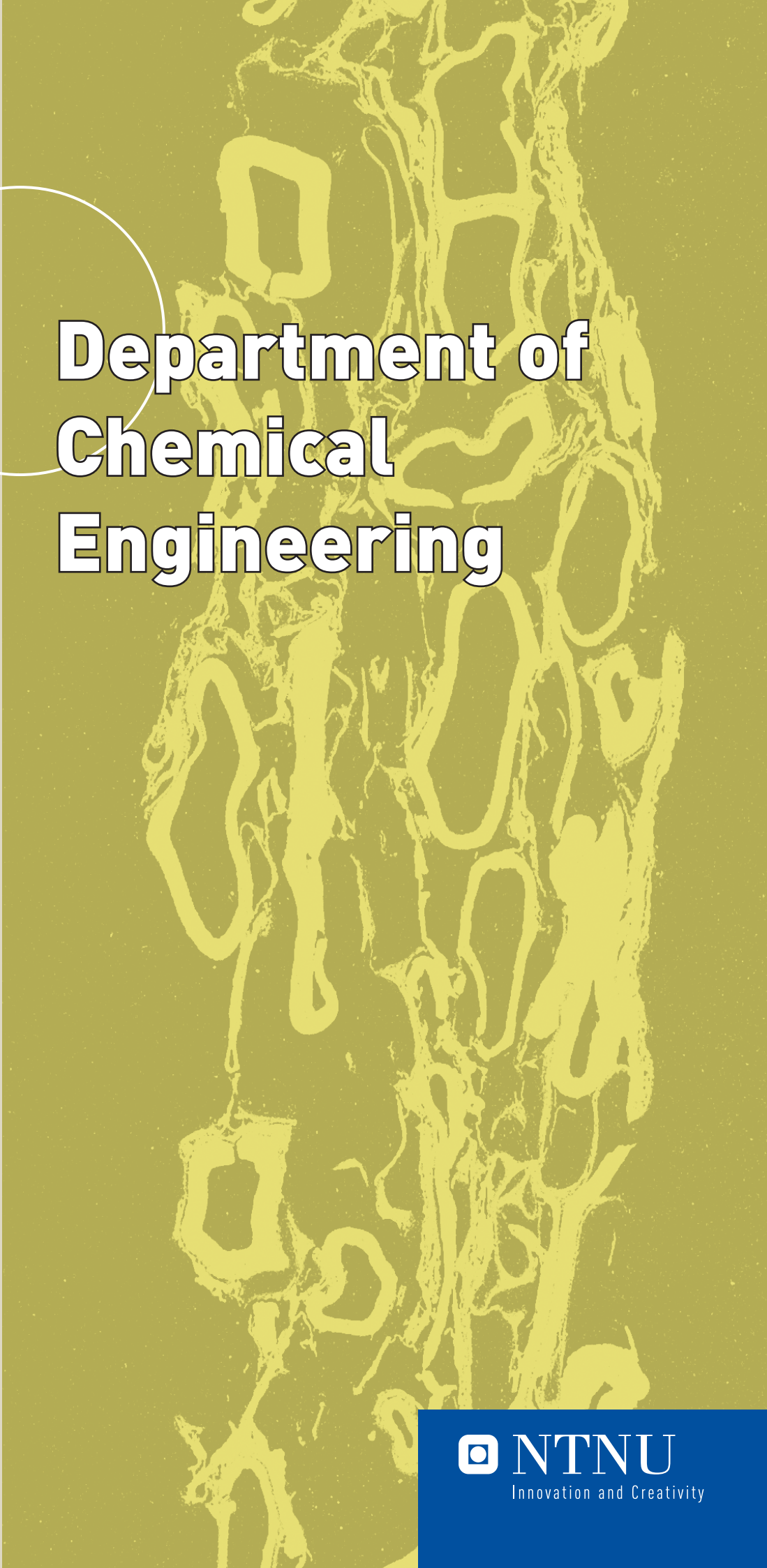
Department of Chemical Engineering

Annual Report 2007



NTNU
Innovation and Creativity

DEPARTMENT OF CHEMICAL ENGINEERING, NTNU

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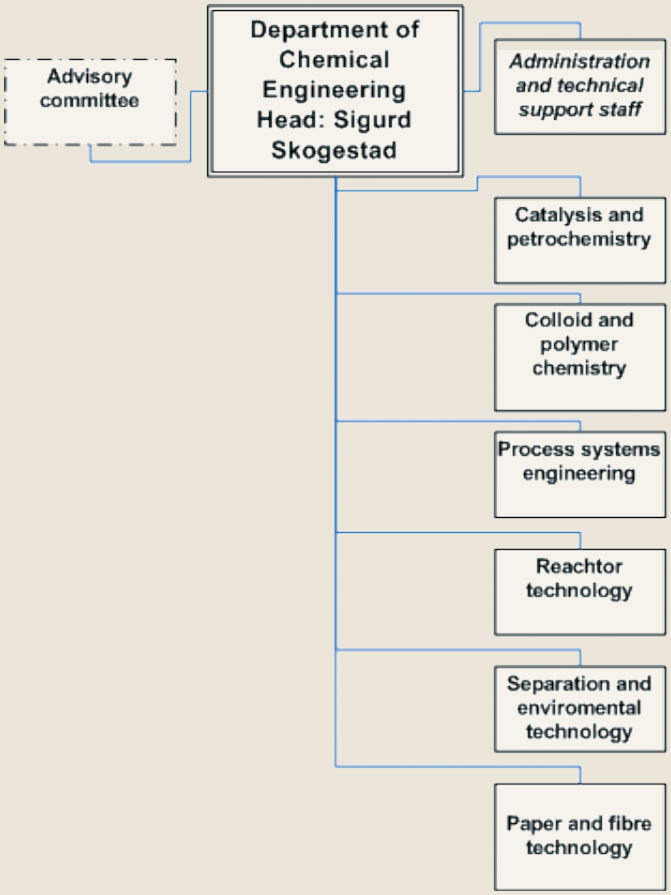
Head of Department:
Professor Sigurd Skogestad
Deputy Head of Department:
Professor Edd A. Blekkan



Department advisory committee
External members:
Chair, Research Director Ole Wærnes, SINTEF
Professor Jon Kleppe, Petroleum Engineering

Internal members:
Professor Heinz Preisig
Professor Hallvard Svendsen
Associate Professor Hilde J. Venvik
Senior Engineer Berit Borthen
PhD-Candidate Ellen Marie Flaten
Student Marianne Lie
Student Kristine Røsting

Staff
Academic staff, see the individual research groups:

Technical and administrative staff:
Head of Administration Tom Helmersen

Administrative staff:
Senior Executive Officer Torgrim Mathisen
Executive Officer Lisbeth B. Roel
Executive Officer Tove Barø
Executive Officer Gerd Sandvik

Technical staff:
Senior Engineer Berit Borthen
Engineer Harry Brun
Engineer Arne Fossum
Engineer Odd Ivar Hovin
Principal Engineer Signe Håkonsen
Principal Engineer Jan Morten Roel
Principal Engineer Cecilie M. Selsbak
Engineer Frode Sundseth
Senior Engineer Bodhild Øvrevoll
Senior Engineer Asbjørn Øye

COVER PAGE (Photo by Per Olav Johnsen, PFI).
SEM cross sectional image of newsprint based on Norway Spruce and recycled printing paper. Such images are the basis for quantitative characterisation of paper structure by image analysis.

DEPARTMENT OF CHEMICAL ENGINEERING, NTNU

http://www.chemeng.ntnu.no

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Prepared and edited by Lisbeth Blekkan Roel, Tom Helmersen, Sigurd Skogestad

CHAPTER 1: INTRODUCTION

Introduction to Annual Report 2007

By Sigurd Skogestad (Head of Department)

2007 was another successful year for the Department of Chemical Engineering at NTNU. Once again, the research output, as expressed by number of graduated Ph.D. candidates and publications, reached an all time high. The number of credited publications in international journals reached 108, after having increased steadily over the last years from 46 (2003), 48 (2004), 76 (2005), 74 (2006), to 108 (2007).
The number of "publication points" in 2007 was 99,6 or 2,6 points per research man-year (academic faculty, postdocs, researchers). This ranks us as number 21 among all Departments in Norway, and number 7 at NTNU.

Furthermore, 15 Ph.D. graduated in 2007, which is equal to the all time high from last year (2006). In summary, the research output remains very strong, and the Department continues to attract significant research funding, as can be seen from the number of new PhD students, which was 18 in 2006 and 15 in 2007. The number is expected to remain high in 2008, partly because of a number of new projects funded by the GASSMAKS program of the Norwegian Research Council (NFR).

The main challenge for the Department is the low student enrolment and output of Master graduates. For more than 15 years, until 2002, the Department graduated on average more than 60 MSc *(siv.ing.*) per year, but since 2004 it has dropped to about 30, and it is expected to remain at this low level at least until 2010. Our Department does not have a separate intake of students and our main recruitment base is the students entering the 5-year program in *Chemistry and Biotechnology*. About 50% of these industrial students choose our Department for their specialization after the second year. This fraction has remained almost constant over the last 30 years. The main reason for our low student numbers is therefore a drop in the intake to the first year, which is presently at about 70, whereas it historically (over the last 30 years) was around 120.

Partly in response to this situation, we are starting up a new 2-year International Master program in Chemical Engineering in August 2008. We are planning for 5-10 students starting in 2008, and expect to increase the number to about 15 in 2009. The international master students are integrated into our existing 5-year program. Thus, all courses in the 4th and 5th year will be offered in English.

In terms of future plans and faculty recruitment, we follow quite closely the Departments strategic plan from April 2003.
In February 2007, Dr. Magne Hillestad joined the Department as Professor in Process Design, and in August 2007, Dr. Jon Samseth joined as Adjunct Professor (20% position) in Nanostrcutured polymer membranes.
A position in systems biology was announced in December 2006, and Dr. Nadav ("Nadi") Skjøndal-Bar started as Associate Professor (*Førsteamanuensis*) in January 2008.

The Department has now completed a major replacement of its academic staff. 12 (of 19) new fulltime faculty members have been hired since 2001.

There have been a number of press notices about the Department in 2007, including an article in *Chemical Enineering* (November 07), about professor May-Britt Hägg's new membrane for removing CO_2 from flue gas, and a large feature about professor Hallvard Svendsen's work on CO_2 capture in Norways largest newspaper VG (see page 13).

Carlos Alberto Dorao, who received his PhD in 2006 with Professor Hugo Jakobsen as his advisor, was in May 2007 awarded the Exxon Mobil prize for the best fundamental PhD at NTNU during 2006-07.

A complete renovation of the main lab in the 3rd floor in Chemistry building 5 (K5) was completed in 2007. About 2/3 of the total cost of about 6 million NOK were paid by the Department, which unfortunately has almost exhausted our savings.

The next major project is the renovation of Chemistry building 4 (K4), which will finally start in 2008 and is expected to be completed in 2009. The two top floors, which have been empty since the Department of Materials Science moved out at the end of 2005, will house the Department's activity on CO_2 removal, including SINTEF. The freed space in K5 may then be made available for parts of the Colloid and polymer group who are presently renting space in the PFI building.

FACTS ABOUT THE DEPARTMENT OF CHEMICAL ENGINEERING

The Department of Chemical Engineering is located at the Gløshaugen campus of the Norwegian University of Science and Technology (NTNU) in Trondheim. NTNU is the only university in Norway that awards engineering degrees in all areas.

The Department offers a 5 year program leading to the degree of *sivilingeniør* (M.Sc.) in chemical engineering. Most of the students start at NTNU in their first year, but about 10 to 20% enter in the fourth year based on a 3-year engineering Bachelor degree. On top of this we offer a 3 year doctoral program leading to a Ph.D. degree in chemical engineering. In addition, we offer a 2 year International Master Program in Chemical Engineering.

The Department can trace its roots back to 1910 when the Norwegian Institute of Technology (NTH) started up in Trondheim with engineering chemistry as one of the seven majors. After the Second World War, three applied Departments were formed, namely pulp and paper chemistry (*treforedlingskjem*i, 1946), chemical engineering (*kjemiteknikk*, 1949) and industrial chemistry (*industriell kjemi*, 1950). These merged in 1999 to the present Department of chemical engineering (*kjemisk prosessteknologi*).

The objectives of the Department are:

1. *Education.* Offer a Master Degree in Chemical Engineering which is internationally recognized and makes the candidates attractive on the labour marked.
2. *Research*. Research shall be on an international level, and in some areas internationally leading.
3. The Department shall be attractive in order to recruit the best candidates, including academic faculty, PhD students and undergraduate students. The social environment shall be very good so that everyone feels welcome.

The permanent staff in 2007 included

- 13 technical/administrative
- 20 academic, incl.14 Professors and 6 Associate Professors (*Førsteamanuensis*)

The non-permanent staff in 2007 included

- 4 technical
- 8 Adjunct Professors (*Professor II*) (20% *position)*
- 78 PhD students
- 25 Post.docs and researchers

The Department also houses 6 Professor emeritus and 4 visitors, in addition to a large SINTEF group.

Student production

Year	MSc	PhD
1994	60	11
1995	79	2
1996	57	5
1997	67	9
1998	46	13
1999	81	8
2000	69	10
2001	18(*)	11
2002	75	12
2003	44	7
2004	30	10
2005	25	13
2006	19	15
2007	31	15

(*) Transition from 4.5 to 5 year program.

MSc students 2006/07

5th year	34
4th year	35
3rd year	16

New PhD students (exchange students not included)

2003	20
2004	10
2005	9
2006	18
2007	15

CHAPTER 2: RESEARCH

CATALYSIS GROUP

Academic staff
Professor Anders Holmen
Professor Edd A. Blekkan
Professor De Chen
Professor Magnus Rønning
Associate professor Hilde J. Venvik
Adjunct professor Kjell Moljord
Adjunct professor Erling Rytter

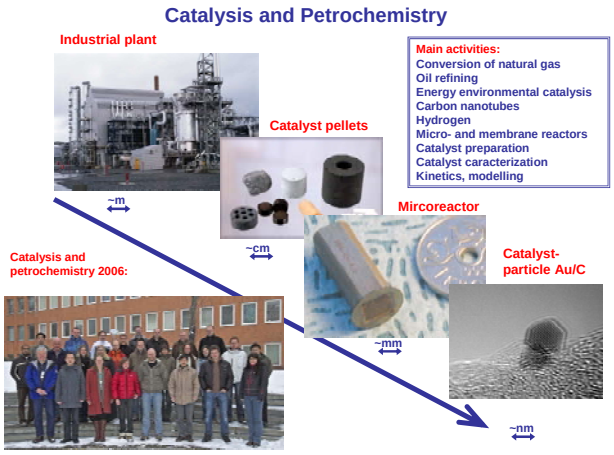
Post.docs.
Anna Maria Lind (from 01.03.07)
Santhosh Kumar Matam
Jianmin Xiong (until 29.11.07)
Tiejun Zhao

PhD. candidates
Øyvind Borg (until 31.03.07)
Fatemeh Hayer
Hamidreza Bakhtiary
Sara Boullosa Eiras
Svatopluk Chytil (until 14.09.07)
Saima Sultana Kazi (from 15.04.07)
Li He
Hoang Anh Dam
Hilde Dyrbeck (until 14.09.07)
Bjørn Christian Enger
Nina Hammer
Silje Fosse Håkonsen
Ingvar Kvande (until 30.11.07)
Astrid Lervik Mejdell
Hilde Meland
Saima Sultana Kazi (from 15.04.07)
Esther Ochoa Fernandez (until 31.07.07)
Xuyen Kim Phan
Juan Maria Schena (from 10.09.07)
Espen Standal Wangen (until 31.05.07)

Researchers
Geir Haugen (until 31.07.07)

Guests
Fernando Bimbela (PhD student from Zaragoza, Spain)
Ping Li (Professor from East China Univ. of Science, China)
Sara Lögdberg (PhD student from KTH, Sweden)
Jun Zhu (PhD student from East China Univ. of Science, China)

The Organization
The research and teaching in catalysis, petrochemistry and related subjects (including surface science, adsorption and physical studies of porous materials, reaction kinetics and process engineering) is organised in the Catalysis Group, a joint effort where the university (NTNU, former NTH) and the research company (SINTEF, a large polytechnic research organisation) cooperate and share laboratories and equipment.



Personnel from the two organisations work together and participate in teaching and research. About 10-15 students graduate each year (M.Sc.). The group participates extensively in international networks, research programs etc., and cooperates closely with a number of universities and research groups inside and outside the EU.

The group and the laboratories
At present the group comprises about 40 people: 5 professors, about 10 fulltime research scientists holding Ph.D's, 4 Post.doc's and 20 Ph.D students. The laboratories and equipment include a large number of microreactors for catalyst studies, several small pilot plants, all the necessary equipment for catalyst and material characterization (chemisorption, physical adsorption, Temperature Programmed techniques (TPR, TPD, thermal analysis), XPS, Auger spectroscopy, STM, FTIR and others). Recently, *in situ* IR/Raman and the TEOM-technique (Tapered Element Oscillating Microbalance) have been introduced in the laboratory, and we were the first group in Europe to utilize the TEOM technique in catalyst studies. Cooperation with the Departments of Physics (surface science), and Materials Science and Engineering, the other groups at the department of Chemical Engineering (all aspects of chemical and process engineering, particularly reactor engineering and colloid and polymer chemistry) and other departments ensures a wide scope and a high quality of the work. The research is funded by the Norwegian Research Council and by industry and spans from fundamental studies of ideal surfaces to studies of real catalysts to process development work in small pilot plans.

The projects
A description of the Group as well as further details of all the projects are given in our Annual Report.

Natural Gas Conversion
Natural gas is an abundant hydrocarbon fuel and chemical feedstock, and utilizing this resource with

minimum environmental impact is a major challenge to catalysis. It is the main goal of the present programme to study catalytic processes for conversion of natural gas to chemicals and fuels including hydrogen. The programme includes production of synthesis gas, Fischer-Tropsch synthesis, and dehydrogenation of C_2-C_4 alkanes. Work on methanol and DME synthesis wasrecently initiated. The work is carried out in close collaboration with Norwegian industry and SINTEF. The group also participates in a Centre for Research Innovation (SFI-INGAP) focusing on the use of natural gas.

Hydrogen Technology
Particular attention is directed towards hydrogen technology: Catalysis is important in the production of hydrogen from hydrocarbons. Natural gas in an important source of hydrogen, and research is thus linked to syngas issues. In addition, the conversion of "transportable" hydrogen carriers such as propane, methanol (bio) ethanol and (bio) glycerol is studied. Of particular relevance is the integration of CO_2 separation technologies in hydrogen production processes, and this is targeted through sorption enhanced reactions and membrane reactors (see below). The group is also involved in development of improved fuel cell catalysts based on carbon nanofibers (also below). Collaborations include SINTEF as well as Norwegian industry. Hydrogen technology is also part of the MIT-NTNU cooperation.

Design and Preparation of New Catalysts and Supports
The catalytically active material is the key to any catalytic process, and the preparation of these, highly specalized functional materials is an important industry. Understanding the preparation methods, and developing new techniques is therefore a central research area.This programme deals with new methods to prepare supports and catalysts such as flame spray pyrolysis and spray drying, as well as the preparation and use of structured, mesoporous supports. New hybrid materials are also being synthesized where the active metal is included in the support during production. This work is done in collaboration with the Ugelstad laboratory and SINTEF

Carbon Nanofibres
Carbon nanofibres (CNF) have several interesting properties such as high resistance to strong acids and bases, high electric conductivity (similar to graphite), relatively high surface area and high mechanical strength. These unique properties lead to a large number of applications, such as catalyst supports, selective sorption agents, energy storage, composite materials, nano-electric and nano-mechanical devices, as well as field emission devices. The programme includes synthesis of carbon nanofibres and nanotubes of different morphology and the use of CNF/CNT in applications such as heterogeneous catalysis, fuel cells and conversion and storage of energy. This is done in collaboration with other groups at NTNU, SINTEF and Norwegian Industry

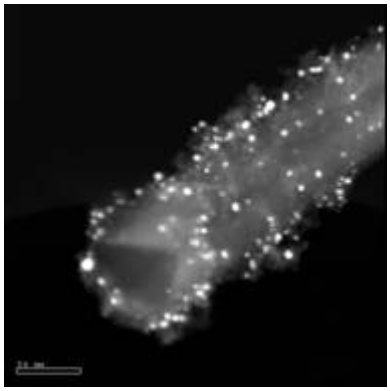


Image of Au and TiO_2 catalyst nanoparticles on carbon nanofibres

Novel reactor concepts and structured supports
Emerging reactor technologies such as microstructured reactors and (catalytic) membrane reactors are being developed and tested. The use of structured supports such as monoliths and foams is being studied, particularly for short contact time reaction systems such as partial oxidation and oxidative dehydrogenation. The work on microstructured reactors, where channels micrometer dimensions (1-1000μm) and up-scaling by parallelization is applied to enable new properties/possibilities, is performed in collaboration with Forschungzentrum Karlsruhe in Germany. Membrane reaction concepts based on novel Pd thin film technology are being developed together with SINTEF, and a partnership with MIT, Norsk Hydro and Statoil is directed towards the use of high-temperature proton-conducting membranes in hydrogen production with CO_2 capture.

Oil Refining
Upgrading of crude oil and oil fractions is an important subject of research, especially due to new environmental legislation demanding more efficient processes. The programme includes catalytic reforming, isomerization, hydrotreating/ hydrocracking and heavy oil upgrading. The work is carried out in close cooperation with SINTEF and the industry.

Biomass Conversion
Biomass as a raw material for energy and chemical products is growing in importance, especially as a partial answer to the CO_2 issue. We are involved in several projects through international collaborations.

Fundamental Studies in Heterogeneous Catalysis
Several experimental techniques are used to study the details of solid catalysts. We are working together with Department of Physics on the use of Transmission Electron Microscopy and Scanning Tunneling Microscopy. We focus on characterisation of catalysts at working conditions and for this purpose we are using the European Synchrotron Radiation Facility in Grenoble and together with the Ugelstad Laboratory we have recently purchased new facilities for IR and Raman spectroscopy. The TEOM (Tapered Element Oscillating Microbalance) is also a powerful technique for studying important phenomena like catalyst deactivation, diffusion in porous materials and adsorption, absorption and desorption.

COLLOID- AND POLYMER CHEMISTRY GROUP (UGELSTAD LABORATORY)

Academic staff
Professor Johan Sjöblom
Professor Preben C. Mørk (until 31.08.07)
Associate professor Wilhelm R. Glomm
Associate professor Gisle Øye
Adjunct professor Jan Genzer (until 28.02.07)
Adjunct professor John D. Friedemann (until 26.08.07)
Adjunct professor Egil Gulbrandsen
Adjunct professor Michael Stöcker
Adjunct professor Per Stenius
Professor emeritus Arvid Berge

Scientists
Heléne K. Magnusson
Sebastien Simon

Post.docs.
David Arla (until 05.08.07)
Yanru Fan (from 21.11.07)
Brian Grimes (from 01.02.07)
Cedric M. Lesaint
Kristofer Paso
Sondre Volden

Phd candidates
Asal Amiri (from 22.10.07)
Martin Andresen (until 12.09.07)
Dorota Dudásová
Umer Farooq (from 01.10.07)
Martin Smestad Foss (until 17.09.07)
Martin Fossen (until 31.08.07)
Ann-Mari Dahl Hanneseth
Ingvild Andersen Johnsen (until 12.10.07)
Serkan Keleşoğlu (from 17.09.07)
Marta Lopez Garcia (until 30.06.07)
Erland Nordgård (from 25.09.06)
Anne Silset
Simone Less
Bjørn Thomassen

Guests
Iva Králová, (PhD from Brno University, Czech Rep.)
Weijun Zen (Xinjiang University, China)
Shahaan Abbasi (Qatar)
Ronaldo Goncalves (Brasil)
Jeremy Salas (France)

Overview:
The Ugelstad Laboratory was founded in honour of Professor John Ugelstad at the Norwegian University of Science and Technology in January 2002 (Department of Chemical Engineering). The laboratory specializes in surfactant chemistry and its technical applications, emulsions and emulsion technology, preparation of polymers and polymer particles and their technical applications, plasma chemical modification of surfaces and silica-based chemistry.

Applications include crude oil production and processing, pulp and paper, biomedicine, catalysis and materials science.
The main purpose is to raise the national level of colloidal science by establishing a modern educational, research and development laboratory within the field of colloid, polymer and surface chemistry.

Diploma and Ph.D. studies are offered within these topics, often in close collaboration with industrial companies. The aim is to educate highly qualified candidates for industrial positions. In order to attract the best and most motivated students and researchers, the laboratory has invested in new and modern instrumentation. The laboratory also participates in international exchange programmes, and hosts internationally renowned guest researchers and lecturers.

The Ugelstad Laboratory is sponsored by industrial companies, the Research Council of Norway (NFR), research institutes and NTNU. All the members are annually invited to a presentation of the recent research activities at the laboratory. This is combined with the Ugelstad Lecture, where invited scientists lecture within the field of colloid, polymer and surface chemistry.

Research Activities:
In the following paragraphs, selected ongoing research programs for 2006 are briefly described. For a complete description of the research activities at the Ugelstad Laboratory, please visit our web page: http://www.chemeng.ntnu.no/research/polymer/ugelstadlab/

Improved Oil recovery by Low Salinity Waterflooding: Surface Chemistry and SCAL Studies (VISTA 2007 – 2010)
The project focuses on how the surface chemistry of reservoir surfaces can contribute to improved oil recovery by low salinity waterflooding. An important goal is to understand the interaction mechanisms between the solid surfaces and surface active components in crude oils as the extension of the electrical double layer varies.

Multiphase Flow Assurance Innovation Centre (FACE) – Centre for Research-Based Innovation (SFI) 2006-2014
An increasing fraction of hydrocarbon reserves are difficult or impossible to produce and process today mainly due to the complexity of the fluids. Production of these reserves will require new and innovative technologies. FACE will develop the knowledge base for the new predictive tools that will be essential in order to develop the new, innovative production solutions. It is expected that new SMB's will be generated based on knowledge and technology from the centre as well as development of new or improved products in existing companies.

The research is focused on transport and separation aspects of three thematic topics, i.e. heavy crude oils, dispersed systems (emulsions), and solid particulate suspensions (hydrates, wax, sand and fines). Fluid characterization is a central tool to describe complex fluids within the three thematic topics and a necessary input to hydrodynamic modeling.

We will use existing laboratories to perform both small-scale and high-pressure, large-scale flow experiments in pipes and separators. These experiments will be accompanied by multidimensional model development and their verification.

Collaborative effort between NTNU, SINTEF, IFE and UiO.

Particle-stabilized emulsions/Heavy crude oils, 2003 - 2007
The project aims at a better understanding of stabilizing and destabilizing mechanisms of water-in-crude oil emulsions based on heavy and particle-rich crude oils for improved separation and transport. The main technological goals to achieve will be to improve the water/oil/gas separation and sub-sea transport of multiphase systems. Separation: mechanisms of stabilization / destabilization / electrocoalescence / water and oil quality. Transport: energy input / emulsion stability / rheological models.

Technical collaboration: Ugelstad Laboratory, Sintef Energy, Statoil ASA and Vetco.

Treatment of Produced Water: Characterization and New Treatment Strategies.
Petromaks program (NFR).
The research tasks in this program will contribute to the development of new and improved technology for a more efficient and cost effective treatment of produced water from offshore installations. A fundamental necessity of developing and designing any treatment scheme is the knowledge and understanding of the fluid to be treated. The work on treatment strategies will focus on two areas: treatment of suspended constituents and of dissolved/soluble constituents. A major factor in achieving a zero harmful discharge to sea is the removal of suspended solids and dispersed oil from produced water. Particle separation is a fundamental process in any treatment process for the production of high quality effluent from an aqueous stream. The removal of dissolved constituents in produced water is necessary within the zero harmful discharge network. One of the research tasks in this proposal is to investigate the applicability of biological degradation of specific target compounds.

Development of new bio based materials using nanotechnology.
The main objective of this project, which is a collaboration with SINTEF and PFI is to create new functional biofibre-based materials with industrially attractive properties. Functionalized nano-sized cellulose microfibrils (MFC) will be developed by modification of never-dried MFC using tailored chemical coupling reactions.

Thermoresponsive Polymer Brushes on Nanoparticles and Surfaces (NFR FRINAT 2007-2010)
An interesting category of amphiphilic polymer systems are those who undergo phase transitions in response to environmental stimuli such as temperature and pH. These have been widely investigated for drug delivery, separations and diagnostics applications. The aim of this project is to develop an understanding - both mechanistic and applied - of different thermo-responsive polymers adsorbed to planar surfaces and particle substrates. Changes in structural and dynamic properties of the systems under various conditions will be examined.

This project is a collaborative effort between the Ugelstad laboratory and Dept. of Chemistry, UiO, with several international partners.

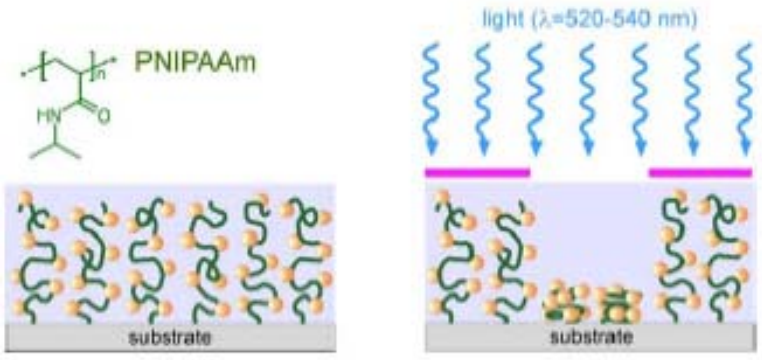


Figure 1: Schematic illustration of the "T-jump" modulated conformational transitions in surface-anchored PNIPAAm brushes. Gold nanoparticles will be loaded inside the brush and will attach to the NIPAAm monomers via H-bonds. Light having a wavelength close to the plasmon band of Au will be used to locally heat the particles, which in turn will cause collapse of the PNIPAAm chains. Through employment of a mask placed between the light course and the polymer, the PNIPAm collapse can be spatially modulated.

Structure, behaviour and reactivity of tetrameric naphthenic acids (ARN) in bulk and at w/o interfaces 2005-2008

The naphthenate R&D group at Statoil has done very systematic work during the past years to identify the structure of the naphthenic acid being the most active in forming metalnaphthenate deposits, which is a severe obstacle in processing of acid crudes. The results from the Statoil research in this field are pioneering, and have lead to the discovery of the so-called ARN naphthenic acid, which represents an acid family of C80 tetramers. The results from the Statoil discovery have recently been published, and one can foresee a heavy international scientific follow-up in this area in the years to come.

The objective of this programme is to focus on combining the efforts of the Statoil Naphthenate R&D Group and from our recently completed VISTA project. In the new VISTA programme, we are going to undertake a fundamental study of the ARN family of naphthenic acids with regard to clarify the structure(s), the physico-chemical properties, the interfacial activity and reactivity, selectivity in reaction patterns with multivalent cations, filmforming properties, etc.

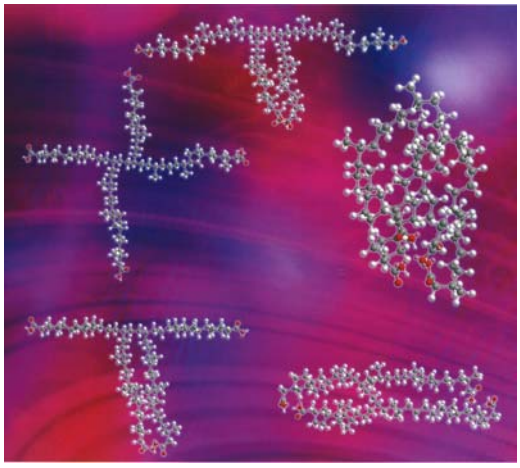


Figure 2: Archeal C_{80} isoprenoid tetraacids responsible for naphthenate deposition in crude oil processing.

Official opening of the new laboratory in 3rd floor,Chemistry building 5 (K5) by Head of Department Sigurd Skogestad and Professor Johan Sjøblom.

PROCESS SYSTEMS ENGINEERING GROUP

Academic staff
Professor Sigurd Skogestad
Professor Terje Hertzberg (until 30.11.07)
Professor Heinz A. Preisig
Associate professor Tore Haug-Warberg
Adjunct professor Kim H. Esbensen (until 28.02.07))

Post.docs.
Stefan de Graaf (Cybernetica)
Eduardo Shigueo Hori (until 30.11.07)
Sridharakumar Narasimhan

PhD candidates
Antonio Carlos Brandao Araújo (until 19.01.07)
Elvira Marie B. Aske
Olaf Trygve Berglihn
Håkon Dahl-Olsen
Ivan Dones
Magnus Glosli Jacobsen (from 06.08.07)
Jørgen Bauck Jensen
Johannes Jäschke (from 20.08.07)
Tore Lid (until 20.06.07)
Andreas Linhart
Bjørn Tore Løvfall
Henrik Manum
Heidi Sivertsen
Jens Petter Strandberg

Guests
Gerrit van Straten (Wageningen University, The Netherlands, 10.06. – 11.07.)
Sven Gruetzmann (PhD student from Hamburg Technical University, Germany, 18.06.-18.08.)
Jakub Osusky (PhD student from Slovak University of Technology, Bratislava, 16.04.-26.05.)

Process systems engineering deals with the overall system behaviour and how the individual units should be combined to achieve optimal overall performance. Important topics are multi-scale process modelling, operation and control, design and synthesis, and simulation, statistics and optimization. The group presently consists of more than 20 people, in addition to about 6 Diploma and project students. The group closely cooperates with other systems-oriented departments at the university, including Engineering Cybernetics, Energy and Process Engineering, and Industrial Ecology, and also with SINTEF. The process systems engineering activity at NTNU (PROST) holds high international standards and was already in 1994 recognized as a strong-point center, both by NTNU and SINTEF.

At present, the main activities in the group are within process control and process modelling including efficient thermodynamic calculations. A new area from 2008 is systems biology, where Nadi Bar started as Associate professor in January 2008.

Industrial use of advanced process control increases rapidly, and candidates who combine process knowledge and control expertise are in high demand in industry. Control is an enabling technology, thus basic for any industry-based society. The use of advanced control is transforming industries previously regarded as "low-tech" into "high-tech". In process control (Skogestad, Preisig), the objective of the research is to develop simple yet rigorous tools to solve problems significant to industrial applications (of engineering significance).

From left: Theo, Ivan, Ramprasad, Bjørn Tore, Henrik, Johannes, Stefan, Tore, Sigurd, Sridhar, Heinz, Helge, Magnus, Olaf, Tone, Heinz, and Mehdi

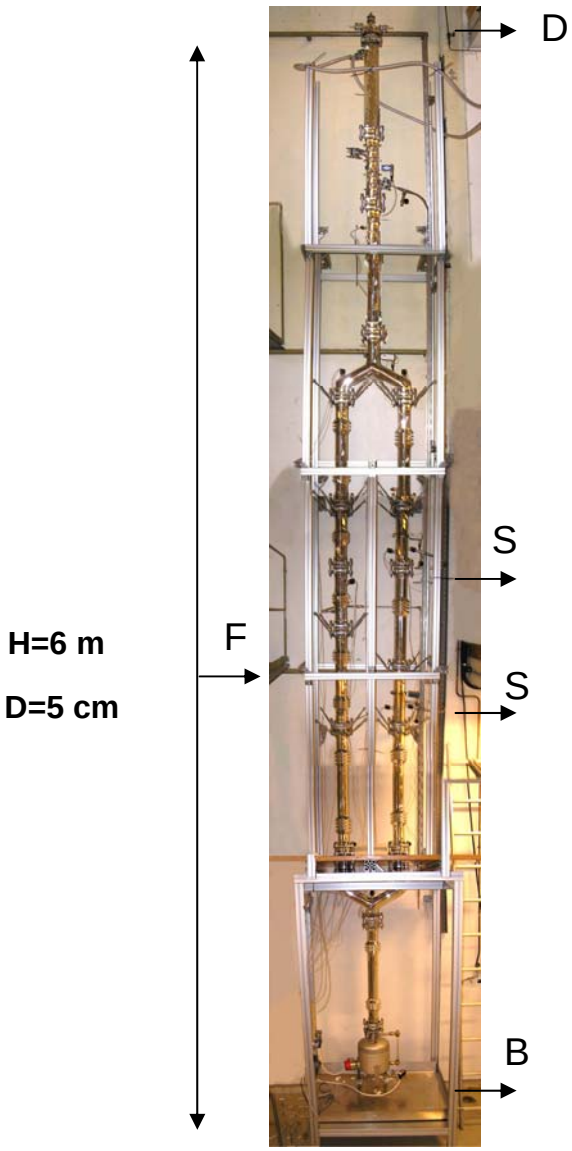
Up to now, the design of the overall "plant-wide" control structure has been based on engineering experience and intuition, whilst the aim has been to develop rigorous techniques. The concept of "self-optimizing control" provides a basis for linking economic optimization and control (Skogestad). For example, for a marathon runner, the heart rate may be a good "self-optimizing" variable that may be kept constant in spite of uncertainty. Control is done in a hierarchical construct. At the bottom of the hierarchy, the main issue is to "stabilize" the operation and follow the setpoints provided by the layer above. Further up in the hierarchy one finds optimising control co-ordinating the control of units and plants. A special case is sequential control, which is used to implement recipes in batch operations but also is the basics of handling start-up and shut-down as well as all fault and emergency handling. Another important concept is controllability, which links control and design. Here the main focus is on applications, which currently include reactor and recycle processes, distillation columns, gas processing plants, cooling cycles including liquefied natural gas (LNG) plants, low-temperature polymer fuel cells and anti-slug control. Small-scale experimental rigs have been built to study anti-slug control and novel distillation arrangements. In most cases, control is an "add-on" to enable and improve operation, but the anti-slug rig demonstrates how control in some cases can be used to operate the system in a completely different manner.

The Kaibel distillation column (see picture) is 6 meter high and 5 cm in diameter and can be used to study "thermally coupled" columns, including the three-product Petlyuk column and the four-product Kaibel column. The research in this area will be strengthened in 2008, through a grant from the research council where 2 new PhD students will be hired. Dr. Ivar Halvorsen from SINTEF and Sigurd Skogestad manage this integrated distillation project. The group also has an automatic drink mixer, which is used for demonstration purposes and to study sequence control based on automata theory (Preisig).

The centre piece of process systems engineering is the model. Modelling is seen as a difficult and time consuming operation. The step-wise approach developed in this group has transformed the art of modelling into a nearly procedural operation, which has been captured in a program environment. The modelling operation is thereby lifted up from writing equations to choosing concepts and mechanisms. The equations are then generated and assembled automatically taking the applicable equations from a data base that has buildt applying mechanistic descriptions where ever applicable. Multi-scale modelling is supported by enabling order-of-magnitude assumptions, which automatically induce model reduction thereby eliminating structure-related mathematical problems. The overall objective in the group is to develop efficient object-oriented software tools that implement this method and assist in developing consistent and structurally solvable process models on different scales that match the particular application. The technology is physics-based with extensions to allow for grey-box modelling. It aims at replacing various graphical interfaces to simulators and generates code for the major chemical engineering simulators such as gProms, Matlab, Modelica etc. but will also be able to generate stand alone, application-tailored simulators.
The fourth generation of a high-level modelling tool is presently being developed (Preisig), which we aim to apply to large-scale plants, including the Mongstad refinery. It incorporates object-oriented tools for efficient thermodynamic modelling, which extend into the efficient computation of thermodynamic information. Rather than a traditional implementation of activity or fugacity coefficients, emphasis is put on the use of structured equation sets governed by thermodynamic consistency rules (Haug-Warberg). The thermodynamic models are implemented in symbolic form with automatic differentiation capabilities and serves as the basis of several industrial strength simulations (YASIM, CADAS) and energy accounting tools (HERE) in co-operation with Norsk Hydro and Yara. A primary aspect of thermodynamic (and other physics) modelling is the required consistency of physical units. We have a procedure to obtain self-consistent models, including automatic generation of gradients. This technique has so far been tested up to sixth order gradients, which are needed for higher-order critical point calculations.

The model generally needs to be fitted to experimental data, and the group has always has a strong focus on statistical methods and experimental design (Hertzberg). Although Terje retired as professor in 2007, he is still active in this area, and in particular, in teaching. Unfortunately, professor Kim Esbensen had to discontinue his service as Adjunct Professor (professor II) because of heavy work load.

Funding comes from the Norwegian Research Council, the Gas Technology Center at NTNU and SINTEF, from industry (Statoil, Gassco, Hydro) and from the EU (Promatch program).



Kaibel Distillation column.

REACTOR TECHNOLOGY GROUP

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Hans Kristian Rusten
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Zhengjie Zhu

Guests
Feng Quin (PhD student from Tsinghua University, China, from 01.09.07)

The Reactor Technology group has concentrated its activities in fields directly supporting the design and development of chemical reactors and reactive separations. The most important research areas are:

- CO_2 capture by absorption into reactive absorbents
- Mathematical modeling of chemical reactors.
- Experimental analyses of fluid flow and heat transfer phenomena in chemical reactors.
- Multiphase flow modeling.
- Experimental validation of numerical models.
- Environmental technology (e.g., gas cleaning of CO_2).

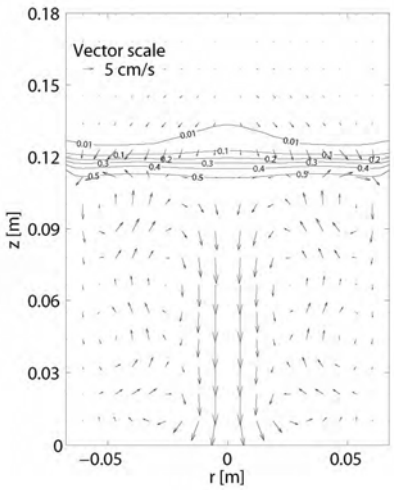
The research in these fields comprises both experimental and theoretical studies and we have a large range of well instrumented cold flow multi-phase reactors, as well as in-house software for multi-phase reactor simulations.

We are active users of Matlab, however, the computationally demanding models are implemented in FORTRAN 90 and C++. Application areas are special chemicals reactors, polymer production, synthesis gas and methanol synthesis, membrane reactors, and reactive absorption of acid gases (e.g. CO_2) including membrane contactors.

A stirred tank used for studies of heat transpt and flow phenomena.

Educationally the main objective of our group is to educate MSc for the Norwegian industry and to raise the national scientific competence in our field of research through PhD studies.

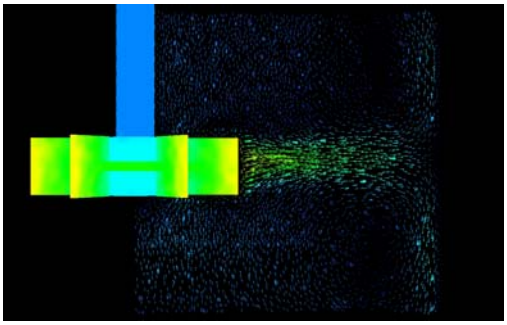
Research activities
The most important research projects are described in the following paragraphs. For a more comprehensive description, see our home pages: (http://www.chemeng.ntnu.no/research/reactmod/).



Flow pattern in a bubbling fluidized bed.

Modeling of multi-phase reactors
We have for more than 15 years been developing in-house CFD codes for simulating multiphase flows in chemical reactors. We also license the commercial CFD code FLUENT. Lately, our main focus has been put on developing modules for bubble/droplet break-up and coalescence within the population balance equation (PBE) framework.
The PBEs are solved accurately by efficient spectral methods designed for this particular purpose.

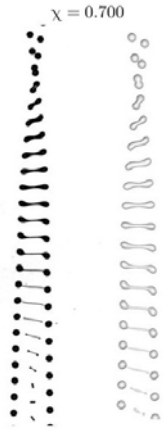
We are also investigating the performance of chemical reactive systems like fluidized beds, fixed bed reactors and agitated tanks. At present we are working with the design of suitable reactors for sorption enhanced reaction processes (SERP) like steam reforming with absorbents for CO_2.



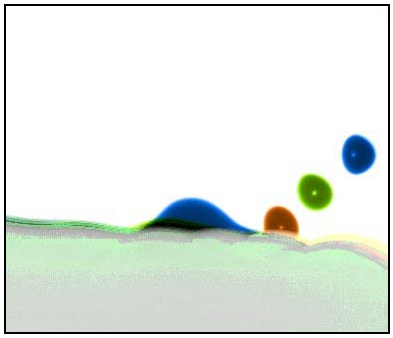
Simulation of the flow pattern from a turbine impeller.

The conventional 1D and 2D steady-state reactor models are normally run on standard PCs whereas the more computationally demanding dynamic 2D and 3D single and multiphase flow simulations are run on the national super-computers located at the university.

Removal of droplets from high pressure gases
An area of great importance for the Norwegian gas producing industry is the separating out of droplets from high pressure gases. Downstream process equipment e.g. compressors, separation processes or chemical reactors suffer disturbed operation or break-down if gases are not droplet free. Today's units are not good enough at high pressures, and robust and reliable solutions must be found in particular for sub-sea completions. The projects HiPGaS and now HiPGLS were established for studying the phenomena governing such separations. In collaboration with eleven industrial partners separation rigs have been established for both low and high (<150 bar) pressures at NTNU and at the StatoilHydro research center. Tests within the project have also been performed at semi-industrial scale at the K-lab facility at Kårstø. Results from the high pressure rigs are unique and form a basis for model validation. In addition a laser laboratory is built for the study of droplet/droplet and droplet/surface collisions and for studies on the stability and break-up of liquid surfaces leading to re-entrainment of droplets. The studies are performed with a strong interaction between experiments and numerical models which run in either desktop computers or the national High Performance Computing resources. For a compilation of video on experiments and numerical modelling results see: http://www.nt.ntnu.no/users/dupuy/video.php



Droplet collision leading to break-up. Experimental result to the left and model right.



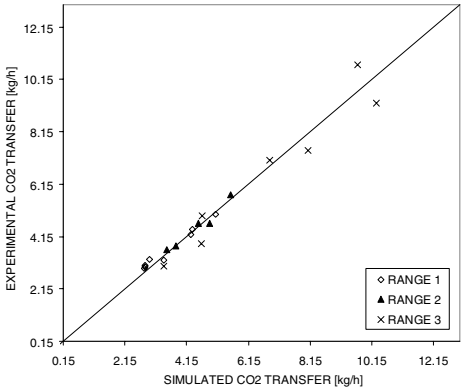
Droplet generation from liquid film re-entrainment. Fake colors to identify different time steps.

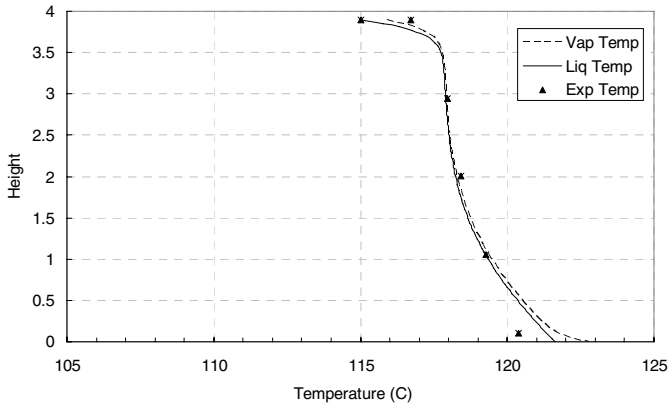
CO_2 removal from exhaust gases and natural gas.

The activity in this area comprises several projects, partly funded by the Research Council, industry and the European Union. Our work is concentrated along two axes, one studying CO_2 capture from off gases from fossil fueled power plants and from the iron and steel-making industry, and the other directed toward the removal of acid gases from natural gas. We have been heavily involved the EU FP6 Integrated Project CASTOR, see http://www.co2castor.com, being in charge of developing new solvent systems for CO_2 capture from exhaust gases from coal and natural gas fired power stations. The aim in CASTOR is to develop new solvents and process equipment that enables capture CO_2 at a cost of 20-30€/ton CO_2. This work involves al the steps from theoretical screening by use of computational chemistry, through experimental screening, characterization of equilibria, thermal properties, transport properties and kinetic, to testing in a laboratory pilot plant. In parallel we develop rigorous thermodynamic models and models for the mass transfer. In addition we have developed a full rate based simulator for the whole absorption/desorption process. In the ongoing EU FP6 project CAPRICE we are in charge of pilot plant data collection and simulation software validation. The work from CASTOR is now continued in the EU FP7 project CESAR where we also

have a leading role. Other projects in this area are EU FP6 ULCOS, and the Norwegian Research Council financed BIGCO2. In the CCERT, a JIP with four industrial partners, fundamental problems are addressed through 6-7 PhDs and 2 post docs..

Laboratory pilot plant for CO_2 capture by absorption





Comparison between simulated and experimental CO_2 mass transfer and desorber temperature profile


Ukens tema

Det handler om å redde
Det er bare snakk om hva vi er

Professor Hallvard Svendsen and Nils Røkke, SINTEF
(VG December15th 2008)

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Lei Shao
Willy Thelin (until 15.01.07)

Guests
Antti Tynys (PhD student from HUT, Finland)

The research in the group of Separation and Environmental Technology is focused upon the two main areas of membranes and crystallization/ precipitation. Material development, characterization and process simulations are key activities.

1. Membranes for gas separation and osmotic processes

The Memfo group (www.chemeng.ntnu.no/memfo) had during 2007 8 PhD-students, 3 Post.docs., 2 research scientists, 1 adjunct professor, and the head of the group, professor M-B Hägg).

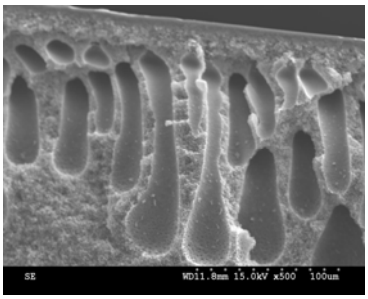
The group has extensive activities both on basic membrane material development, as well as membrane gas separation processes, modelling and simulations. The main focus for the research is CO_2 capture by membranes (from flue gas, natural gas sweetening, biogas upgrading) and hydrogen recovery from various mixed gas streams. In addition to these energy focused applications, we also do research on membranes for chlorine separation. The membrane materials in focus are various types of polymers, nano-composites, carbon membranes, and modified glass membranes. The international network is extensive, with co-operation both within EU-projects, USA, Japan, the Nordic countries and Russia.

Brief description of sample projects

a) EU FP6 project NaturalHy (www.naturalhy.net)
The project involves about 40 partners, and the main idea is to investigate the possibility of using the European gas network for co-transport of hydrogen with natural gas. Realising that the society only slowly will convert to hydrogen based energy, the idea is that hydrogen may be injected into the gas net at various places where it is produced, and then separated from the natural gas at points along the line where pure hydrogen is needed (e.g. for fuel cells). The task into which Memfo is doing research, is development of a suitable membrane for hydrogen recovery. Carbon molecular sieve membranes are investigated for this purpose. One post doc is engaged in the research, and very promising results have been documented. The project continues for 1 more year. The project co-ordinator is Gasunie in the Netherlands.

b) Membrane development for selective CO_2 capture
The membrane material being developed in this project contains a specific "carrier" which makes it selective for CO_2 while other gas components are being retained. The material is based on a polymer containing fixed amine groups as carriers. A significant progress has been achieved during the last couple of years, both with respect to CO_2-flux and selectivity compared to the other components in a mixed gas. The obtained results have drawn international attention. The membrane is now patented, and there are big expectations for the further development. Preparation for small scale pilot testing is now being done. One research scientist and two PhD students are working on the project. A focus on process development has also been initiated. Project partners are NFR, Statoil and Alstom, where the focus is CO_2 capture from flue gas as well as IGCC. There has also been interest from industry on other applications where CO_2 is present in the gas stream (natural gas sweetening, CO_2 removal from anaesthetic gas.)

***SEM-picture** showing a cut through a composite membrane. Thickness of selective layer is~2μm*



c) EU FP6 project NanoGloWa (www.nanoglowa.com)
The project kick-off was in November 2006 and the project is focusing on "Nano-structured membranes against Global Warming" (NanoGloWa). Memfo is a major partner in the project; task leader for two work packages focusing on development of carbon membranes and polymeric materials for CO_2 capture from power plants. The project also includes spinning of hollow fibres, module development and durability tests. One Post.doc. and one PhD student were attached to the project in 2007.

d) EU FP7 project DECARBit
The project is coordinated by Sintef and had kick-off in Feb 2008. The focus is pre-combustion separation. Carbon membranes are going to be tailored for this separation. The project also includes module development and durability tests.

e) KMB GASSMAKS project RECCO2
Preparation for the start-up of this project has been done in 2007. The objective is CO_2 removal from high pressure natural gas streams using a polymeric blend membrane. The project includes material development, pilot construction, durability tests and simulations.

f) Two projects within the Nanomat program / NFR
These projects are in cooperation with Sintef and North Carolina State University. In both projects the material development for hydrogen – CO_2 separation are in focus. There are two PhD-students on the US-side; one PhD and one Post doc on the NTNU-side, in addition to one "associated PhD" on the NTNU-side. The materials under development here are nano-composites (so called mixed matrix) and block copolymers – very challenging and very promising. Within this project a NASA award was granted during 2005 for a US patent.

g) Development of hybrid membrane for chlorine purification
Memfo is one of very few groups in the world doing research on membranes for the purification of chlorine gas. This is probably for security and safety reasons, and the challenge of handling this poisonous gas. The project is extremely challenging, but if successful, it will be a major step towards simplification of expensive and complicated unit operations for recovery of chlorine from various process streams. Chlorine is one of the major chemicals used in chemical process industry worldwide. The materials in focus are glass and perfluorinated polymers. There is co-operation with Japanese research in this project. Small steps forward have been documented during 2007, and one post doc is currently on the project. There is a major interest from industry in this project.

h) Development of membranes for pressure retarded osmosis
Statkraft has during the last decade been working towards a process for producing osmotic power using pressure retarded osmosis. The last three years Memfo has been participating with one research scientist in an international group developing membranes for this purpose. Other participants in the group are Sintef, GKSS (Germany) and EMI Twente (the Netherlands).

i) Project on membranes for osmotic processes - POPMOP
Towards the end of 2007 Memfo was granted a KMB project from Nanomat/NFR supported by Aqualyng, Statkraft and StatoilHydro. The project is aiming at studying and optimizing the synthesis of polymers for osmotic processes. Two PhD students and one research scientist will be attached to the program.

j) Various
The Memfo group works very much as a team rather than as individual projects. Hence the simulation of processes is handled whenever needed by those who have the competence. Likewise; the concern for environmental issues, leads to the focus also on biogas upgrading to vehicle fuel quality (biomethane). Carbon membranes has proved to be suitable for upgrading of biogas; documented by experiments and discussed in publications.

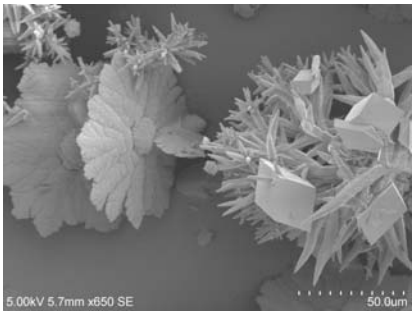
Memfo is also an active partner in the EU-project ENGAS http://www.ntnu.no/engas - a special project which promotes the laboratory facilities at NTNU/Sintef within energy, and make them available for international co-operation.

2. Crystallization
The research within crystallization is focused at kinetics of nucleation, crystal growth, and agglomeration in order to predict and control the particle size distribution and shape of crystalline particulate products for scale prevention and effects on down-stream processes like solid-liquid separation and powder characteristics. The crystallization group also investigates fundamental mechanisms in the early formation of solid particles which are of particular interest in the wet synthesis of nano-particles. Work to rebuild the crystallization laboratory was started in 2006 and this was completed in 2007. Here we present two projects and some of the results obtained in 2007.

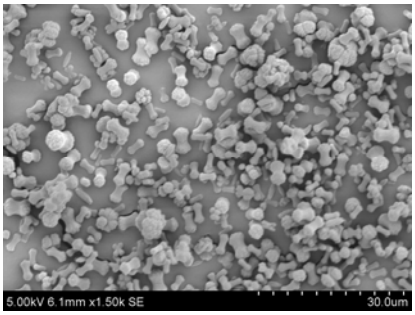
Optimisation of Glycol Loop Design and Operation
The aim of the project is to develop a simulation tool for glycol loops in processing of natural gas. This necessitates a deep understanding of the precipitation and crystallisation behaviour of salts and scale-forming carbonates in ethylene glycol (MEG) and water mixtures. Kinetics of calcium carbonate precipitation in the glycol injection point off-shore and the crystallization and separation of salts in the on-shore glycol reclamation units will be the main research tasks. The project is in collaboration with Institute of Energy Technology, Norway (IFE) and financed by several international oil and gas companies and the Research Council of Norway (NFR). Glycol injection point off-shore and the crystallization and separation of salts in the on-shore glycol reclamation units will be the main research tasks.

Studies performed in the crystallization group in 2007 have shown that the MEG significantly affects the induction time for precipitation, the particle size, and the

polymorphic composition of calcium carbonate. This will impact on the design of glycol loops and it also emphasises the need to update existing thermodynamic calculation packages to include these variations in the solid phase.



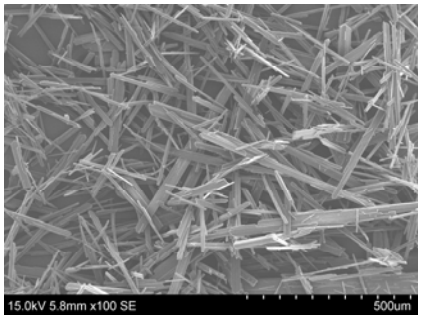
The polymorphic compostion of calcium carbonate at 50 ºC in water.



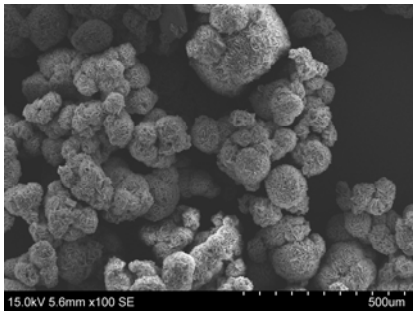
The effect of adding ethylene glycol to the precipitation of calcium carbonate at 50 ºC at comparable supersaturation.

Industrial Crystallization and Powder Technology
The goal of this project is to relate the filtration and washing characteristics and the resulting dry powder flow properties to the underlying growth and agglomeration phenomena. It involves studies of inorganic salts and pharmaceuticals, and the primary target for the activity at NTNU is to link the parameters in the crystallisation process to the subsequent filtration step by focusing on common mechanisms for these selected systems. The project is in collaboration with POSTEC at Tel-Tek and is financed by the Research Council of Norway (NFR) and Norwegian industry partners.

In 2007 we have investigated the effect of supersaturation and temperature on the particle design of pharmaceutical compounds. We have identified a general mechanism of crystal growth switching whereby the particle shape is dramatically altered. This is illustrated for the precipitation of sodium glutamate by switching from the well-known needle crystals of β-glutamic acid to spherical particles of the same polymorph. Filtration resistance measurements as well as powder flow properties measured by uniaxial testing has shown that these spherical particles are unwanted, and in some cases the conditions can be met to avoid their formation.



Conventional needle-shaped crystals of sodium glutamate.



Switching from needles to spherical crystals of sodium glutamate.

3. Membrane separation of liquids:
In 2006 Professor Norvald Nesse retired, but the work within separation of liquids with membranes which was his main research field, are continued in the group of Memfo; partly by involvement in the sample project mentioned below but also on production of biofuels and purification processes using membranes.

Sample project: **Developing Pressure Retarded Osmosis (PRO) for power production**.
Membrane separations in liquid media are well established in many processes and expected improvement may often be small and incremental, but still there are many open problems.
Reverse osmosis is today one of the major methods for desalting ocean water into freshwater. Osmotic effects demands that a high pressure on the saltwater side of the membrane modules must be applied to override the osmotic pressure difference between sea water and freshwater. If the applied pressure in the cells is lower than the osmotic pressure the water flow is reversed and freshwater flows into the saltwater compartment, thus increasing the volume of moderately pressurized saltwater. This is the principle of Pressure Retarded Osmosis (PRO), which may be used to produce electric energy as the surplus water on the saltwater side may be run through turbines for power production. The potential for power production at the outlet of every river that flows into the ocean is very large.
To make this principle to work economically, the membrane and its function is of very large importance. One of the problems to eliminate or reduce is the gradually fouling of the membranes by different impurities in the water and also the possibility of bacterial and algae growth on the membranes. This will gradually reduce the water flux through the membrane.

These problems have been investigated in two doctoral projects. The studies are performed in experimental membrane rigs, equipped with automatic cleaning cycles and remote data reading.
One set of experiments is performed in small cells which are designed to uncover the types of fouling that may occur on contacting Norwegian river water with sea water from a fjord. Cleaning procedures and frequencies of are tested during the experiments which run continuously for several months. Verifying experiments for comparison are performed in a local laboratory.
Another set of experiments on a larger rig is aiming at optimizing membrane modules of a new construction for use in salinity power plants. Included in this part of the project is also computer modelling of the flow through the modules. The experiments are done in cooperation with SINTEF and others, and are partly financed by Statkraft.

Professor May-Britt Hägg an postdocss Arne Lindbråten and Jon Arvid Lie with some of the new hollow fibre membranes which can remove CO_2 from biogas.

PAPER AND FIBRE TECHNOLOGY GROUP

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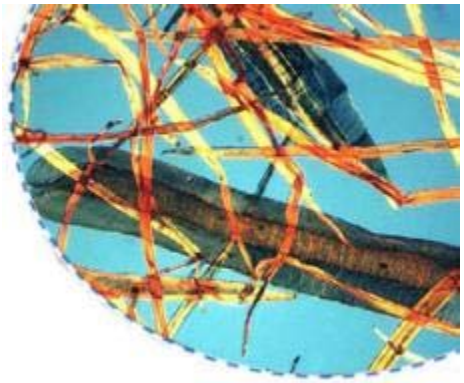
Marius Rusu (from 08.11.07)
David Vaaler



The size distributions of fibres and fines are essential for the papermaking properties of a pulp.

Teaching

The Paper and Fiber Technology group provides chemical engineers and PhDs for the Norwegian pulp and paper industry. The estimated need from the industry is 8-10 engineering graduates and about 2 PhD candidates per year. During 2006 3 MSc and 4 PhD candidates graduated from our group. We also gave two industry courses in Pulp and Paper technology and a course in pulp and paper technology at The Norwegian University of Life Sciences (UMB).

Partners

The Paper and Fibre group, Paper and Fibre research Institute (PFI) and parts of the Ugelstad laboratory (colloid and surface chemistry) are located in the same building on the NTNU Gløshaugen campus and are working in close cooperation. We also cooperate closely with pulp and paper industry partners such as Norske Skog, Södra Cell, Borregaard, Peterson and Voith.

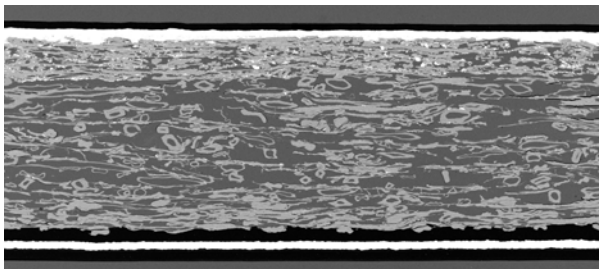
Research

Our research is focused on improvements in the pulp and paper process and on improved end product quality. Examples are:

- Improved runnability of printing paper by use of fracture mechanics as a tool in paper quality optimization.
- Reduced energy consumption and/or better fibre properties of mechanical pulp through high intensity refining, co-refining of different raw materials or pre-treatment of wood chips.
- Reduced print through defect in newsprint by optimized sheet structure
- Better strength and surface properties of wood-containing paper by use of micro-fibrillar cellulose as an additive.
- The influence of paper structure on mechanical, optical and surface properties of paper.

Trends

The last years a new activity on use of cellulose based particles in composite materials have started. Both better oxygen barrier and mechanical properties may be obtained by using cellulose fibres or fibrils as reinforcement in thermoplastic composites. Together with PFI a new research activity on the use of wood based bio-fuel production have also started. The goal is cost effective production of bio-diesel and ethanol from wood. Further, energy effective production is one of the primary concerns of the pulp and paper industry and thus also an important research area now and in the future.



The mechanical and barrier properties of a paper material depend on the material choice and structure. The SEM image of the cross section of a liquid board shows (from top) a Polyethylene (PE), mineral coating, kraft pulp, CTMP, kraft pulp, PE, Aluminium layer and PE.

CHAPTER 3: PUBICATIONS

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Johan Sjöblom, Editor-in-Chief:
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114. **Sheridan, Edel; Hagg, May-Britt**. Preparation of Carbon Molecular Sieve Membranes by Pyrolysis [Vitenskapelig foredrag]. KIFEE - Kyoto International Forum on Materials, Energy and Enviornment; 04.12.2007 - 07.12.2007

115. **Sheridan, Edel; Hagg, May-Britt**. The Development of Carbon Hollow Fibre Membranes for CO_2 separation in Industry [Vitenskapelig foredrag]. Network Young Membrains 9; 27.09.2007 - 28.09.2007

116. **Sheridan, Edel; Hagg, May-Britt**. The Development of Hollow Fibre Membranes for the Separation of CO_2 from flue gases [Vitenskapelig foredrag]. The 4th Trondheim Conference on CO_2 capture, transport and storage; 16.10.2007 - 17.10.2007

117. **Silberova, Bozena; Aartun, Ingrid; Venvik, Hilde Johnsen; Walmsley, John C.; Holmen, Anders**. Effects of catalyst loading in partial ozidation and oxidative stem reforming of propene over Rh-impregnated alumina foams [Vitenskapelig foredrag]. 8th Natural Gas Conversion Symposium; 27.2007 - 31.05.2007

118. **Simon, Sebastien Charles; Theiler, Stefan; Knudsen, Agnethe; Øye, Gisle; Sjøblom, Johan**. Rheological properties of particle-stabilised emulsion [Poster]. The 8th International Conference on Petroleum Phase Behavior and Fouling; 10.06.2007 - 14.06.2007

119. **Strandberg, Jens; Skogestad, Sigurd**. Optimal operation of a 4-product integrated Kaibel column [Vitenskapelig foredrag]. 14th Nordic Process Workshop; 23.08.2007 - 25.08.2007

120. **Svendsen, Hallvard Fjøsne**. CCS Technologies for the future [Vitenskapelig foredrag]. 14th RSCE 07-Frontiers in Chemical Engineering,; 04.12. - 05.12.2007

121. **Svendsen, Hallvard Fjøsne**. CCS Technologies for the future [Vitenskapelig foredrag]. The 4th Trondheim Conference on CO_2 Capture, Transport and Storage ; 16.10.2007 - 17.10.2007

122. **Svendsen, Hallvard Fjøsne**. CO_2 fangst og lagring [Vitenskapelig foredrag]. Presentasjon for Næringsministeren 2007

123. **Svendsen, Hallvard Fjøsne**. Learning from CASTOR: solvent, pilot plant and modeling work [Vitenskapelig foredrag]. 10th MEETING of the INTERNATIONAL POST-COMBUSTION CO_2 CAPTURE NETWORK ; 24.05.2007 - 25.05.2007

124. **Svendsen, Hallvard Fjøsne**. Post combustion CO_2 Capture [Vitenskapelig foredrag]. US.Norwegian Summer School 2007

125. **Svendsen, Hallvard Fjøsne; Dorao, Carlos Alberto; Jakobsen, Hugo Atle**. Modeling Bubble columns [Vitenskapelig foredrag]. International Workshop on Industrial Multiphase flows and Reactors; 06.12.2007 - 07.12.2007

126. **Svendsen, Hallvard Fjøsne; Tobiesen, Finn Andrew**. Modelling of absorber and desorber for CO_2 capture [Vitenskapelig foredrag]. IFP 2007

127. **Tucho, Wakshum Mekonnen; Mejdell, Astrid Lervik; Klette, Hallgeir; Walmsley, John C; Holmestad, Randi; Bredesen, Rune**. H2 permeation and microstructure studies of 1.5 µm Pd/Ag membranes [Poster]. NANOMAT Conference; 05.06.2007 - 07.06.2007

128. **Tucho, Wakshum Mekonnen; Walmsley, John C; Holmestad, Randi; Mejdell, Astrid Lervik; Venvik, Hilde Johnsen; Bredesen, Rune; Klette, Hallgeir**. Microstructural studies of thin self-supported Pd/Ag membranes tested in air and in inert gas: a comparative study [Vitenskapelig foredrag]. FUNMAT meeting; 08.06.2007 - 08.06.2007

129. **Volden, Sondre; Glomm, Wilhelm**. Adsorption of Cellulose and PNIPA Am-polymers on Planar and Curved Surfaces [Vitenskapelig foredrag]. Gjesteforelesning 2007

130. **Volden, Sondre; Opedal, Nils; Roel, Marius; Glomm, Wilhelm**. Plasmonic Nanoparticles: Preparation and characterization [Vitenskapelig foredrag]. Gjesteforelesning 2007

131. **Wangen, Espen Standal; Blekkan, Edd Anders**. Characterisation of products from cracking of heavy oils [Poster]. Molecular Structure of Heavy Oils and Coal Liquefaction Products; 12.04.2007 - 13.04.2007

132. **Xiong, Jianmin; Blekkan, Edd Anders; Walmsley, John C.; Holmen, Anders**. Synthesis of nano-sized cobalt colloids sypporten on γ-Al_2O_3 [Poster]. EuropaCat VIII; 26.08.2007 - 31.08.2007

133. **Zhang, Xiangping; Strømman, Anders Hammer; Preisig, Heinz A.; Dones, Ivan; Solli, Christian; Hertwich, Edgar G.**. Modeling-based method: early planning and design of an Eco-industrial Park [Vitenskapelig foredrag]. 2007 International Society of Industrial Ecology Conference; 17.06.2007 - 20.06.2007

134. **Zhao, Tiejun**. Universal principles in CNF/CNT synthesis [Vitenskapelig foredrag]. 3rd NTNU Seminar - Synthesis and Applications of Carbon Nanofibers/Nanotubes 2007

135. **Zhao, Tiejun; Ochoa-Fernandez, Esther; Rønning, Magnus; Chen, De**. Fabrication and High-Temperature CO_2 Capture Properties of Nanocrystalline Na2ZrO3 [Poster]. NANOMAT conference 2007; 04.06.2007 - 09.06.2007

136. **Zhao, Tiejun; Ochoa-Fernandez, Esther; Rønning, Magnus; Chen, De**. Preparation and High-temperature CO_2 capture properties of nanocrystalline Na_2ZrO_3 [Poster]. 2nd NTNU NanoLab User Meeting 2007

137. **Zhao, Tiejun; Ochoa-Fernandez, Esther; Rønning, Magnus; Chen, De**. Preparation of nanocrystalline alkali zirconate as high-temperature CO_2 acceptors [Vitenskapelig foredrag]. International conference on clean energy technology 2007

138. **Zhao, Tiejun; Zhu, Jun; Kvande, Ingvar; Chen, De; Zhou, Xinggui; Yuan, Weikang**. Controlled Synthesis Of Carbon Nanostructures By Growth Temperature [Vitenskapelig foredrag]. EuropaCat VIII, 2007; 26.08.2007 - 31.08.2007

139. **Zhu, Zhengjie; Dorao, Carlos Alberto; Jakobsen, Hugo Atle**. A LSDMM Solution To A Coalescence Dominant PBE [Poster]. PBM 2007 - 3rd International Conference on Population Balance Modelling; 19.09.2007 - 21.09.2007

CHAPTER 4: EDUCATION

Chemical Engineering

The specialization in Chemical Engineering starts in the third year with the basic technological courses in Separation Technology, Reaction Engineering, Thermodynamics and Process Design. In the fourth year the students elect further specializations for the remaining of the studies. The students choose between 6 specializations: Petrochemistry and Catalysis, Colloid and Polymer Chemistry, Separation Technology, Reactor Technology, Process Systems Engineering and Pulp and Paper Chemistry.

The goal of the education is a Master (MSc) at a high international level in Chemical Engineering.

Students with a bachelor degree in a relevant area from colleges can be admitted to the fourth year of the MSc-degree programme (2 year MSc programme). The degree provides the candidates qualifications for jobs in a wide range of industries, as well as the public sector and in research. It is also the basis for admission to the PhD-studies in Chemical Engineering.

Master courses given in 2007:

Number	Course title	Year	Registered	Passed	
TKP4100	Fluid Flow and Heat Transfer	2	67		47
TKP4105	Separation Technology	3	56		40
TKP4110	Chemical Reaction Engineering	3	72		56
TKP4115	Surface and Colloid Chemistry	3	40		23
TKP4120	Process Engineering	2	134		114
TKP4125	Paper and Fiber Technology	4	3		2
TKP4130	Polymer Chemistry	4	21		20
TKP4135	Chemical Process Dynamics and Optimization	4	9		7
TKP4140	Process Control	4	10		8
TKP4145	Reactor Technology	4	5		5
TKP4150	Petrochemistry and Oil Refining	4	29		23
TKP4155	Reaction Kinetics and Catalysis	4	44		38
TKP4160	Transport Phenomena	4	25		14
TKP4165	Process Design	4	35		30
TKP4170	Process Design, Project (autumn)	4	17		17
TKP4171	Process Design, Project (spring)	4	6		6
TKP4510	Catalysis and Petrochemistry, Specialization Project	5	11		11
TKP4515	Catalysis and Petrochemistry, Specialization Course	5	10		10
TKP4520	Colloid and Polymer Chemistry, Specialization Project	5	7		7
TKP4515	Colloid and Polymer Chemistry, Specialization Course	5	7		7
TKP4530	Reactor Technology, Specialization Project	5	1		1
TKP4535	Reactor Technology, Specialization Course	5	1		1
TKP4540	Separation and Environmental Technology, Specialization Project	5	7		7
TKP4545	Separation and Environmental Technology, Specialization Course	5	7		7
TKP44550	Process Systems Engineering, Specialization Project	5	5		5
TKP4555	Process Systems Engineering, Specialization Course	5	5		5
TKP4560	Paper and Fibertechnology, Specialization Project	5			
TKP4565	Paper and Fibertechnology, Specialization Course	5			
TKP4850	Experts in Team, Interdisciplinary Project	4	23		23
TKP4500	Final Year Design, for Spanish students	5	5		5

Master theses 2007

Berntsen, Helene
Sorption enhanced steam reforming of ethanol
Supervisor: De Chen

Bjørn, Christian Melby
Destabilization of water-in-oil crude oil emulsions in a compact electrostatic coalescer
Supervisor: Johan Sjöblom

Ekerbakke, Hilde
CO_2 absorption : changing equilibrium
Supervisor: Hallvard Svendsen

Fossan, Åse-Lill
Catalyst systems for Fischer - Tropsch synthesis
Supervisor: Anders Holmen

Haugbråten, Kristin Sarsten
A multivariate approach to water-in-crude oil emulsion stability and destabilization
Supervisor: Johan Sjöblom

Haugen, Petter Hande
Optimal Operation and Control of Kaibel Distillation Column
Supervisor: Sigurd Skogestad

Haugland, Lise
Preparation, characterization and catalytic testing of platinum/SBA-15 catalysts.
Supervisor: Edd A. Blekkan

Huynh, Dao Bich Thi
Effect of Coarse Fibre Fractions in Sulphate pulp on paper properties
Supervisor: Øyvind W. Gregersen

Håland, Torfinn
Synthesis and characterisation of colour agent formed by production of x-ray contrast medium
Supervisor: Dick Malthe-Sørenssen

Jacobsen, Magnus Glosli
Optimal operation of cooling cycle/LNG process
Supervisor: Sigurd Skogestad

Jensen, Kristian Holm
Hollow Fiber membrane spinning
Supervisor: May-Britt Hägg

Jentoft, Gunn Heidi
Adsorption of surfactants and indigenous crude oil components onto model surfaces for gas hydrates, as studied by Quartz Crystal Microbalance.
Supervisor: Johan Sjöblom

Jørgensen, Vegard
Numerical investigation of integrated reactor-separator designs for pre-combustion with CO_2 Capture
Supervisor: Hugo A. Jakobsen

Kompalla, Thomas
Petroleum Flow Assurance - Rheological Properties and Wax Deposition
Supervisor: Johan Sjöblom

Kordahl, Sina
Advanced Processes for Natural Gas Conversion
Supervisor: De Chen

Krogstad, Marit Kristin
Numerical analysis of multicomponent mass diffusion in catalyst pellets for combustion with and without carbon dioxide (CO_2)-capture
Supervisor: Hugo A. Jakobsen

Mellbye. Andrea Strindberg
Investigation of crystallization processes with ATR-FTIR and Lasentec FBRM
Supervisor: Jens-Petter Andreassen

Nilsen, Robert
Preparation, characterization and testing of platinum catalysts based on SBA-15.
Supervisor: Edd A. Blekkan

Noreng, Lars Erik
Particle interactions at liquid-gas surfaces and adsorption onto particles in bulk solutions.
Supervisor: Gisle Øye

Pettersen, Martin Vignes
Characterization of adsorbents for heavy oil upgrading
Supervisor: Edd A. Blekkan

Riseggen, Henning
Viscosity measurements in hydrocarbon mixtures.
Supervisor: Hallvard Svendsen

Schønning, Magnus
CO_2 absorption: VLE measurements
Supervisor: Hallvard Svendsen

Sletengen, Kine
Design and preparation of heterogeneous catalysts for the water-gas shift reaction
Supervisor: Hilde J. Venvik

Solberg, Anette
Partial oxidation of methane by chemical looping
Supervisor: Anders Holmen

Tandstad, Ingfrid Karin
SSITKA - studies of Ficher-Tropsch catalysts.
Supervisor: Anders Holmen

Tjosevik, Marie
Jet stability in gas-liquid systems.
Supervisor: Hallvard Svendsen

Tomter, Anne
Autoignition of synthesis gas leaks
Supervisor: Anders Holmen

Vårdal, Ingeborg Herum
Characterization of heavy oils by spectroscopic methods
Supervisor: Edd A. Blekkan

Østli, Kristian
A study of hydrotalcite supported catalysts for selective hydrogen combustion.
Supervisor: Edd A. Blekkan

5rd year students 2007/2008

Aulie, Martin Håkon
Beinset, Morten
Bekkevold, Jan Petter
Bergstedt, Elin
Braathen, Bjarne
Elde, Ingrid Elise
Ellingsen, Christian
Evensen, Trond
Fagerbekk, Siri Albertsen
Fahadi, Jalal
Fjeldstad, Lars Johann
Fostenes, Siv Monica
Frøseth, Fredrik
Fævelen, Erlend Schou
Haukebø, Siv Hustad
Husås, Ranveig
Jonassen, Øystein
Jøndahl, Mari
Karlsen, Cathrine Hval
Kleppa, Gøril
Knudsen, Agnethe
Lie, Marianne
Opedal, Nils
Pettersen, Tone Sejnæs
Skogestad, Hanne
Smedsrud, Helge
Solsvik, Jannike
Spets, Øyvind
Theogene, Uwarwema
Tveten, Erik Zakarias
Vatneberg, Stine V.
Zhu, Ye
Aarhoug, Kristin

4rd year students 2007/2008

Bjartnes, Kirsti
Borander, Andreas Høiem
Enaasen, Nina
Helberg, Ragne Marie Lilleby
Holsæter, Hege Christine
Høyen, Ragnhild
Haaversen, Linn christine Loe
Johansen, Hege Døvle
Jonassen, Øystein
Kalstad, Tone
Mæhle, Inger Roksvåg
Nenningsland, Andreas Lyng
Nergård, Liv-Turid
Roll, Sebastian
Røsting, Kristine
Sjulstad, Johanne Schjellungen
Storsæter, Kathrine
Tuvnes, Eirik Fatnes
Tørneng, Eirik Fatnes
Vaktdal, Hanne Margrethe
Vattekar, Petter Tangen
Vik, Camilla Berge
Østbye, Helene
Aaserud, Jo

3rd year students 2007/2008

Almeland, Silje Kreken
Bøen, Runar Holten
Helgestad, Dag-Erik
Hesstvedt, Camilla
Hyllestad, Elisabeth Lovise R.
Jacobsen, Julie Berild
Jens, Christian
Lillebø, Andreas Helland
Munkejord, June
Ringstad, Renate
Roel, Carl Marius
Roset, Stine Thysnes
Røed, Anders Haukvik
Skarsgard, Torstein Gaarder
Skjeldestad, Kjetil
Tvedt, Arne Hetland

Student exchange 2007

16 students from our Department (10 females and 6 males).

Name	To Institution	Programme	Period
Braathen, Bjarne	Universität Karlsruhe, Germany	Erasmus	01.09.06 – 01.08.07
Evensen, Trond	Curtin University, Perth, Australia	Individual	01.02. 07 –30.06.07
Fagerbekk, Siri Albertsen	ETH, Zürich, Switzerland	Erasmus	01.09.06 – 01.07.07
Fahadi, Jalal	American Univ. of Sharjah, United Arab Ermirates	Individual	01.01.07 – 30.06.07
Haaversen, Linn Christine L.	University of Granada, Spain	Erasmus	01.10.07 – 01.07.08
Holsæter, Hege Christine	University of Bath, England	Erasmus	01.09.07 – 30.06.08
Karlsen, Cathrine	Ecole Nationale Supérior des Ing., France	Erasmus	04.09.06 – 30.06.07
Pettersen, Tone Sejnæs	University of British Colombia, Canada	Bilateral	01.09.06 - 01.06.07
Sjulstad, Johanne	ETH Zurich, Switzerland	Individual	28.08.07 – 15.02.08
Skogestad, Hanne	University of Texas, Austin, USA	Bilateral	30.08.06 – 01.06.07
Tørneng, Eirik Fatnes	University of California, Santa Barbara,USA	Erasmus	01.09.07 – 30.06.08
Tøsdal, Kjersti Blytt	Universität Karlsruhe, Germany	Erasmus	20.10.06 – 20.08.07
Tuvnes, Henrik Johan	University of California, Santa Barbara,USA	Individual	01.09.07 – 30.06.08
Vaktdal, Hanne Margrethe	École Supérieure de Chimie Physique Électronique de Lyon, France	Erasmus	01.09.07 – 31.12.07
Vatneberg, Stine Vemmestad	Technische Universitãt Berlin, Germany	Erasmus	01.09.06 – 01.08.07
Vattekar, Petter Tangen	University of Calgary, Canada	Individual	01.09.07 – 30.06.08

24 exchange students to our Department, (14 females and 12 males)

Name	From Institution	Programme	Period
Bengoechea Cabonargi, Ander	University of the Basque Country, Bilbao, Spain	Erasmus	07/08
Bonet, Ana Domingo	Universitat Rovira I Virgili, Spain	Erasmus	07/08
Cagigas, Ana	Universidad del Pais Vasco, Spain	Erasmus	07/08
Campllonch Roig, Roger	Universidad Rovira I Virgili, Spain	Erasmus	06/07
Carlier, Matthieu	Ecole Nationale Supérieure (ENSIACET) France	Erasmus	07
De Wispelaere, Irene Martine	RWTH Aachen, Germany	Erasmus	07
Domingo Bonet, Anna	Universitat Rovira i Virgili, Spain	Erasmus	07/08
Garcia Aparici, Daniel	Universidad Autonoma de Madrid, Spain	Erasmus	06/07
Hernaiz Esteban, Joseba	University of the Basque Country, Bilbao, Spain	Erasmus	06/07
Hoffmann, Martin	Technische Universität Berlin, Germany	Erasmus	07/08
Iñigo Arrillaga, Mikel	University of the Basque Country, Bilbao, Spain	Erasmus	06/07
Korak, Julie	University of Colorado, USA	Free mover	06/07
Lavall Jambert, Maria	Universitat Politecnica de Catalunya, Spain	Erasmus	07/08
Lopez Gutierrez, Bartolome	Universidad de Granada, Spain	Erasmus	07/08
Machado Miguens, Andrea C.	Universidad Simón Bolivar, Venezuela	Bilateral	07/08
Melgareo, Jose Enrique Sanchez	Universidad de Granada, Spain	Erasmus	06/07
Mir Gaya, Eva	Universitat Politecnica de Catalunya, Spain	Erasmus	07/08
Paldusova, Daniela	Institute of Chemical Technology Prague, Czech Republic	Erasmus	07
Sanchez Melgareio, Jose Enrique	Universidad de Granada, Spain	Erasmus	06/07
Salas, Jérémie	Université Franche-Comté Besancon, France	Individual	07/08
Schubert, Marco Peter	University of Emden, Germany	Fellowship	07/08
Terra, João	Universidade Técnica de Lisboa, Portugal	Erasmus	06/07
Voigt, Carolin	University of Applied Science, Emden, Germany	Individual	07
Wing Lam, Cheong	The Hong Kong Polytechnic University, China	IAESTE	07

PhD courses given:

KP8100 Advanced Process Simulation
KP8102 Wood Chemistry in Pulping and Paper Making
KP8104 Industrial Crystallization and Precipitation
KP8105 Methematical Modelling and Model Fitting
KP8106 Gas Cleaning with Chemical Solvents
KP8107 Advanced Course in Membrane Separation Process
KP8108 Advanced Thermodynamics: With applications to Phase and Reaction Equilibria
KP8109 Environmental Catalysis
KP8110 Membrane Gas Purification
KP8111 Catalytic Conversion of Hydrocarbons
KP8112 Applied Heterogeneous Catalysis
KP8113 Characterizaton of Heterogeneous Catalysts
KP8115 Advanced Process Control
KP8116 Colloid Chemistry for Process Industry
KP8117 Paper Physics and Paper Chemistry
KP8118 Advanced Reactor Modelling
KP8119 Surfactants and Polymers in Aquous Soutions
KP8120 Colloid Chemistry and Functional Materials

PhD-Theses 2007

Andresen, Martin
Surface Modification of Microfibrillated Cellulose
Supervisor: Johan Sjöblom

Araujo, Antonio Carlos Brandao
Studies of Plantwide Control
Supervisor: Sigurd Skogestad

Borg, Øyvind
Role of Alumina Support in Cobalt Fischer-Tropsch Synthesis
Supervisor: Anders Holmen

Chytil, Svatopluk
Platinum supported on mesoporous silica SBA-15: preparation, characterization and catalytic properties
Supervisor: Edd A. Blekkan

Dyrbeck, Hilde
Selective catalytic oxidation of hydrogen and oxygen-assisted conversion of propane
Supervisor: Edd A. Blekkan

Fossen, Martin
Aggregation, Interfacial Properties and Structural Characteristics of Asphaltene Solubility Fractions
Supervisor: Johan Sjöblom

Grainger, David Ryan
Development of carbon membranes for hydrogen recovery
Supervisor: May-Britt Hägg

Johnsen, Cecilie Gotaas
Experimental and Numerical Investigation of Droplet Phenomena
Supervisor: Hugo A. Jakobsen

Johnsen, Ingvild Andersen
The impact of dissolved hemicelluloses on adsorption of wood resin to TMP fines
Supervisor: Johan Sjöblom

Kvande, Ingvar
Carbon nanofiber supported platinum catalysts
Supervisor: De Chen

Lid, Tore
Data reconciliation and optimal operation. With applications to refinery processes
Supervisor: Sigurd Skogestad

Ochoa-Fernandez, Esther
CO2 Acceptors for Sorption-Enhanced Steam Methane Reforming
Supervisor: De Chen

Thelin, Willy
Fouling in pressure retarded osmosis
Supervisor: Norvald Nesse

Wangen, Espen
Characterisation and pyrolysis of heavy oils
Supervisor: Edd A. Blekkan

Zenith, Federico
Control of Fuel Cells
Supervisor: Sigurd Skogestad

PhD students from our Department visited other Universities in 2007

Name	University/Country	Period
Beck, Ralf	Laapenranta University, Finland	02.10.06 – 28.02.07
Dahl-Olsen, Håkon	University of Minnesota, USA	18.09.05 – 31.12.06

7 PhD exchange students visited our Department in 2007 (2 female and 5 male).

Name	University/Country	Group located
Bimbela, Fernando	Universidad de Zaragoza, Spain	Catalysis and Petrochemistry Group
Gruetzmann, Sven	Hamburg Technical University	Process Systems Engineering Group
Králová, Iva	Brno University, Czech Republic	Colloid- and Polymer Group
Lögdberg, Sara	KTH, Sweden	Catalysis and Petrochemistry Group
Ousky, Jakub	Slovak University of Technology, Bratislava	Process Systems Engineering Group
Qin, Feng	Tsinghua University, Beijing, China	Reactortechnology Group
Tynys, Antti	HUT, Finland	Catalysis and Petrochemistry Group
Zhu, Jun	East China University of Science, Shanghai China	Catalysis and Petrochemistry Group

Suplementery education

EVU-course KP6001 Offshore Processing, 15.01. – 19.01, and 29. 01. – 02.02.2007. There were 11 participants, those who passed the exam got 6 ECTS.

Responsible for the course: Professor May-Britt Hägg and Adjunct Professor John Daniel Friedemann

Seminars and meetings organized by the Department in 2007

Workshops:

Eurokin Meeting – Workshop on Dynamic Methods, 02.10.2007, 30 participants

Clean Energy by use of Membranes, Workshop CEPEME, 27.04.2007

Seminars:

Seminar on Catalysis for Clean Energy, International seminar, 30 participants, 23.08.2007

3rd NTNU Seminar – Synthesis and Applications of Carbon Nanofibers&/Nanotubes, International seminar, 40 participants 14.02.2007

Seminar in Heterogeneous Catalysis
Professor Georg Schaub, Enger-Bunte-Institut der Universität Karlsruhe, Germany,
Reasearch in Karlsruhe on Fischer-Tropsch synthesis, 27.06.2007

Professor De Chen, Chinese-Norwegian Seminar on Catalysis for Clean Energy, 23.08.2007

Professor Dendy Sloan, Kelly Miller, Carolyn Koh, Colorado School of Mines, USA,
Gas Hydrate Short Course, May 29-31. 2007

Associate professor Hilde Venvik: Basics of solar cells, 23.03.2007

PhD student Fernando Bimbela, Hydrogen production by catalytic steam reforming of bio-oil, research at the GPT, 21.09.2007

PhD student Fatemeh Hayer, Compact production of di-methyl-ether (DME), 16.11.2007

Professor Bjørn Lindman, Lund University,
Surfactant and Polymer Solutions. Bulk and Interfacial Aspects, 21-22 of August 2007

Seminar in Industrial Crystallization, Oslo, arranged by Crypow at NTNU, SINTEF and Tel-Tek, 29.11.2007 Responisble for the seminar Associate professor Jens-Petter Andreassen and Adjunct professor Dick Malthe-Sørenssen. 22 participants

Guest lectures:

Professor Arthur J. Ragauskas, Georgia Institute of Technology, USA
Biofuel from wood - an American perspective, 03.05.2007

Professor Ton Backx, Eindhoven University, The Netherlands
Model reduction for model based control, 20.06.2007

Professor Kai Sundmacher, Max Planck Institute, University of Magdeburg, Germany.
Fuel Cells: Modelling and Dynamics , 29.06.2007

Dr. Valerie Dupont, Energy and Resources Research Institute, School of Process, Environmental and, Materials Engineering, The University of Leeds, UK
Reasearch in bio- and wastefuels at Leeds University, 27.06.20/07

Professor Janne Laine, Department of Forest Products Technology, Helsinki University of Technology, Finland
Papermaking chemistry, *Utilisation of different nanostructures*, 30.08.2007

Dr. Stig Are Gundersen, Lignotech R&D, Borregaard Ind.
Lignosulphonates as emulsion stabilizers – Agrochemical case study, 30.08.2007

CHAPTER 7: ORGANIZATION - ECONOMY

Organization (also see cover page)

The Head of department is elected for a four-year period (mid 2005 – mid 2009). The scientific staff is divided in to six research groups. Each research group has a representative in the management team. The Management team has also representatives from the Ph.D's, the students and technical staff. The management team meets every second week and discusses running matters. In addition, the department has 14 persons in a technical and administrative staff to support teaching and research of all the research groups.

Administrative responsibilities of faculty

Faculty Educational Committee (Department representatives)	Professor Edd Anders Blekkan
Faculty Research Committee (Department representatives)	Professor Hallvard Fjøsne Svendsen
Study Program Chemical Engineering and Biotechnology (Industriell kjemi og bioteknologi) (Department representatives)	Professor Øyvind W. Gregersen
Exchange of Norgwegian students taking courses abroad (approval of course program), and approval of course program for visiting exchange students.	Professor Øyvind W. Gregersen
International Master program	Assosiate Professor Jens-Petter Andreassen

Department Economy

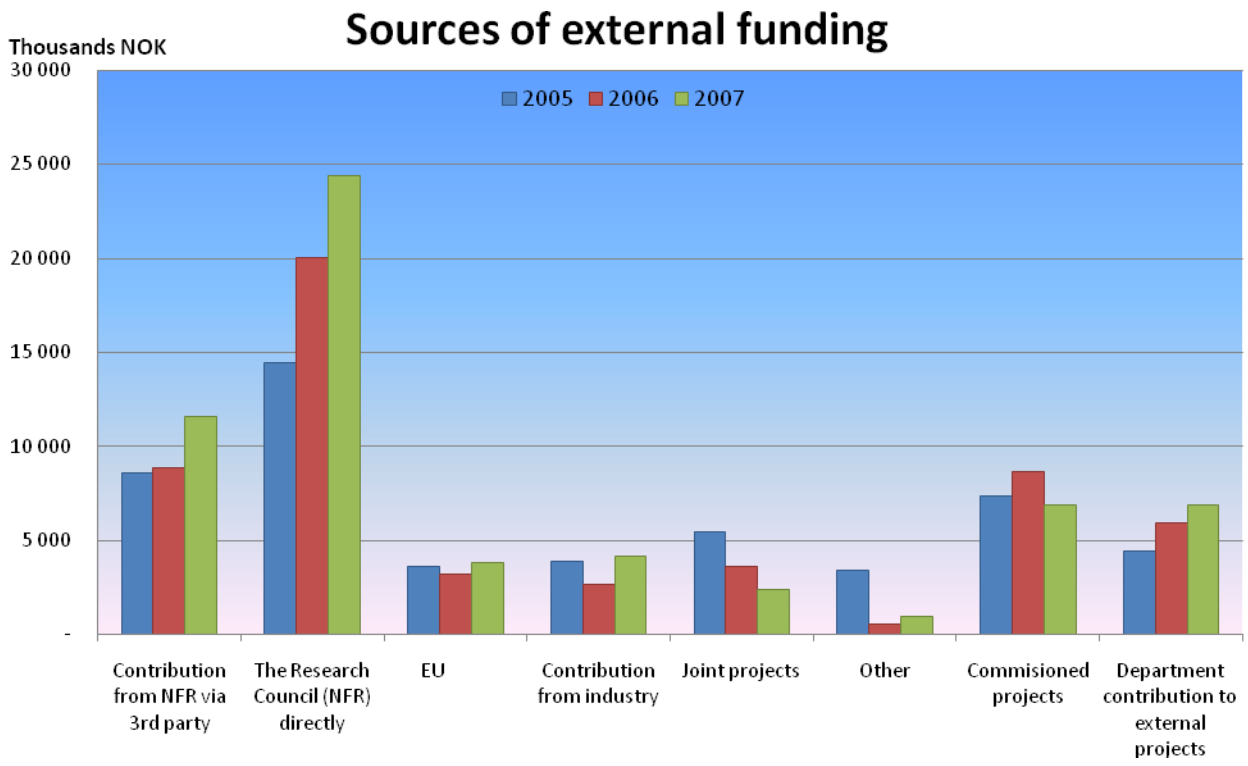
The department has three main sources of income: regular funds from the University, strategic funding from the University and external projects. In terms of external funds, including contributions from the research Council and industry, the situation is very good. However, a recent change in the NT-faculty budgeting principles seems to result in a reduction in our income of abourt 4 million NOK from the University from 2007 to 2008. The regular funds from the University were about 26,5 million NOK in 2007. These funds are mainly used to pay salaries to the permanent staff. More details are shown in Table 1.

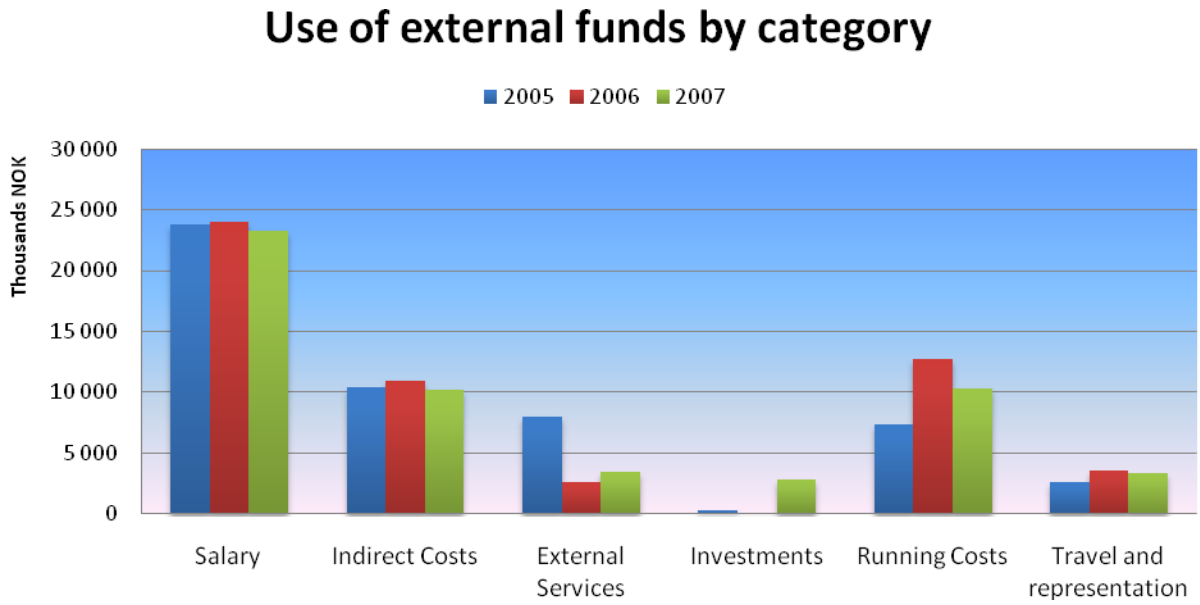
Accounts	2004	2005	2006	2007
Income:				
University funding	20 556 093	22 129 000	24 434 113	26 554 529
Overhead external projects	2 153 815	2 153 815	2 390 000	2 846 260
Sum income	22 709 908	24 282 815	26 824 113	29 402 796
Expences:				
Wages	17 703 181	19 216 318	22 514 217	21 260 668
Investment				2 546 924
Operating expenses	3 937 176	3 660 005	3 818 963	3 472 929
Sum expenses	21 640 358	22 876 323	26 333 180	27 280 521
Result	1 069 551	1 406 492	490 933	2 120 268

Table 1. Departments income from University and spending.

External funding

In addition to the funding shown in Table 1, the Department has a yearly income from external contributors of approx 54,3 million NOK. Details are shown in Tables 2 and 3. Most of the costs are related to salary for PhD candidates. The main contributor to the external research activity is The Norwegian Research Council (NFR). Most of these projects are at the Department, but the second largest external source is NFR projects where we contribute as a third party. Industrial contributions and commissioned research has been growing, but the level of funding has now stabilized. The growth in EU-funding is pleasant, and is important because of The University focus on EU-funding that gives extra credit from the Ministry. We have several joint industrial programmes with industry partners from countries in Europe, North-America, South America and Asia. External funding from commissioned research was approx 11,3% in 2007, and the customers come the above mentioned areas and Africa.





Strategic funds from University

The third source of income is strategic funding from the University to support research and academic profile. These funds are used for investments in research equipment or PhD or Post doc. positions. In 2007 we got 4 new positions from University because of the good evaluation we obtained on our application for Center of Excellence where 2 of the applications went to the final round. The applicants also got an operating grant both from University and Faculty.

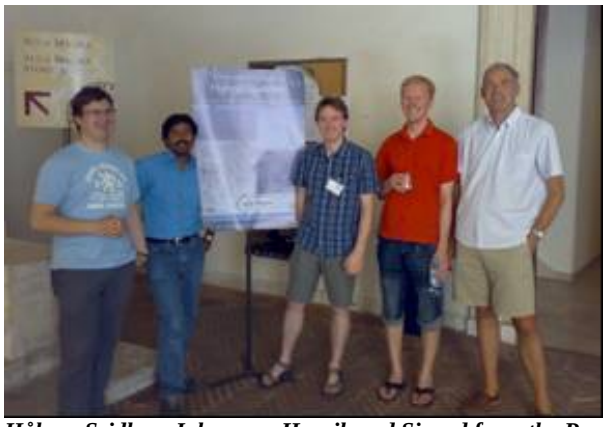
Prospects for 2008

From the budget given us by the Faculty, it seems like he funding from the University is increasing steadily, from 22129 (2005), 22842 (2006), 25397 (2007) to 30270 (2008) (all numbers in thousand NOK). However, the Departments contributes overhead on external project to the NT faculty, which over the same period has increased from 2686 (2005), 3292 (2006), 3633 (2007) to 12658 (2008). The estimated jump by about 9 millions NOK from 2007 to 2008 is because of a recent increase in overhead on salaries (from 15% to 40%.) Subtracting the overhead to the NT faculty, the net funding from the University to the Department over the last few years is 19443 (2005), 19550 (2006), 21764 (2007) and 17612 (2008).

Some pictures of different activities at the Department

Our buildings, from right: K4, K5, Experimental hall and PFI-building (blue)

PhD candidate Hanna Knuutila works on CO_2 removal



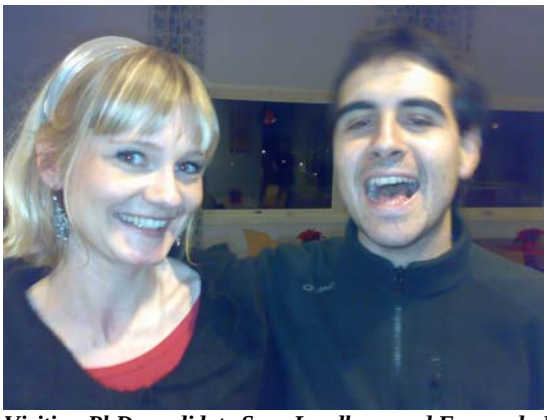
Håkon, Sridhar, Johannes, Henrik and Sigurd from the Process Systems Group in Siena (Italy)

Professors Anders Holmen and Magne Hillestad

Technical-administrative staff at the weekly meeting Monday morning

Øyvind Gregersen, Hanna Knuutila, Asbjørn Øye and Arne Lindbråten

Størker Moe presents a new area at the Research Days 2007: Biofules from wood



Visiting PhD candidate Sara Løgdberg and Fernando Bimbela at the Department Christmas Party on 19th December 2007

LIST OF TELEPHONE NUMBERS

95878	Amiri, Asal, Ph.D. candidate	PFI-3405
94209	Andreassen Jens-Petter, Associate Professor	K5-208
50336	Aronu, Ugochukwu Edwin, Ph.D. candidate	K4-420
91559	Aske Elvira Marie B, Ph.D. candidate	K4-206
97018	Bakthiary Hamidreza, Ph.D. candidate	K5-M12
50318	Barø Tove, Administrative assistant	K5-101
92837	Beck Ralf, Ph.D. candidate	K5-146
94138	Berge, Arvid, Professor Emeritus	K4-116
93692	Berglihn Olaf Trygve, Ph.D. candidate	K4-218
94157	Blekkan Edd Anders, Professor	K5-429
90638	Borge Tone, Ph.D. candidate	K5-225
91664	Borthen Berit, Chief Engineer	PFI-2101
94141	Boullosa Eiras Sara, Ph.D. candidate	K5-411
94144	Brun Harry, Engineer	K5-341
94125	Chao, Zhongxi, Ph.D. candidate	K5-145
93149	Chen De, Professor	K5-407
94312	Dam, Anh Hoang, Ph.D. candidate	Kh-108
93691	Dahl-Olsen Håkon, Ph.D. candidate	K4-225B
94125	Dar, Hassan Jamil, Ph.D. candidate	K5-145
95867	Deng Liyuan, Ph.D. candidate	K4-210
93942	Dones Ivan, Ph.D. candidate	K4-212
90338	Dudásová Dorota, Ph.D. candidate	K5-339
94110	Dupuy Pablo, Ph.D. candidate	K5-244
50372	Eide-Haugmo, Ingvild, Ph.D. candidate	K4-430
94187	Enger Bjørn Christian, Ph.D. candidate	K5-M09
94120	Erga Olav, Professor Emeritus	K5-237
50537	Eriksen Øyvind, Post doctor	PF-3207
95878	Fan, Yanru, Post doctor	PFI-3405
50339	Farooq, Umer, Ph.D. candidate	K5-340
92837	Flaten Ellen Marie, Ph.D. candidate	K5-146
94143	Fossum Arne, Engineer	K5-019
94158	Glomm Wilhelm R. Associate Professor	K5-336
94029	Gregersen Øyvind, Professor	PFI-2109
90338	Grimes Brian, Post doctor	K5-339
98354	Hammer Nina, Ph.D. candidate	K5-M5
94159	Hanneseth Ann-Mari Dahl, Ph.D.candidate	PFI-3407
94125	Hartono Ardi, Ph.D. candidate	K5-145
94108	Haug-Warberg Tore, Associate Professor	K4-231
93145	Hayer Fatemeh, Ph.D. candidate	Kh-106
92839	He Li, Ph.D. candidate	K5-421
94136	He, Xuezhong, Ph.D. candidate	K5-216
94031	Helle Torbjørn, Professor emeritus	PFI-2109
50304	Helmersen Tom, Office Manager	K5-101
94113	Hertzberg Terje, Professor	K4-314
94110	Hessen Erik Trøien, Ph.D. candidate	K5-244
94122	Hillestad Magne, Professor	K5-213
94151	Holmen Anders, Professor	K5-401
94026	Hovin Odd Ivar, Engineer	Kh-155
51128	Huang, Fan, Ph.D. candidate	K5-443
94033	Hägg May-Britt, Professor	K5-204
50540	Håkonsen Signe, Senior Engineer	PFI3404
95714	Jacobsen, Magnus Glosli, Ph.D. candidate	K4-225B
94132	Jakobsen Hugo Atle, Professor	K5-209
50331	Jäschke, Johannes, Ph.D. candidate	K4-225B
94145	Kazi, Saima Sultana, Ph.D. candidate	K5-443
94149	Kelesoglu, Serkan, Ph.D. candidate	K5-308
50327	Kim Inna, Ph.D. candidate	K4-412
95867	Kim Taek-Joong, Researcher	K4-208
90336	Knuutila Hanna, Ph.D. candidate	K4-420
50540	Lesaint Caterina, Senior Engineer	PFI-3404
994105	Lesaint Cédric, Post doctor	K5-324
50924	Less Simone, Ph.D. candidate	PFI-3408
94114	Lie Jon Arvid, Post doctor	K5-247
94161	Lind, Anna M., Post doctor	K5-430
93138	Lindbråthen Arne, Post doctor	K5-223
39691	Linhart Andreas, Ph.D. candidate	K4-225B
50338	Luo, Xiao, Ph.D. candidate	K4-414
50331	Løvfall Bjørn Tore, Ph.D. candidate	K4-225D
94120	Malthe-Sørenssen Dick, Adjunct Professor	K5-238
94136	Manum Henrik, Ph.D. candidate	K4-216
94155	Matam Santhosh Kumar, Post doctor	K5-432
94153	Mathisen Torgrim, Higher Executive Officer	K5-101c
50322	Mejdell Astrid Lervik, Ph.D. candidate	Kh-109
94032	Moe Størker, Associate Professor	PFI-2108
94147	Moljord Kjell, Adjunct Professor	K5-M11
94148	Mørk Preben C., Professor	K4-116
94133	Nesse Norvald, Professor Emeritus	K4-312
94112	Nilsen Tom-Nils, Senior Researcher	K4-204
50325	Nordgård, Erland, Ph.D. candidate	K5-306
50537	Nordhagen Håkon, Ph.D. candidate	PFI-3207
93942	Panahi, Mehdi, Ph.D. candidate	K4-212
94111	Patanou, Eleni, Ph.D. candidate	Kh-251
93147	Paso Kristofer, Post doctor	K5-304
95879	Patruno Lucioano, Ph.D. candidate	K5-245
50397	Paunonen, Sara, Ph.D. candidate	PFI-3103
94208	Phan Xuyen Kim, Ph.D. candidate	K5-M12
92807	Preisig Heinz A, Professor	K4-221
50318	Samseth, Jon, Adjucnt Professor	K4-312
90638	Sheridan, Edel, Post doctor	K5-225
91657	Simon, Sebastien, Post doctor	PFI-3406
94156	Rane, Shreyas P., Ph.D. candidate	Kh-105
94139	Roel Jan Morten, Engineer	Kh-155
94150	Roel Lisbeth H B, Executive Officer	K5-101
50536	Rusu, Marius, Ph.D. candidate	PFI-3206
94147	Rytter Erling, Adjunct Professor	K5-M11
94121	Rønning Magnus, Associate Professor	K5-408
94136	Sandru Marius, Ph.D. candidate	K4-216
94193	Schubert, Marco, Ph.D. candidate	Kh-250
91605	Selsbak Cecilie Mørk, Senior Engineer	PFI-3402
94073	Setekleiv Eddie, Ph.D. candidate	K5-M6
50331	Shao Lei, Ph.D. candidate	K4-225B
94159	Silset Anne, Ph.D. candidate	PFI-3407
91657	Simon Sebastien, Post doctor	PFI-3406
95714	Sivertsen Heidi, Ph.D. candidate	K4-225B
95505	Sjöblom Johan, Professor	K5-344
94124	Skjøndal-Bar, Nadav	K5-234
94154	Skogestad Sigurd, Professor	K4-232
94114	Sporleder, Federico, Ph.D. candidate	K5-247
50344	Steineke Fredrik, coordinator	K4-221 B
93692	Strandberg Jens Petter, Ph.D. candidate	K4-218
94106	Sundseth Frode, Engineer	K5-033
94100	Svendsen Hallvard, Professor	K4-435
91668	Tanase, Mihaela, Ph.D. candidate	PFI-3205
50346	Tellefsen, Silje Kufaas, Ph.D. candidate	K4-430
94119	Thorsen Gunnar, Professor Emeritus	K5-M8
94146	Tsakoumis, Nikolaos, Ph.D. candidate	Kh-107
94136	Uddin, Mohammad, Ph.D. candidate	K4-216
94182	Vanhaecke, Estelle, Post doctor	K5-430
92831	Venvik Hilde , Associate Professor	K5-406
94149	Volden Sondre, Post doctor	K5-308
94193	Wang, Hongmin, Post doctor	K h-250
50372	Wang, Yuefa, Post doctor	K5-156
50536	Xhanari, Klodian, Ph.D. candidate	PFI-3206
95728	Yelchuru, Ramprasad, Ph.D. candidate	K4-220
94155	Zhao Tiejun, Post doctor	K5-432
95728	Zhu Zhengjie, Ph.D. candidate	K4-220
50342	Øvrevoll Bodhild, Senior Engineer	PFI-3403
94018	Øye Asbjørn, Chief Engineer	K4-118
94135	Øye Gisle, Associate Professor	K5-307

Annual Report for Department of Chemical Engineering, NTNU

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