaluation starting in February 2010 and also in the NRC mid term evaluation summer/autumn 2009, the industry will be asked to evaluate FACE more formally.

KPI No. 9: Involvement of the industrial partners. FACE staff is in quite frequent contact with the industry, and from this we get an impression of how they see FACE. FACE industrial partners gave feedback on the 2010-2012 plans (3 rounds of industrial input), at 2 larger FACE meetings, at the meeting series where the partners are meeting FACE one by one, and through more informal discussions. An important involvement in FACE from the industry comes through the in-kind contributions. In-kind for 2009 has been defined, and the in-kind for 2009 was delivered according to the plans. Some of the partners chose to deliver their in-kind 2009 as cash. A PhD has also now been incorporated in the in-kind program (from partner FMC), and this is very positive. A more thorough analysis on how this work should be part of the internal evaluation starting spring 2010.

KPI No. 10: Scientific cooperation across institute lines. The scientific work in FACE shows a significant number of examples of integrated work for the first two years in FACE, and we have had focus on this. Such examples must be encouraged and strengthened from 2010.

11 Recruiting

Recruiting of PhD students now seems a bit simpler than in 2008, and FACE is back on track with the PhD/postdoc recruiting plan. Including the PhDs/postdocs in the 2010-2012 plans, FACE intends to educate 15 PhD/postdocs. This then also includes the FMC PhD candidate delivered as in-kind.

12 External presentations

In cooperation with Aker Solutions, FACE arranged a 1/2 day Flow Assurance seminar for industrial representatives in Stavanger. Approximately 40 industrial representatives participated. Presentations were given on related activities at IFE, SINTEF and NTNU in addition to presentations from FACE.

13 Deviations

The FACE work in 2009 is carried out according to the current plans, and work postponed from 2007 and 2008 was, as planned, carried out in 2009. We are therefore back on track with the FACE work after two years with less efforts than originally planned.

The development of plans 2010-2012 has taken longer time and been more difficult than expected. It may therefore be possible that the 2010 work will start late awaiting the Board approval of the three year period plan.

Attachment: Excel sheets with costs, staff and publications.