Technical University of Denmark

Annual Report **2007**

DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

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CONTENTS

ANNUAL REVIEW

"The education, research and innovation of the Department shall ensure our position among the best chemical engineering departments in Europe".

NEW NAME – **SAME AMBITIONS**

Kim Dam-Johansen,
Professor, Head of Department.

On 1st January 2008, the name of our department was changed to the **Department of Chemical and Biochemical Engineering** – in Danish **DTU Kemiteknik**. This was a consequence of our long-term effort to establish a significant research-based activity in industrial biotechnology. Indeed, the new name emphasizes that the department nowadays takes responsibility for Product Design as well as Process Design and Production with internationally-competitive research and education programmes in all the major industrial sectors - chemical, biotechnological, food, pharmaceutical and energy- related industries.

This broad perspective of Chemical and Biochemical Engineering was also underlined when we organized and hosted a major international congress in 2007 on behalf of the European Federation of Chemical Engineering (EFCE). The European Congress of Chemical Engineering (ECCE-6) was held at the Bella Center in Copenhagen from 16th to 20th September 2007. Held every second year, it is one of the major events of the EFCE and in Copenhagen we attracted some 1100 participants from 60 countries with 1000 papers presented as oral and poster contributions. In addition 4 plenary lectures and 45 keynote lectures from leading industrial and academic speakers from around the world were presented. We were delighted by the excellent scientific level of the technical program and I would like to express my thanks to all the participants and in particular to Professor Rafiqul Gani who was the main organizer of the congress.

FACULTY

During the last year we have succeeded in attracting and promoting a number of strong Faculty members at all levels. During 2007 Anne Ladegaard Skov was employed as assistant professor, Anker D. Jensen was appointed full professor and John Woodley came to DTU Kemiteknik from UCL, where he was full professor of Biochemical Engineering. Martin E. Vigild and Georgios Kontogeorgis have both been promoted as professors (Docents in Danish) and we have succeeded - by a grant from Haldor Topsøe - to attract Jan-Dierk Grunwaldt from ETH as new professor in Heterogeneous Catalysis.
I certainly welcome all our new faculty members and I am looking forward to follow the expanding research.

GRANTS AND MONOGRAPHS

In 2007 we also succeeded in attracting several significant and new external grants for research. In the field of biotechnology Professor Anne Meyer received a grant for a large project on "Biological Production of Dietary Fibres and Prebiotics". Haldor Topsøe granted a chair in heterogeneous catalysis as well as a partly sponsored parallel chair. In addition, our activities related to high temperature processes have expanded significantly with a grant from the Danish National Advanced Technology Foundation to establish the scientific background for "New and Environmentally-friendly Processes for Cement Production" in collaboration with FLSmidth A/S. In the petrochemical area Professor Erling H. Stenby received grants for the project "Advanced Oil Recovery Methods" from the Danish Research Council for Technology and Production Sciences. Furthermore our activities in quantitative product design with special focus on heavy duty coatings for marine and industry was further expanded with a grant from the Hempel Foundation. Finally, in the field of quantitative product design two monographs from the department were published.

INTERNATIONAL COOPERATION – AND SUMMER SCHOOL

Research based on international cooperation and close research relationships with other university departments has for many years been of the utmost importance to us. This international perspective is now developed to also cover cooperation in education. In Europe the Bologna agreement is in full operation, which means that there is a mechanism to allow the increased mobility of students among European universities and we welcome this development. We would like to see even more students coming to Denmark for their master's degree and we believe that our Danish students will benefit from studying abroad at our very strong sister departments either for short periods of a few months or for longer periods.

Our expanding international cooperation is not limited to Europe. In 2007 we established an international summer school in "Process Technology and Unit Operations Laboratory" and welcomed 26 students from the USA. We expect to increase this activity further and would like to welcome more students to use our well equipped unit operations laboratories and pilot-plant facilities.

IMPRESSED BY SISTER DEPARTMENTS

During the last couple of years I have had the chance to visit several sister departments around the world. I am enormously impressed by the capabilities and the continuous development in those departments. At DTU Kemiteknik we will do our utmost to remain an attractive partner in this competitive environment. Our ambition remains (with partners and through collaboration) to secure steady progress in the field of chemical and biochemical engineering to the benefit of our global society.

I wish you all an inspiring and pleasant read and would like to welcome new partners from industry and other universities in the coming year.

Kim Dam-Johansen
Professor, Head of Department

ADVISORY BOARD

PER FALHOLT · EXECUTIVE VICE PRESIDENT · NOVOZYMES A/S

In terms of industrial collaboration KT is at the front line and our co-operation is exemplary. To Novozymes it is very important that possible future technologies are developed and tested within a university framework where new valuable employees get their education and where real solutions to major challenges to society are found. KT fully answers these demands, benefiting both society and Novozymes.

KNUD PETERSEN · VICE PRESIDENT · DONG ENERGY

Over the last 20 years a strong platform for cooperation has been established between KT and the Danish energy sector, creating stability and competitiveness and allowing for fine-tuning of research in new areas benefiting both Dong Energy and KT. This collaboration ensures an ongoing dialogue between researchers and employees in the energy sector and has significantly optimized efficiency in the sector.

ALLAN SKOV · VICE PRESIDENT · CHEMINOVA A/S

Excellence in education and research is a precondition for Danish industry to stay competitive in the harsh environment of international business today. KT's contributions in these fields are important for society in general and instrumental for the continuing development of Cheminova.

LARS BANG · EXECUTIVE VICE PRESIDENT · H. LUNDBECK A/S

Scientific research at university level is a prerequisite for the development of Lundbeck's chemical activities in Denmark. We have had a beneficial cooperation with KT for several years, collaborating on PhD projects and recruiting several of its candidates. Furthermore, it has been a great advantage to be able to draw on the knowledge of KT's scientific staff as advisors/consultants.

BJERNE CLAUSEN · DIRECTOR OF RESEARCH & DEVELOPMENT · HALDOR TOPSØE A/S

Working closely with the best research groups within the fields of our core competences is of major importance to Haldor Topsoe A/S. Our cooperation with KT enables us to resolve research challenges beyond our competences and resources and is an important source of inspiration and knowledge for employees at Haldor Topsoe, benefiting their own and the company's development.

KIM PANDRUP CHRISTENSEN · VICE PRESIDENT, TECHNICAL DIVISION AND R&D · FLSMIDTH A/S

FLSmidth's close cooperation with KT ensures focused and long-term emphasis on development and innovation, both core elements in FLSmidth's strategy to keep a leading position in the market.



DTU Chemical Engineering organized the 6th European Congress of Chemical Engineering (ECCE-6) which took place at the Bella Center in Copenhagen in September 2007. In five days ECCE-6 was a vibrant forum for 1100 participants from industry and academia who shared knowledge, learned about the latest developments, made new contacts and much more.

SCIENCE FOR A BETTER LIFE

1100 CHEMICAL ENGINEERS, STUDENTS AND INDUSTRY ASSOCIATES PARTICIPATED IN **ECCE-6 ORGANIZED BY DTU CHEMICAL ENGINEERING**

From 16 to 20 September 2007 more than 1100 participants from around 60 countries gathered at the Bella Center in Copenhagen where the 6th European Congress of Chemical Engineering (ECCE-6) took place. ECCE-6 - organized by Professors Rafiqul Gani and Kim Dam-Johansen from DTU Chemical Engineering - featured a technical program divided into 6 main themes and special symposia.

The 6 main conference topics were: Sustainable process-product development and green chemistry; Advancing the chemical engineering fundamentals; Multiscale and/or multidisciplinary approaches to process-product innovation; Systematic methods and tools for managing the complexity; Integration of the life sciences and engineering and educating chemical engineers for the coming challenges. Special symposia were organized on "Process intensification", "Innovations in food technology", "Environmental protection & sustainability" and "Chemical product design and engineering" and a special workshop on the "Future of european chemical engineering education in a globalized

Rector of DTU Lars Pallesen speaking at the opening session of the ECCE-6. At the table from left to right: Professor Jiri Drahos, President of the EFCE, Professor Kim Dam-Johansen, Head of DTU Chemical Engineering and Professor Rafiqul Gani.

world". In addition, three special "invited" sessions were organized on "Multiscale modelling"; "Energy issues" and "Biotechnology".

SCIENCE FOR A BETTER LIFE

Key themes at the conference were 'sustainability' and 'the role of the chemical engineer in the future'. Leading practitioners from the world of chemical engineering and related fields discussed how chemical engineers have a unique opportunity for creating better products and a cleaner environment.

A total of 1050 papers were presented as plenary lectures, keynote lectures, oral presentations and poster presentations, organized in 142 sessions and covering all aspects of, and challenges to, Chemical Engineering. In five days, ECCE-6 provided opportunities for participants from industry as well as academia for knowledge sharing, networking, learning about the latest developments, student-industry contacts and much more.

ECCE-6 offered the participants a broad cultural program with the option of sightseeing tours to must-see sites in and around Copenhagen and the social highlight was the conference dinner held at Wallmanns Saloner just opposite Tivoli in Copenhagen. The conference was rounded off by the presentation of the EFCE Student Mobility Award.

HIGHLIGHTS 2007

* CEO Achim Noack from Bayer Technology Services stated that the task of the chemical engineer of tomorrow is to create a "science for a better life": "In areas such as food, water and power, chemical engineers have exactly the right competencies to solve some of the challenges faced today," Noack said at the conference, "we need their skills when developing and producing plant protection to ensure healthy food. In the field of energy, we must develop bio based alternatives to fossil fuels, and when we reclaim water, we need an understanding of systems biology to ensure the consumer has a completely pure product".

JANUARY 2007

The book "Chemical Product Design: Toward a Perspective through Case Studies" edited by Ka M. Ng from Hong Kong University of Science and Technology and Professors Rafiqul Gani and Kim Dam-Johansen from DTU Chemical Engineering was issued by the publishing house Elsevier.

13 JANUARY

Major grant from the Danish Strategic Research Council to new center at DTU Chemical Engineering

Center for Biological Production of Dietary Fibres and Prebiotics is established at DTU Chemical Engineering, based on a grant of 20 million DKK from the Danish Strategic Research Council to Professor Anne S. Meyer.

6 FEBRUARY

CAPEC M.Sc. Student receives prize from industry

CAPEC M.Sc. student Nanna Petersen - being a Novo scholarship recipient - receives second prize for her presentation of her Master project at the Danish pharmaceutical company Novo Nordisk A/S. Nanna's excellent project was on "Identification of batch fermentation for model predictive Control".

26 FEBRUARY

The plastic industry and DTU holds pilot course on polymers at DTU Chemical Engineering

37 teachers in chemistry and physics from Danish primary schools met at DTU Chemical Engineering for the first of a series of courses about polymer technology.

1 APRIL

John Woodley professor at BioEng

John Woodley takes office as professor at the BioEng center at DTU Chemical Engineering. John Woodley comes from a position as professor at the University College London, England.

30 MAY

IVC-SEP Discussion Meeting 2007

The 2007 IVC-SEP Discussion Meeting took place at the LO-school in Elsinore. This year there was four presentations from member companies. Jacob Nygaard Knudsen from DONG Energy gave a presentation on the "First year operation experi-

Professor and President of the EFCE Jiri Drahos is giving an award to Dr. Trevor Evans on behalf of EFCE for his services to the EFCE and the chemical engineering community.

ence with a 1 t/h CO_2 absorption pilot plant at Esbjerg coal-fired power plant", Jeff Creek from Chevron, USA gave a presentation on "Flow assurance challenges", Paul van Lingen, Mærsk Olie og Gas AS informed about "Perspectives of EOR by gas injection in chalk reservoirs" and finally Fredrik Saff from Shell. The Netherlands gave a presentation on "CO_2 injection for EOR and storage: Modelling challenges".

4 JUNE

CAPEC's annual meeting and 10 year anniversary

CAPEC had its Annual Meeting 2007 at the Crown of Scandinavia (the ferry from Copenhagen to Oslo and back), from 4-6 June, where coworkers of CAPEC presented their latest research results and achievements in the areas of property prediction; product-process synthesis/design; modelling; process control and monitoring and process-tools integration to 84 participants from the CAPEC industrial consortium member companies and invited guests.

12 JUNE

Successful workshop on chemical product design and development at PPEPPD 2007, Creete

A very successful workshop on Chemical Product Design and Development was organized by Prof. Rafiqul Gani during PPEPPD-2007 in Creete, Greece on 21 May. The workshop attracted more than 60 participants

15 JUNE

CHEC celebrates its 20 years anniversary

The annual meeting of the research center CHEC marks its 20th year anniversary. One of the highlights of the day were the presentations made by three of CHEC's previous PhD students, now employed in the industry: Hanne Philbert Nielsen from Novozymes A/S, Lars Skaarup Jensen from FLSmidth A/S and Claus Weinell, Hempel A/S.

HIGHLIGHTS 2007

* "We need a balance between what the Earth produces and what we use," said Per Falholt, Novozymes' Chief Scientific Officer at ECCE-6, "we are closer to having the theoretical knowledge that will allow us to change to biological processing when producing energy, food, and in time chemicals".

27 JUNE

Haldor Topsoe A/S and DTU Chemical Engineering establish two new professorships

Haldor Topsøe A/S and DTU Chemical Engineering strengthen their collaboration by establishing two new professor positions in the field of catalysis and chemical engineering. "The Haldor Topsoe Chair in Heterogeneous Catalysis and Chemical Engineering" financed by Haldor Topsoe was taken in January 2008 by Jan-Dierk Grunwaldt who comes from ETH Zürich. On June 1st 2007 Anker Degn Jensen from DTU Chemical Engineering took up the second position partly sponsored by Haldor Topsoe A/S.

JULY-AUGUST 2007

Summer School for American students

26 chemical engineering students from the US universities Virginia Tech and Ohio's Case Western spent their summer in Denmark participating in a unit operations summer school arranged by DTU Chemical Engineering.

AUGUST 2007

The book "Design and development of biological, chemical, food and pharmaceutical products" by Søren Kiil, Martin E. Vigild and Johannes A. Wesselingh was issued by the publishing house Wiley.

16-20 SEPTEMBER

1100 Chemical Engineers, students and industry associates participated in ECCE-6 organized by DTU Chemical Engineering

From 16 to 20 September 2007 more than 1100 Chemical Engineers, partners from the related industry and students in the field were gathered in the Bella Center in Copenhagen for the 6th European Congress of Chemical Engineering (ECCE-6) organized by Professors Rafiqul Gani and Kim Dam-Johansen from DTU Chemical Engineering.

27 SEPTEMBER

Joint research project between DTU and FLSmidth A/S supported by the Danish National Advanced Technology Foundation

Researchers from DTU join chemical engineers from FLSmidth A/S in a research project focusing on environmentally friendly cement production. The Danish National Advanced Technology Foundation supports the research with a 25 m DKK grant.

9 OCTOBER

OilSim instructor course

14 teachers from 11 Danish high schools meet at the research center IVC-SEP to participate in the instructor course for OilSim.

26 OCTOBER

PhD student from DTU Chemical Engineering receives the Peter Gorm-Petersens Grant

Georgios Folas received this grant as recognition for his highly successful PhD project at DTU Chemical Engineering (IVC-SEP), a PhD entitled "Modelling of Complex Mixtures Containing Hydrogen Bonding Molecules" with G.M. Kontogeorgis as main supervisor.

9 NOVEMBER

Annual Polymer Day organized by Danish Polymer Center

40 researchers, PhD students and representatives from industry met at DTU for the Polymer Day arranged by the Danish Polymer Center.

Denmark is the world leader in terms of the relative amount of straw used for production of electricity. DTU Chemical Engineering has been working closely with Danish power plants to increase the efficiency and reduce operational problems and harmful emissions from power plants partly based on straw as a fuel.

RESEARCH & INNOVATION

Visions for sustainable solutions

20th anniversary for Combustion and Harmful Emission Control at DTU Chemical Engineering

Pushing the limits for modelling of oil and gas behaviour

Proteins meet polymers in medical research

TWO NEW KT PROFESSORS ON THE FUTURE CHALLENGES FOR CHEMICAL ENGINEERING:

VISIONS FOR SUSTAINABLE SOLUTIONS

Sustainability is the key word for the future of chemical engineering. John Woodley and Anker Degn Jensen who both took chairs as professors at KT in 2007 were swift to wield this as a fact when they met for an interview about the challenges facing their research and chemical engineering in general - now and in the future.

Professor Anker Degn Jensen.

"There are some major issues facing mankind in the coming years," says John Woodley, "the global population increase means that we have put great pressure on energy supplies, on being able to produce enough chemicals and also enough food. This is a point in time when chemical engineering has an immense amount to contribute to society."

Anker Degn Jensen nods in agreement and gives an example of the vital role of chemical engineering: "If we were not able to produce ammonia as efficiently as it is done today, the population of the planet would be much less."

Society's increasing demands for environmentally friendly yet cost effective engineering solutions present an array of new challenges to chemical engineers:

"There is a big need for multidisciplinary research and it is increasing," says John Woodley, "one of the big challenges is to work out how we can collaborate and work together as closely as possible with different disciplines."

Anker Degn Jensen supplements: "For many years the individual disciplines have been progressing and now we have reached a state of complexity where close collaboration is the only way to make completely new types of processes."

BROADENING THE FIELDS OF COLLABORATION

John Woodley began work as a Professor of Chemical Engineering at KT in April 2007, coming from a position as Professor of Biochemical Engineering at the Department of Biochemical Engineering, UCL, London, UK. Woodley works in the BioEng Center and his field of research is addressing the synthesis of chemicals using enzyme technology and the associated process design and scale-up.

Anker Degn Jensen was assigned professor in August 2007 after having worked as an associate professor at KT since 2000. He is part of the CHEC research centre and his research deals with efficient high temperature processes for clean and efficient energy conversion using catalysis and particle technology.

When Woodley and Jensen talk about broadening the fields of collaboration it is more than theory: The two have submitted a joint proposal aimed at making sustainable fuels and chemicals for a future where the petroleum based chemicals are under pressure or running out.

"Part of my vision is to take biomass and be able to make chemicals from

it, so we have a completely new type of chemistry. Enzyme technology with it's high selectivity is very well suited to this," John Woodley explains, "and a part of that involves the area which Anker is working in but it also needs people from e. g. the chemistry department and new approaches to catalysis as well. Using combinations of chemical and biocatalysis, completely new structures can be made from biomass but also alternative ways of producing already existing chemicals, different polymers for instance. For both these and any new types of compounds the challenge is to make them in an environmentally friendly way."

Anker Degn Jensen elaborates, "one route you could go is to take the biomass and gasify it, turn it into syngas (a mixture of CO and H_2) and over a catalyst you can make a range of different products. This is already being done with the petrochemicals and you can in principle do the same thing with biomass. But that opens new issues on how to gasify biomass compared to the petrochemicals. We are also working to improve catalysts, so you can make bioalcohols which is based not on a fermentation process but a high temperature gasification route."

Getting the ideas and research right and working across disciplines is just one aspect of bringing chemical engineering forward in the 21st century: The road from research lab to full-scale production facility in industry can be long and winding, and from the academic point of view there is the constant challenge of finding and educating not only the right people but also the sufficient number of people.

RECRUITING THE BEST

"A real challenge for the future is how universities can keep developing technical larger scale facilities in the pilot plant. Unlike most other departments around the world we at DTU are actually committed to developing a world-class pilot facility and see that as a very important part of the vision for the future," John Woodley says.

"The companies we work with feel the increased competition from globalization and that means we have to do more to support those companies - to make sure that we have something in Europe which is special and different from what is going on elsewhere."

"Another major issue is how to be able to recruit enough really good PhD students," says Anker Degn Jensen, "that means recruiting from all over the world and showing what DTU has to offer. And making certain that enough students pick chemical engineering."

When asked where they would like to see KT in ten years it takes only seconds for Woodley and Jensen to dish up a prospect they both support:

"In ten years KT should be the leading chemical engineering department in Europe and one of the leading in the world. And the Department should have established a very clear leadership on how to develop sustainable solutions in food, biotech, energy and chemical processing."

Professor John Woodley.

20TH ANNIVERSARY FOR COMBUSTION AND HARMFUL EMISSION CONTROL AT DTU CHEMICAL ENGINEERING

CHEC's initial work in the early 80s was a response to the acid rain debate and the research group's primary focus, reduction of harmful emissions from power plants, was consolidated in 1987 when the group took the name CHEC (Combustion and Harmful Emission Control). In 2007 celebrated it's 20th anniversary. It was a landmark for a research group which has grown considerably and increased its pool of knowledge and resources - while maintaining a versatile scientific approach enabling it to dynamically apply its resources to new fields.

FLUID BED COMBUSTION (FBC)
Combustion of solid fuels takes place in a heated bed of sand-like material suspended within a rising column of air. The sand-particles behave like a liquid (fluid) making the process look like boiling water. Desulfurization inside the reactor can be accomplished by adding limestone.

SELECTIVE NON-CATALYTIC NOX-REDUCTION (SNCR)
At temperatures between 900-1000°C ammonia is injected into the furnace causing ammonia and NO to react, forming free nitrogen which is harmless and makes up 80 pct. of our atmosphere.

The challenge CHEC took on at the beginning in 1987 was to establish fundamental science-based knowledge to support the highest energy efficiency and to reduce, or prevent, the emission of environmentally harmful substances - primarily SO_2 and NO_X - from power plants and energy intensive industrial processes.

Kinetic modelling of combustion processes, particle technology and extensive research into **Fluid Bed Combustion (FBC)** were among the first research topics. The main focus was on the formation and possible control of emissions inside the combustors by different approaches (e.g. by adding calcium carbonate to react with sulphur dioxide or ammonia injection at high temperatures for **Selective Non-Catalytic NO_X-Reduction (SNCR)**). Already at that time the process ideas were tested at full scale in cooperation with the power plants - in parallel to the fundamental research in the laboratories at DTU. At a later stage **Re-burning** was investigated. This allowed a 50-60% reduction of SO_2 and NO_X emissions. As the regulatory demands for cleaner flue gas grew in the early 90s, CHEC expanded step-by-step the research to new fields covering e.g. gasification processes and downstream flue gas cleaning by **Wet Flue Gas Desulfurization** and **Selective Catalytic Reduction of NO_X**.

THE INTRODUCTION OF BIOMASS

In the early 90s as the discussions about using biomass and waste as fuels for power production were initiated, CHEC was amongst the prime movers. Full-scale tests of cofiring straw with coal at several power plants were documented – both with respect to combustion phenomena, pollution formation, formation of corrosive deposits inside the boilers and the influence of the biomass on downstream flue gas cleaning processes. Based on the full scale tests CHEC broadened its research field and went into research areas like catalytic processes and poi-

SELECTIVE CATALYTIC REDUCTION (SCR)
A means of converting NO_x into N_2 and H_2O with the aid of a catalyst. Ammonia is added upstream at flue gas temperatures around 350°C.

REBURNING
Injection of a secondary fuel into the boiler above the primary combustion zone. NO_x formed in the primary process reacts with the secondary fuel to form eg ammonia and HCN. N_2 is finally released in the second combustion process.

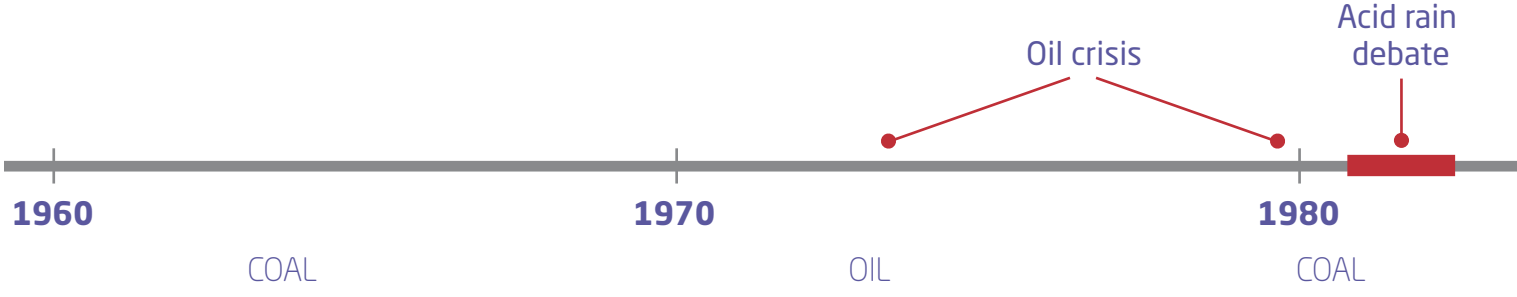
WET FLUE GAS DESULFURIZATION
Flue gas containing SO_2 is led into a giant reactor where it reacts with a suspension of finely grained chalk. SO_2 enters the liquid phase and reacts with the chalk to form gypsum which is filtered out. All gypsum made from desulfurization in Denmark is used in the plasterboard industry.

soning of the **SCR Catalysts**. The use of biomass and waste caused an array of new challenges in areas like ash and deposit formation, corrosion related issues and residual product utilization. The first plants to use biomass for electricity production would simply corrode away over a short time span and there was little understanding of the processes behind this. Over the years CHEC has mapped the fundamental process chemistry in this field and today the group is consulted on a regular basis by power companies when operational problems occur, or new plants are being designed.

When DTU Chemical Engineering built its high-temperature pilot-plant facility in 2000 the CHEC group expanded its laboratory work to larger scale – facilitating the testing of theories and validation of mathematical models for scaling-up of processes to industrial units – both covering combustion phenomena, ash and deposit formation, pollution formation and control of harmful emissions. By strengthening the bridges between theory and practical experimentation the pilot-plant has developed into a valuable asset to both researchers and students.

NEW INDUSTRIAL FIELDS

Due to the immense accumulation of detailed data and the close collaboration between the increasing number of researchers and technicians in CHEC there are now several cases where acquired knowledge from one area has been used as the basis for new research in another. For example in the late 90s CHEC established the presently intensive research into environmentally friendly cement production based on previous documented design methodology. In collaboration with FLSmidth A/S, one of the world's largest companies in the cement production, CHEC research results were applied to the design of calciners with low emissions of nitrogen oxides. In this work, CHEC could draw on previous research in fluidized bed combustion and in in-situ NO_X control technologies such as reburning. Interestingly, research in issues related to cement production has been steadily increasing up to the present day and in September of 2007 a major collaborative project, aimed at ensuring more efficient and environmentally-friendly cement production, was established between CHEC, FLSmidth A/S and the Danish National Advanced Technology Foundation.



In a similar way early CHEC research into selective non-catalytic NO_x reduction, an approach originally developed for traditional power plants, was successfully applied to waste incineration plants. Today the technology is implemented in many waste-based combined heat and power plants in Denmark.

CHIMNEY-FREE POWER PRODUCTION

Reduction of CO_2 emission has been of importance to CHEC since the earliest days of the center in 1987 – but has become an even more important research field over the recent years. And with the prospect of regulators demanding further reduction of CO_2 the field is likely to maintain a strong focus. The technologies currently having most attention within CHEC are gasification and **Oxyfuel Combustion**. Within just a few years we may see power plants that have no emissions at all – "chimney-free" power production.

Since Kim Dam-Johansen, today Professor and Head of Department at DTU Chemical Engineering, laid the foundation for the groups work in the early 80s the CHEC group has grown steadily and today more than 50 people are employed as part of CHEC. Over the last ten years it has expanded the research activities to cover Coatings Science and Engineering, Pharmaceutical Production and Biochemical Engineering in cooperation with the other centers and groups at the department. With the current and future research challenges within these areas plus the increased regulatory calls for CO_2 emission control, the new major project concerning cement production and brand new fields like liquid fuels production, it seems evident that the 20th anniversary of CHEC marks the beginning of a new journey, possibly leading to further new and yet unknown areas of research.

A VIEW OF THE FUTURE: THE ALL-IN-ONE POWER PLANT

The future of the energy sector may look completely different from anything we have known so far. Associate Professor Peter Arendt Jensen envisions that energy production will be seen as a tightly integrated whole:

»It is possible that production of energy for transportation, electricity and heat will be integrated in power plants or in cement production plants that will look and function in new ways. The use of wind farms has gained momentum and this puts higher demands on the adaptation capacity of the power plants. The plants may need to go from low to high production and *vice-versa* in a very short time. And maybe the power plants of tomorrow will deliver new products - producing fuel for transportation part of the time. This in turn could mean that the spectrum of fuels applied would be even bigger, comprising biomass, coal and waste,« Peter Arendt Jensen predicts.

OXYFUEL
Combustion of fuels in an atmosphere of pure oxygen and recirculated flue gas resulting in emission consisting of CO_2 which can be compressed and disposed of - and removed from the atmosphere - e.g. by pumping it into underground oil fields.

GASIFICATION
A process where a gas composed of CO and H_2 (syngas) is produced from biomass and coal as a step in production of liquid fuels that can be used for transportation.

PHD PROJECT BY GEORGIOS FOLAS SETS NEW STANDARDS:

PUSHING THE LIMITS FOR MODELLING OF **OIL AND GAS BEHAVIOUR**

In 2003 Georgios Folas started work on a PhD project entitled "Modelling of complex mixtures containing hydrogen bonding molecules" with the intention of developing advanced, mathematically based computer models to accurately describe the behaviour of mixtures used by the oil and gas industry. Folas' project was highly successful and in 2007 he received the Peter Gorm-Petersen´s Grant for work which has already been put into practical use by the oil industry and holds promise for further use in other chemical engineering fields.

GEORGIOS FOLAS ABOUT DTU CHEMICAL ENGINEERING:

Georgios Folas took his Master's Degree in chemical engineering at the National Technical University of Athens, Greece, and is currently employed at Aker Kværner in Norway. He remembers his time at DTU Chemical Engineering as a pleasant one: "I enjoyed it very much, both being in Denmark and at DTU Chemical Engineering. The Department has really high standards and facilities and you can get a lot of help from people. I also appreciated the fact that the library is very well organized and gives access to most of the scientific literature. Having fast access to the literature is something that helps a lot in theoretical research - and the IVC-SEP group where I did my research is international and people are very friendly," says Georgios Folas.

Georgios Folas´ PhD project was about thermodynamic modelling of mixtures that contain water, glycols/alcohols and hydrocarbons.

"It is well known that classical models with traditional mixing rules fail to describe the phase behavior of those mixtures," explains Georgios Folas, "we used an advanced equation of state (CPA) which is specifically developed for such types of mixtures."

The CPA (Cubic-Plus-Association) model is a relatively new model first published in 1996 by Professor Georgios Kontogeorgis. The CPA model provided the basis for. The development of the CPA equation itself was the result of the collaboration between the Technical University of Athens (NTUA) and Shell which took place in 1996, outlining the industrial need for accurate models for phase equilibria.

The main purpose at that time was to model the phase equilibria of water, methanol and hybrocarbon mixtures. The basic idea was to develop an equation of state that was as simple as possible but could accurately capture the physics of the complex systems which could not be described with traditional equations of state that the gas industry was using at that time (and still use today).

Since 1999, Statoil (today Statoilhydro) further contributed to the development of the model. The focus was the phase equilibria of mixtures containing glycols, water and hydrocarbons.

Phase equilibria is important for several processes related to transportation and further processing of natural gas or oil. (PHOTO: Øyvind Hagen / StatoilHydro).

"Phase equilibria is important for several processes related to transportation and further processing of natural gas or oil. Accurate phase equilibria calculations contribute to the optimization of the processes and minimization of the cost," says Georgios Folas.

The Professors Georgios Kontogeorgis, Michael Michelsen and Erling Stenby supervised the PhD which was of direct industrial interest. Indeed, the project was sponsored by Statoilhydro and Folas spent approximately 7 months in the Research Center of Statoilhydro in Trondheim where he did various types of experimental measurements at conditions of interest to the gas industry.

"The purpose was mainly to measure accurately the solubility of the glycol in the gas phase," explains Georgios Folas, "such measurements are both expensive and time consuming, and consequently the data available in the literature were scarce, and their accuracy questionable. We believed we developed a very accurate method for glycol content measurements in the gas phase."

The data from these measurements can be used for the development and validation of thermodynamic models, related for example to the transportation of natural gas in long distance multiphase pipelines.

Finally, during Folas' research stay in Statoil's R&D Department, the model was applied to gas phase water content measurements in equilibrium with solid or hydrate phases. Accurate description of the equilibrium water content of natural gas is of great importance to natural gas processors.

His prized research has been applied into practical use for instance in the Snøhvit in the north of Norway and Statoil has continued the research, by supporting two new PhD projects.

IN SEARCH OF BETTER MATERIALS: PROTEINS MEET POLYMERS IN MEDICAL RESEARCH

Polymer research allows for taylor-made materials and designs that hitherto have been expensive or impossible to produce and one area that benefit from this is the medical field. PhD student Charlotte Juel Fristrup works on designing new polymer-based containers and devices which heed the high demands of advanced, protein-based drugs.

Charlotte Juel Fristrup's research is focused on polymers' compatibility with proteins. Her PhD project which is carried out in close cooperation with Novo Nordisk A/S is titled "Polymers for Pharmaceutical Packaging and Delivery Systems" and is as much about basic research as it is geared towards the practical application of - among other possible uses - production of new types of containers for liquid drugs.

"The goal is to synthesize polymer materials which are compatible with proteins and at the same time can be used as a coating for other polymer materials," explains Charlotte Juel Fristrup. "In practical use these materials can be used to make new kinds, and designs, of containers or devices which can be put into contact with protein solutions, without the material affecting the protein or vice versa. The storing of different types of medicine is just one of many possible applications."

The idea for the project originates from Novo Nordisk A/S and the course of the PhD has been outlined in close cooperation between Charlotte Juel Fristrup and Rüya E. Nielsen from Novo Nordisk A/S.

VERSATILE MATERIALS

"Part of my job is to ensure that the results of the project can be turned into applied knowledge in Novo Nordisk A/S and eventually be used in our future devices or containers," says Rüya E. Nielsen who sees some really exciting long term implications of this research:

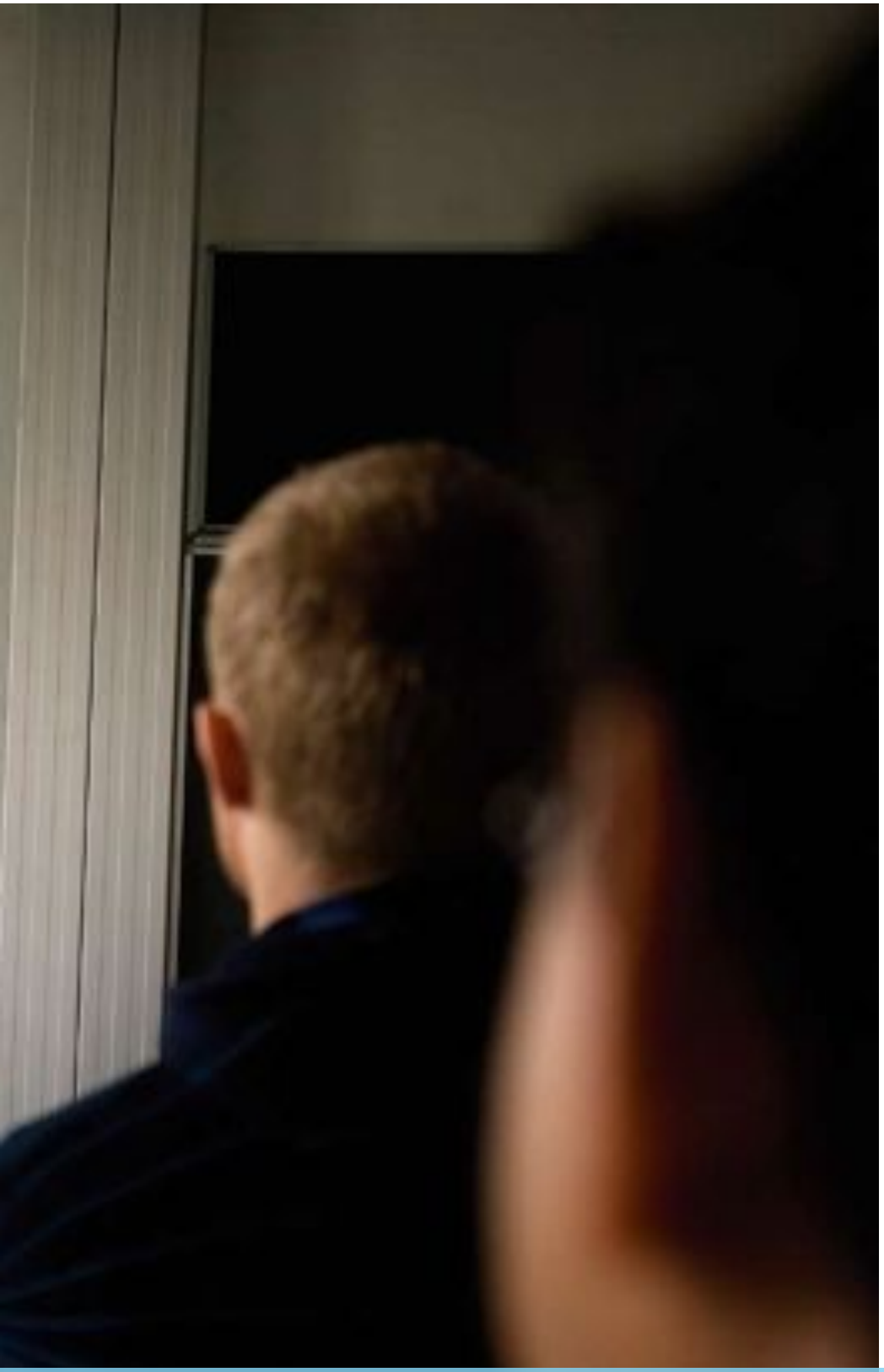
Rüya E. Nielsen, Novo Nordisk A/S (left) and PhD student Charlotte Juel Fristrup.

"When we look at the already existing materials that come into close contact with medicine, they are almost always made of glass and only very few materials can be used for the protein solutions Novo Nordisk A/S produces."

"Plastics are much more versatile materials than glass. They offer a great deal of freedom of design which we can utilize to create innovative products. On the other hand, there is a long list of requirements for the materials which are in direct contact with liquid drugs - most importantly they should not jeopardize the user safety in any way - they have to be non-toxic and have no negative affect on protein stability or efficacy," Rüya E. Nielsen explains.

Charlotte began working on the project in March 2007 in close cooperation with her supervisors Professor Søren Hvilsted and Associate Professor Katja Jankova. At a later stage the research will take place at the laboratory facilities of Novo Nordisk A/S under supervision of Rüya E. Nielsen and Jens T. Bukrinski.


Input/Output



EDUCATION

26 US students participated in the Summer School at DTU Chemical Engineering

Top grades and versatile skills in the DTU Chemical Engineering Workshop

STRATEGIC GOAL
"In close interaction with Danish and international industry the Department shall continue to ensure optimum career prospects for our graduates".

26 US STUDENTS PARTICIPATED IN THE SUMMER SCHOOL AT DTU CHEMICAL ENGINEERING

26 chemical engineering students from the American universities of Virginia Tech and Ohio's Case Western travelled to Denmark to spend four summer weeks participating in the Unit Operations Lab Summer School at DTU Chemical Engineering. The students not only brought back thorough training in unit operations, but also exquisite memories of Danish culture and insights into Danish chemical engineering practices at production level.

In the words of one of the attending students, Lindsey Miller from Virginia Tech:

"The trip to Denmark was about much more than performing experiments in the lab. Several of us truly fell in love with Denmark and are sure to return for graduate school. The faculty and staff accommodated all of our needs and went the extra mile to make us feel at home, when home was so very far away."

"We were able to see the similarities and differences in international and domestic chemical engineering practices by visiting DONG, Leo Pharma, and Novozymes. We also learned a significant amount about unit operations and when they fail. Each group was allowed to choose which seven experiments to perform based on our own personal preferences and desired career paths. This enabled us to focus on areas of chemical engineering which personally interested us."

Dr. John Walz (far left) with the 26 US students at the DTU Chemical Engineering Summer School who came to Denmark for a course on unit operations but got a taste of Danish history and culture as well – one of their excursions went to the Viking Play at Frederikssund.

As part of the program the students were given a subject for an oral presentation where the assignments were mainly focused on issues within Danish industry, history, politics and society – following a series of cultural activities which had been arranged in advance. On top of this the students arranged their own excursions.

The students were accommodated at Campus Village and both there, and during the course activities, they had the chance to mingle with European students, the latter being at DTU Chemical Engineering and other DTU departments to attend the European Summer Schools.

For 20 years American students from the universities of Virginia Tech, Georgia Tech and Ohio's Case Western have been going to summer school abroad. When Technical Manager Lars Kiørboe learned about this at a conference he was swift to recommend DTU Chemical Engineering and Copenhagen as a qualified Summer School option, a suggestion accepted after a visit by the Head of the Chemical Department at Virginia Tech, Dr. John Walz. Dr. Waltz later joined his students in the summer journey to Denmark and assisted in the course as a grader during the reporting of the experiments.

Lars Kiørboe spent six months organizing the successful summer school - the first of its kind at DTU Chemical Engineering - and is expecting more foreign students from a broader range of universities in the coming years.

TOP GRADES AND VERSATILE SKILLS IN THE DTU CHEMICAL ENGINEERING WORKSHOP

In December 2007 Kristoffer Andersen's successful apprenticeship at the workshop of DTU Chemical Engineering was awarded when he received the top grade - 12 - for his apprenticeship test, a Sterling engine. The engine was the culmination of 40 weeks of education at Copenhagen Technical School and three and a half years at the DTU Chemical Engineering workshop.

"I became deeply fascinated with metal work after I started my education and was very much attracted by the challenges at the DTU Chemical Engineering workshop," says Kristoffer. "Work here is independent with a high degree of responsibility - and the versatility makes it a constant challenge. We rarely make the same thing twice."

The DTU Chemical Engineering workshop has been a tightly integrated part of the Department all the way through its growth and that makes it not just an exciting place to work and study but also an invaluable extension to the research done in the close-by labs. Head of the workshop Ivan Horst Pedersen says:

Kristoffer Andersen's apprenticeship at DTU Chemical Engineering was crowned with the top grade for his apprenticeship test.

"We have thorough experience in sparring with researchers and students, ensuring successful interaction between theory and application. We have the required background knowledge in fields like flue gas temperatures, pressure and vacuum - enabling the engineers to focus on the product while we take care of the practical issues surrounding it."

The workshop employs five people besides the apprentice and the head, and the crew accepts any kind of challenge: "Glueing, welding, cutting - you name it. They can bring on anything," Ivan Horst Pedersen says with a confident smile.

Manual skills however are not enough in a modern chemical engineering workshop - a thorough knowledge about 3D modelling computer programs is also required. Kristoffers excellent skills in this field is part of the reason he earned the highest grade for the construction of the Sterling Engine - which was nominated for the Danish Metal Industry's apprentice award.

And Kristoffer - he will stay at the workshop for at least another year after he finishes his education.

DTU Chemical Engineering is working closely with industrial partners to design novel and environmentally friendly coatings for ocean-going ships.

ORGANIZATION

CHEC

IVC-SEP

CAPEC

DPC.DTU

BioEng

Administration
& Technical support

A vital part of our research is conducted in very close collaboration with industrial enterprises and international research organizations.

The industrial relations cover close joint projects with mutual exchange of staff and cooperation on experimental research ranging from microscale over pilot plants to full-scale industrial production plants. This approach ensures high relevance of our research and efficient exchange of technology, know-how and know-why.

Kim Dam-Johansen, Director of CHEC

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Director, Professor Kim Dam-Johansen | kdj@kt.dtu.dk | Phone: +45 4525 2845

CHEC

COMBUSTION AND HARMFUL EMISSION CONTROL – THE CHEC RESEARCH CENTRE

CHEC is a research centre mainly in the field of Chemical Reaction Engineering and Combustion, emphasizing on high-temperature processes, formation and control of harmful emissions, particle technology and product design.

The research approach involves a combination of modelling and experimental work. Experiments are conducted over scales ranging from small laboratory reactors to full-scale industrial units.

The models typically combine a generic description of the chemical reaction system with a process-specific flow description, and are used to analyze and extrapolate the experimental data, and to provide input for design and optimization.

The work is conducted in collaboration with enterprises and a range of national and international research organizations.

The new field of Product Design covers quantitative formulation engineering using traditional Chemical Engineering methods in the design of products, e.g. granular enzymatic products, and controlled release systems in different fields e.g. advanced coatings.

Waste fuel utilization, methods to reduce CO_2 emissions and production of liquid fuel from biomass have received gradually increasing attention in the CHEC Research Centre over the last years. The work is directed towards pyrolysis of biomass, oxyfuel combustion, gasification, methanol and bioethanol production, as well as fuel cell technology.

During 2007 a major research grant was obtained from the Danish National Advanced Technology Foundation for a joint project with FLSmidth A/S: Future Cement Production Technology.

The CHEC Research Centre collaborates mostly with the following industrial partners

- Babcock & Wilcox Vølund ApS
- B&W Energy A/S
- Danish Gas Technology Center A/S
- Dong Energy A/S
- Energinet.dk
- F.L. Smidth A/S
- H. Lundbeck A/S
- Haldor Topsøe A/S
- Hempel A/S
- MAN Diesel A/S
- Morsø A/S
- Novozymes A/S
- Vattenfall A/S

The industrial support is supplemented with funding from these organizations

- DTU
- Nordic Energy Research
- The Danish Council for Technology and Innovation
- The Danish Research Training Council
- The European Union
- The Public Service Obligation Programme
- Danish National Advanced Technology Foundation

For more than 25 years the IVC-SEP has been a leading research group in the area of applied thermodynamics. In close collaboration with industry, relevant authorities and research organizations, the research of IVC-SEP is implemented in industrial products and processes, and has generated a number of spin-off companies, patents and commercial software.

Our research today covers a wide range of disciplines. The strong effort in thermodynamics is often coupled with reactions, transport processes, computational challenges and surface phenomena. The industrial applications have also expanded over the years and we find the need for further development of IVC-SEP within energy, environment, product design and biotechnology.

Erling H. Stenby, Director of IVC-SEP

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Director, Professor Erling H. Stenby | ehs@kt.dtu.dk | Phone: +45 4525 2875

IVC-SEP

CENTER FOR PHASE EQUILIBRIA AND SEPARATION PROCESSES (IVC-SEP)

The IVC-SEP is a dynamic research group with an excellent track record and international reputation in the areas of applied thermodynamics, transport processes, and mathematical modelling. With seven tenured faculty members the centre covers several topics with both experimental and theoretical research.

Currently, the main activities of the centre are in the areas of complex solutions (including polymers, electrolytes, peptides, and associating chemicals), non-equilibrium thermodynamics (diffusion and thermo diffusion), petroleum chemistry at the molecular level, and finally simulation of petroleum recovery processes (from the pore to reservoir scale). Furthermore the centre is active in several research projects of strategic importance such as CO_2 capture and storage and Enhanced Oil Recovery (EOR).

The Industrial Consortium of IVC-SEP has existed for more than 25 years and continues to be a valuable asset for the research and education at the Department. Many companies support research projects in addition to the membership. For instance the CHIGP project (Chemicals in Gas Processing) which is extensively sponsored by industry (Total, Statoil, BP, and Maersk Oil and Gas).

Furthermore, IVC-SEP participates in a new major effort on the use of CO_2 for EOR in the Danish North Sea. This is a collaboration with DONG Energy, supported by The Danish National Advanced Technology Foundation.

Many students get their first contact to the Danish or international industry through a project in IVC-SEP. In addition to research funding the Consortium members provide experimental data, samples, and fruitful feed- back to the centre.

One of the highlights from 2007 was the grant from the Danish Research Council for Technology and Production Sciences for the Major Research Project "Advanced Oil Recovery Methods - ADORE". The council granted close to € 2 mio. for the 5 year project which furthermore recieves funding from Mærsk Olie og Gas.

In 2007 the Consortium of IVC-SEP consisted of the following members

- Akzo Nobel (NL)
- BP (UK)
- Chevron (USA)
- DONG Energy A/S (DK)
- Eni (I)
- Exxon Mobil (USA)
- Gaz de France (F)
- Haldor Topsøe (DK)
- Institut Français du Pétrole (F)
- Kommune Kemi (DK)
- Linde (D)
- Mærsk Olie og Gas A/S (DK)
- Norsk Hydro (N)
- OMV (AUT)
- Petrobras (BRA)
- RWE Dea (D)
- Sasol (South Africa)
- Saudi Aramco (Saudi Arabia)
- Schlumberger (USA)
- Shell Global Solutions (NL)
- SQM (Chile)
- Statoil (N)
- Total (F)
- Vattenfall A/S (S)
- Welltec (DK)

Briefly, the research objectives of CAPEC are to develop computer-aided systems for process simulation, process/product synthesis, design, analysis and control/operation principally suitable for chemical, petrochemical/oil, pharmaceutical and biochemical industries.

Our computer-aided systems are developed on the basis of fundamental modelling studies that incorporate correlation and estimation of thermophysical and phase equilibrium properties as well as modelling of the underlying phenomena/behavior of the processes and operations.

Rafiqul Gani, Director of CAPEC

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CAPEC

COMPUTER AIDED PROCESS-PRODUCT ENGINEERING CENTRE (CAPEC)

The CAPEC research centre applies a systems approach to develop comprehensive solutions to various industrial problems based on a thorough analysis of scientific issues and actual product/process requirements. The developed systematic methods are generic in character and therefore applicable to a wide range of problems in process and product engineering.

Additionally, the systems approach enables CAPEC to convert the developed methods into software tools for problem analysis and solution. Thus, the research at CAPEC has resulted in the development of a range of generic model-based techniques and their conversion into state of the art computer-aided tools for modelling, synthesis, design, operation, control and analysis – each method dedicated to systematic and efficient process/product engineering.

The research at CAPEC is organized into six research programs within a logical framework ranging from fundamental to applied research. Based on the fundamental modelling at the generic levels, computer-aided methods and tools are developed at the next (intermediate) levels for synthesis, design, analysis and control of process/product/operation. Again, these models, methods and tools are integrated in the final research levels, where end-user solutions are generated for the development of cleaner, safer and sustainable technologies.

Headed by Professor Rafiqul Gani, the CAPEC research centre constitutes a very distinct group of professors and associate professors, researchers, post-docs and PhD students that contribute to the joint activities of KT. Additionally, CAPEC usually hosts around 10 MSc and BSc students plus a varying number of visiting students and international visitors.

In 2007 CAPEC was supported by the following industrial consortium

- Akzo-Nobel (NL)
- Alfa Laval A/S (DK)
- AstraZeneca (S)
- Atomistix A/S (DK)
- BASF (D)
- Bayer AG (D)
- ChemProcessTechnologies (USA)
- Danisco A/S (DK)
- DSM (CH)
- DuPont (USA)
- Einar Willumsen A/S (DK)
- Firmenich (CH)
- FLS-Automation A/S (DK)
- FMC Corporation (USA)
- GlaxoSmithKline (USA)
- ICI Strategic Tech. Group (UK)
- Instituto Mexicano del Petróleo (MX)
- Invensys SimSci-Esscor (USA)
- Kongsberg Maritime (NO)
- Mitsubishi Chemical Corp. (JPN)
- Neste Oil (SF)
- Novozymes A/S (DK)
- NPIL Pharmaceuticals Ltd. (UK)
- Optience (USA)
- Petrobras (Brasil)
- Processium (F)
- ProSim SA (F)
- SCG Chemicals Co, Ltd. (TH)
- Syngenta (UK)
- Unilever (USA)
- VTT Technical Research Centre of Finland (SF)

At the Danish Polymer Centre we are devoted to the application of molecular design, synthesis and processing of polymers to create materials and products with unlimited ranges of properties and applications.

We strive towards this goal in a balanced environment of education, research and industrial cooperation.

Ole Hassager, Director of DPC.DTU

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DPC.DTU

THE DANISH POLYMER CENTRE (DPC.DTU)

The Danish Polymer Centre is devoted to fundamental research in polymers, soft materials and complex fluids and to utilize polymer research in education, technological innovation and industrial collaboration. Organized within the Department of Chemical and Biochemical Engineering, the centre is located in close proximity to polymer activities at the Department of Mechanical Engineering and the Department of Micro- and Nanotechnology. The research is interdisciplinary ranging from chemical synthesis, chemical and physical characterization of polymers and soft materials to fluid mechanics of complex fluids.

Equipped with state of the art instrumentation for polymer characterization, the laboratories at the DPC.DTU provide a common ground for polymer chemists, polymer physicists and chemical engineers. Current techniques include the synthesis of polymers with controlled molar mass, branching structure and functional groups, application of scattering methods for study of complex polymer systems, rheological characterization and the design of multi-phase systems.

MSc in Polymer Engineering

Students in the DTU masters program in Advanced and Applied Chemistry may specialize in Polymer Engineering. This will allow master students to be trained in our laboratories and to engage in research at the DPC.DTU.

Research Consortium in Polymers at DTU

The basic purpose of this consortium which was established in 2006 is to ensure stability and continuity of contact and communication between the Polymer Centre at DTU and those parts of Danish industry, which commercially use polymers. The consortium will run a number of smaller research projects. The consortium will be a greenhouse for conceiving and innovating ideas and plans for future research and educational initiatives.

Graduate School of Polymer Science

Initiated in 2003, the Graduate School of Polymer Science is a research education network between the Department of Chemical and Biochemical Engineering DTU, the Department of Chemistry at Aarhus University, Risø National Laboratory and associated industrial companies. Financial support to the DPC.DTU is provided by the Danish National Research Council, the European Union, the members of the Research Consortium in Polymers and the members of the Graduate School in Polymer Science.

Members of the Research Consortium in Polymers

- Alfa Laval Nakskov A/S
- Coloplast A/S
- Dyrup A/S
- Elektro-Isola A/S
- Grundfos Management A/S
- Hempel A/S
- Nanon A/S
- Novo Nordisk A/S
- Radiometer Medical ApS
- Rockwool International A/S

Members of the Graduate School of Polymer Science

- Aarhus University
- Coloplast A/S
- DTU
- Elektro-Isola A/S
- Grundfos A/S
- NKT Research & Innovation A/S
- Novo Nordisk A/S
- Radiometer Medical ApS
- Teijin Twaron

The goal of the Center for BioProcess Engineering is to create a strong link between generic chemical engineering research and the industrial application of biotechnology.

The vision of the Center is to provide new knowledge led principles for designing new biobased production processes and procucts. At the same time the objective is to hatch top-qualified M.Sc. and Ph.D. cadidates through research based teaching and supervision. We hope that this twofold strategy will contribute to fullfilling the potential of biotechnology to substantially impact indutrial production and hereby contribute to development of new, ingenious, and sustainable processes and products.

Anne S. Meyer, Director of BioProcess Engineering

Director, Professor Anne S. Meyer | am@kt.dtu.dk | Phone: +45 252909

BIOPROCESS ENGINEERING

Center for BioProcess Engineering is a multidisciplinary research center established at the Department of Chemical and Biochemical Engineering, DTU. The purpose of the Center is to strengthen the integration of chemical engineering research with biotechnology via a focused research effort linking generic chemical engineering science with industrial applications of biotechnology. BioProcess Engineering is thus an interdisciplinary research field that employs chemical engineering principles in the industrial application of biologically based reactions and processes. The Center operates at the interface between biotechnology and chemical product and process engineering. Particular focus areas include enzyme catalysed conversions and application of biochemical reaction engineering principles for analysing, modelling, developing, improving, controlling, and scaling-up of industrial biocatalyctic processes. The Center for BioProcess Engineering hosts three larger research structures:

The Novozymes BioProcess Academy was established in 2002 with substantial support from Novozymes A/S. The overall mission of the Academy is to strenghten the integration of chemical engineering, processing technology, and biotechnology. The particular objective is to ensure the education of candidates being highly competent within product and process engineering acquired both in the laboratory and in the pilot plant scale to the booming Danish biotech industry. Currently, 8 full-time, post-graduate students studying for the qualification of Ph.D. as well as 4 M.Sc. students are enrolled with the academy.

The Research Consortium "Innovative BioProcess Technology" was established in 2005 as a major research collaboration between the Department of Chemical and Biochemical Engineering and Department of Systems Biology, DTU and the three major Danish biobased companies: Novozymes A/S, Danisco A/S, and Chr. Hansen A/S. In this Research Consortium generic research tools are being developed to adress three main goals with respect to bioprocess development: I. Procuring the scientific basis for the process, II. Choosing the right process scheme, and III. Quantifying the pace of the biocatalyctic events. This research effort will run for at least 5 years and educate at least 5 Ph.D., 1 post doc, and 10 M.Sc. candidates.

Center for Biological Production of Dietary Fibres and Prebiotics was established in 2007 via a grant from The Danish Council for Strategic Research. The research focus is on developing bioconversion processes for upgrading of plant polysaccharides present in industrial byproduct streams. The objective is to design high value carbohydrate products having potential health benefits.

Centre for BioChemical Engineering cooperates with the following industrial partners

- Chr. Hansen A/S
- Danisco A/S
- Foss Analytical A/S
- Ingenza Ltd
- Iso Mix A/S
- Lyckeby Stärkelsen Amba (Sverige)
- Novo Nordisk A/S
- Novozymes A/S
- Vallø Saft A/S

Our support units provide important services for students, teachers and researchers and are responsible for the full array of technical and administrative functions at the Department.

You will find some remarkable people working as support staff at the Department of Chemical and Biochemical Engineering. Our team enjoys its work and benefits from relationships marked by trust and team spirit, both within our department and with our colleagues throughout the Technical University of Denmark.

May Brandt, MBA, Head of Administration

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ADMINISTRATION & TECHNICAL SUPPORT

SUPPORT STAFF

Innovative teaching, research and consulting require the support of professional services. Our high-quality services enable us to deliver excellent education and project work.

Working in our support units means being a strong partner for our students, teachers and research teams, and accompanying them throughout all phases of their work.

Finances and Administration

Efficient support from our people in accounting, finances and the administrative functions plays an important role within our department. We provide services in many different areas, including financial accounting, project administration, budget consolidation, forecasts, controlling, contracts, travel expense accounting, facility management and general administration.

Corporate Communication

Our webeditor ensures that our website meets our high standards with respect to design and business communication, and writes up the latest company news in our corporate website and annual reports.

Service and Planning

The secretaries are the first point of contact for students, partners and colleagues alike. They handle a multitude of inquiries, information, and tasks, and even under pressure they never lose their diplomatic touch. They play a major role in ensuring that a wide range of internal processes run smoothly.

Information Technology Services

The focus of this unit is knowledge management (databases), IT consulting, IT solutions and support which include ordering, installing, and configuring hardware and software, as well as maintaining the IT back office.

Workshop

Craftsmanship and innovation go hand in hand when the workshop at the Department provides our small and large scale laboratories with custom made, high quality equipment.

Laboratories

Our laboratory technicians ensure high safety standards and efficient caretaking of our laboratories, education and research facilities.

The technical staff at DTU Chemical and Biochemical Engineering.

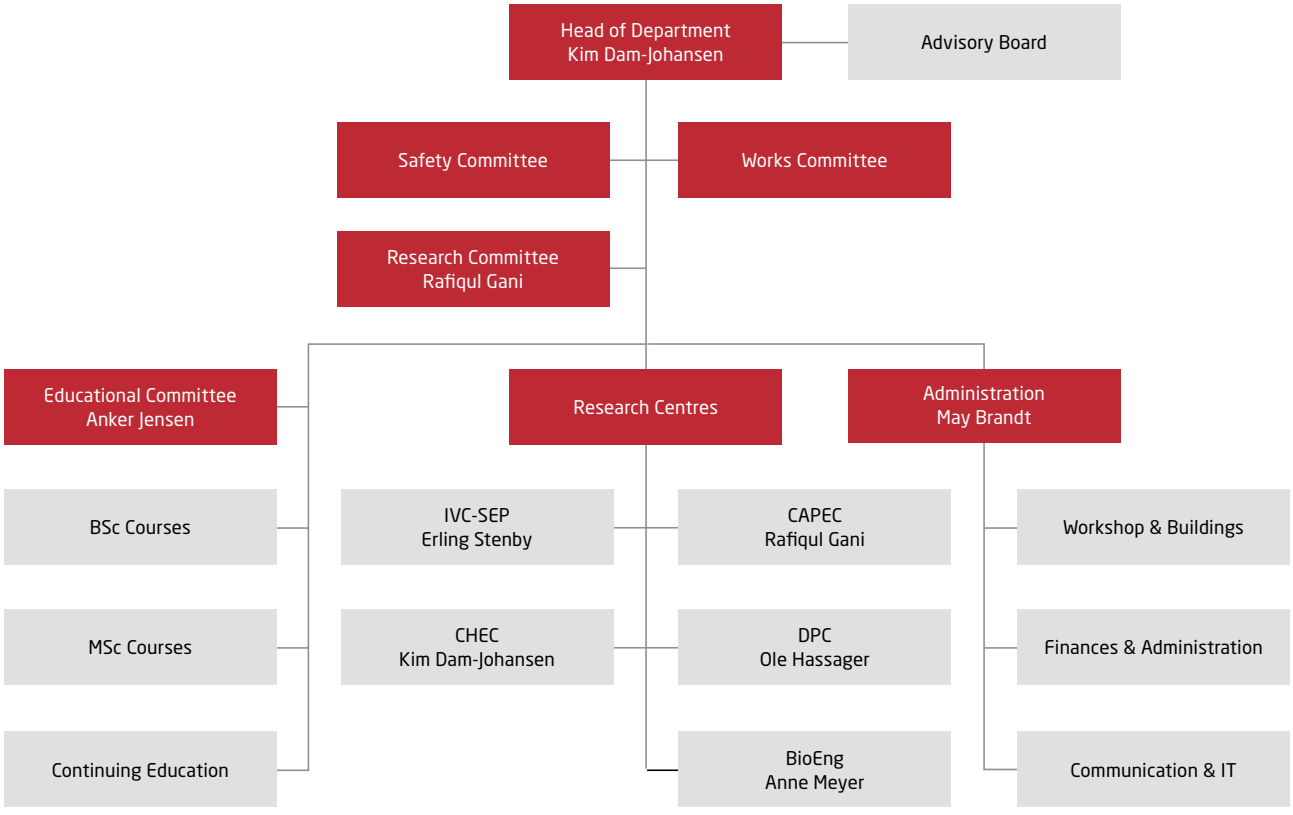
Research into dietary fibres at DTU Chemical Engineering is a step towards providing healthier foods for consumers of the future.

PRODUCTIVITY & STAFF

STUDENT COMMITTEE

Student Committee (from left to right):
Thomas Petersen, Michael T. Jensen, Birgitte Zeuner, Lars Johansen and Johan Bruun.

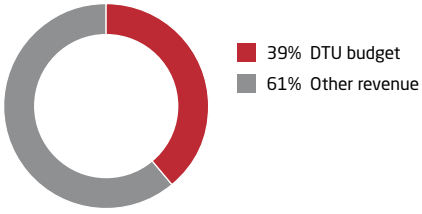
ORGANIZATION



KEY FIGURES
FINANCES AND STAFF 2007

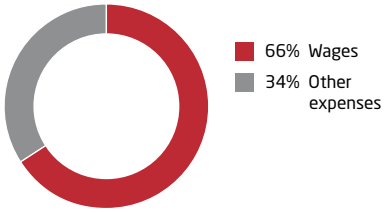
Revenue 2007

(Total 105,654 mill. DKK)



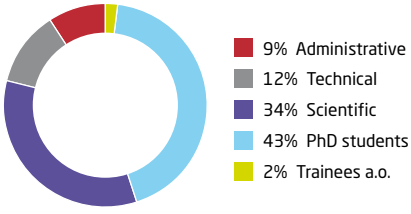
Expenditures 2007

(Total 97,444 mill DKK)



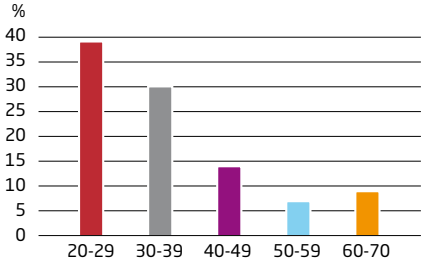
Type of staff

(Total 202 persons)



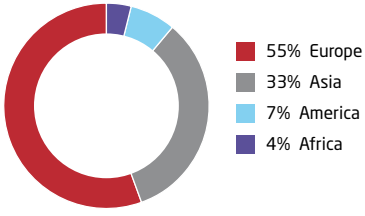
Staff distributed by age

(Total 202 persons)



Foreign scientific staff

(Total 63 persons)



PRODUCTIVITY

TEACHING & EDUCATION 2007
STUDENTS, EDUCATIONAL RESOURCES AND -IMPACT

Students in total (STÅ*)	167
Students per faculty man-year	6.4
Courses in 5-point units	79
Participants in special courses	46
Completed BSc projects	13
Completed MSc projects	51
Total course units	92

*One STÅ is the equivalent of one student studying full time in a year

RESEARCH & INNOVATION 2007
PUBLICATIONS, PATENTS AND COMMERCIALIZED RESEARCH

Scientific publications with referee	107
Contributions to refereed conference proceedings (not indexed in ISI)	22
Contribution to books	5
Citations 2003-2007	2041
PhD theses	18

PUBLICATIONS

Articles in journals

Al-Jibbouri, Sattar (2007). The influence of salt type on the retention of bovine serum albumin in ion-exchange chromatography. Journal of Chromatography A, 1139(1), 57-62

Astrath, Dirk-Uwe; Lottes, Florian; Vu, Duc Thuong; Arlt,Wolfgang; Stenby, Erling Halfdan (2007). Experimental investigation of liquid chromatography columns by means of computed tomography. Adsorption, 13, 9-19

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Rissanou, A.N.; Peristeras, L.D.; and Economou, I.G. Calculation of the Effect of Macromolecular Architecture on Structure and Thermodynamic Properties of Linear - Tri-arm Polyethylene Blends from Monte Carlo Simulation. 11th International Conference on Properties & Phase Equilibria for Product and Process Design, Hersonissos, Crete, Greece, 20-25 May, 2007

Rype, Jens-Ulrik; Garde, Arvid; Vrang, Astrid; Madsen, S.; Jonsson, Gunnar Eigil. Combining Membrane Separation and Fermentation Processes for improved performance. European Congress of Chemical Engineering – 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul. Polymer Property Modeling Using Grid Technology for Design of Structured Products. PPEPPD 2007, Crete, Greece, 20-25 May, 2007

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul. Simultaneous polymer property modeling using Grid technology for structured products. ESCAPE-17, Bucharest, Romania, 27-30 May, 2007

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul. Polymer property modelling using grid technology for design of structured products. European Congress of Chemical Engineering – 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

PUBLICATIONS (CONTINUED)

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul. Polymer Property Modelling for the Design of the Structured Products. AIChE Annual Meeting 2007, Salt Lake City, USA, 5-9 November, 2007

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul. Development of Polymer Property Prediction Models in Parallel Using Grid Technology. AIChE Annual Meeting 2007, Salt Lake City, USA, 5-9 November, 2007

Schäpper, D.; Gernaey, K.V.; Eliasson Lantz, A.; Stocks, S.; and Szita, N. Development of Continuous Culture Microbioreactors. Presented at: European Congress of Chemical engineering - 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Shaeri, J; Wohlgemuth, R; Woodley, John. Systematic evaluation of alternative biocatalytic synthetic routes to D-xylulose-5-phosphate. CRE XI, Bilbao, Spain, 2007

Singh, Ravendra; Gernaey, Krist; Gani, Rafiqul. Model-based Computer Aided Framework for Design of Process Monitoring and Analysis Systems. Advances in Process Analytics and Control Technologies 2007, Edinburgh, 2007

Singh, Ravendra; Gernaey, Krist; Gani, Rafiqul. Design of Process Monitoring and Analysis Systems, using a Model-based Computer Aided Framework. European Congress of Chemical Engineering – 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Singh, Ravendra; Gernaey, Krist; Gani, Rafiqul. Design of Process Monitoring and Analysis Systems. AIChE Annual Meeting 2007, Salt Lake City, USA, 5-9 November, 2007

Singh, Ravendra; Gernaey, Krist; Gani, Rafiqul. Supporting Tools for Design and Validation of Process Analytical Technology System. AIChE Annual Meeting 2007, Salt Lake City, USA, 5-9 November, 2007

Soni, Vipasha; Abildskov, Jens; Jonsson, Gunnar Eigil; Gani, Rafiqul; Karayiannis, N.; Mavrantzas, V. Integrating multilevel modeling aspects to predict gas permeability in polymers for design of membranes. PPEPPD 2007, Crete, Greece, 20-25 May 2007, 2007

Soni, Vipasha; Jonsson, Gunnar Eigil; Gani, Rafiqul. A hierarchal approach based on reverse design algorithm for simultaneous design and analysis of product and processes. ESCAPE-17, Bucharest, Romania, 27-30 May, 2007

Soni, Vipasha; Abildskov, Jens; Jonsson, Gunnar Eigil; Gani, Rafiqul. A General Model and Its Analysis for Membrane Based Separation Processes. The 2nd International Conference on Advances in Petrochemicals and Polymers (ICAPP 2007), Bangkok, Thailand, 25-28 June, 2007

Soni, Vipasha; Abildskov, Jens; Jonsson, Gunnar Eigil; Gani, Rafiqul. Integrating Multilevel Modelling Aspects to Design the Membranes Using Reverse Design Algorithm. The 2nd International Conference on Advances in Petrochemicals and Polymers (ICAPP 2007), Bangkok, Thailand, 25-28 June, 2007

Soni, Vipasha; Abildskov, Jens; Jonsson, Gunnar Eigil; Gani, Rafiqul. Simultaneous product and processes design using reverse design algorithm. European Congress of Chemical Engineering – 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Soni, Vipasha; Morales Rodriguez, Ricardo; Conte, Elisa; Gani, Rafiqul. A Model-Based Systems Approach for Innovation in Integrated Chemical Product-Process Design. AIChE Annual Meeting 2007, Salt Lake City, USA, 5-9 November, 2007

Szewczykowski, Piotr; Jonsson, Gunnar; Berg, Rolf H.; Vigild, Martin E.; Ndoni, Sokol. Gyroid membranes made from nanoporous block copolymers. PERMEA 2007 Membrane Conference, Siofok, Hungary, September 2-6, 2007

Sørensen, Per Aggerholm; Kiil, Søren, Dam-Johansen, Kim; Weinell, Claus. Accelerated testing; faster development of protective coatings. In: ECCE-6 Book of abstracts. European Congress of Chemical engineering - 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Tihic, Amra; Kontogeorgis, Georgios M.; von Solms, Nicolas; Michelsen, Michael L.; and Constantinou, Leonidas. Development of a Group Contribution Simplified PC-SAFT Equation of State. Conference on Properties and Phase Equilibria for Product and Process Design (PPEPPD), 2007, Hersonissos, Crete, Greece, 20-25 May, 2007

Tihic, Amra; Kontogeorgis, Georgios M.; von Solms, Nicolas; Michelsen, Michael L.; and Constantinou, Leonidas. Development of a Group Contribution Simplified PC-SAFT Equation of State. European Congress of Chemical Engineering (ECCE-6), Copenhagen, Denmark, 16-21 September, 2007

Tihic, Amra; Kontogeorgis, Georgios M.; von Solms, Nicolas; Michelsen, Michael L.; and Constantinou, Leonidas. Development of a Group Contribution Simplified PC-SAFT Equation of State. Thermodynamics 2007, Rueil-Malmaison, France, 26-28 September, 2007.

Thomsen, Kaj; and Lin, Yi. Equation of State for Electrolyte Solutions. The European Congress of Chemical Engineering (ECCE-6), Copenhagen 16-21 September, 2007

Vigild, M. E.; Ndoni, S.; Szewczykowski, P.; Guo, F.; Schulte, L.; Mortensen, Kell. Memory of nanoporous elastomeric polymers. 4th European Conference on Neutron Scattering, Lund, Sweden, 25-29 June, 2007

Villadsen, J. Bioreaction Engineering: A discipline striving for independence. European Congress of Chemical Engineering (ECCE-6), Copenhagen, September 16-20, 2007

von Solms, Nicolas. Gas-Polymer Interactions in Carbon Dioxide Refrigeration Plants. 5th International Conference on Heat Transfer, Fluid Dynamics and Thermodynamics, Sun City, South Africa, July 1-4, 2007

von Solms, Nicolas. How can spectroscopy help us to model hydrogen bonding fluids? European Congress of Chemical Engineering (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Wu, Zhenning; Jiang, Juan; Andersen, Thomas E.; Benter, MaikeM Larsen, Niels B.; Jankova, Katja. Novel polymer coatings based on plasma polymerized 2-methoxyethyl acrylate. 9 th International Symposium on Polymers for Advanced Technologies (PAT 2007), Shanghai, China, October 22-25, 2007

Yan, W.; Kontogeorgis, G.M.; and Stenby, E.H. Application of the CPA Equation of State to Reservoir Fluids in Presence of Water and Polar Chemicals. SPE Annual Technical Conference and Exhibition, Anaheim, CA, USA, 11-14 November, 2007

Yilmaz, Ayten; Glarborg, Peter; Livbjerg, Hans. Particle Formation from Gas Cookers. NOSA Aerosol Symposium 2007, 2007

Ödman, Peter; Petersen, Nanna; Johansen, Claus Lindvald; Olsson, Lisbeth; Garnay, Krist V.; Eliasson Lantz, Anna. On-line monitoring of fermentation processes using multi-wavelength fluorescence. 2nd Nordic Meeting on Process Analytical Technologies for young academics, Sweden, Stockholm, 2007

Åkesson, Bernt Magnus; Jørgensen, John Bagterp; Poulsen, Niels Kjølstad; Jørgensen, Sten Bay. A Tool for Kalman Filter Tuning. ESCAPE-17, Bucharest, Romania, 27-30 May, 2007

Åkesson, Bernt Magnus; Jørgensen, John Bagterp; Poulsen, Niels Kjølstad; Jørgensen, Sten Bay. Estimation of noise covariances and indentification of disturbance structure using the autocovariance least-squares method. European Congress of Chemical Engineering – 6 (ECCE-6), Copenhagen, Denmark, 16-20 September, 2007

Åkesson, Bernt Magnus; Jørgensen, John Bagterp; Poulsen, Niels Kjølstad; Jørgensen, Sten Bay. Improving Model Predictive Control Performance Using Systematic Kalman Filter Tuning. NPCW14, Espoo, Helsinki, Finland, 25 August, 2007

Åkesson, Bernt Magnus; Jørgensen, John Bagterp; Poulsen, Niels Kjølstad; Jørgensen, Sten Bay. Improving Model Predictive Control Performance Using Disturbance Estimation. AIChE Annual Meeting 2007, Salt Lake City, USA, 5-9 November, 2007

PUBLICATIONS (CONTINUED)

Chapters in books

Gani, Rafiqul; Dam-Johansen, Kim (2007). Chemical Product Design - A Brief Overview. Computer-Aided Chemical Engineering, 23 (p. 1-21)

Gani, Rafiqul (2007). Case Studies in Chemical Product Design - Use of CAMD Techniques. Computer-Aided Chemical Engineering, 23 (p. 435-458)

Gani, Rafiqul; Abildskov, Jens (2007). Modelling of Chemical Systems to Predict Product Properties. Bröckel,V.; Meier,W.; Wagner,G. (Eds.) Product Design & Engineering, VM-1; Basics & Technologies Germany: Wiley-VCH

Hvilsted, S., P. Forcén, L. Oriol, C. Sánchez, R. Alcalá, and P.S. Ramanujam (2007). Novel Polymer Architectures for Optical Storage. Electroactive Polymers, Materials and Devices, Volume II. S.A. Hashmi, A. Chandra, A. Chandra, (Eds.), S. Chandra (Series Ed.), Allied Publishers Pvt. Ltd., New Delhi, ISBN 10: 81-8424-246-8, Chapter 21, 165-174

Kontogeorgis, Georgios (2007). The hansen Solubility Parameters (HSP) in Thermodynamic Models for Polymer Solutions. Hansen Solubility Parameters - A user´s handbook by Charles Hansen CRC Press

Ng, Ka M.; Gani, Rafiqul; Dam-Johansen, Kim (2007). Product Development - What to Make and How to Make. Computer-Aided Chemical Engineering, 23 (p. 473-489)

Books

Ng, Ka M.; Gani, Rafiqul; Dam-Johansen, Kim. Chemical Product Design: Toward a Perspective through Case Studies. Computer-Aided Chemical Engineering, 23 - Elsevier, 2007

Wesselingh, J.A., Kiil, S., Vigild, M.E. (2007) Design and development of biological, chemical, food and pharmaceutical products, Wiley 2007

PhD dissertations

Christensen, Steen: Thermodynamic Models from Fluctuation Solution Theory analysis of Molecular Simulations

Enevoldsen, Ann Dorrit: Electrically Enhanced Ultrafiltration of Industrial Enzyme Solutions

Gabrielsen, Jostein: CO2 Capture from Coal Fired Power Plants

Guilin, Hu: Emission of SO2 from Cement Production

Hansen, Morten Skov: Investigation of autonomous cell cycle oscillation in Saccharomyces cerevisiae

Hansen, Natanya Majbritt Louie: Synthesis of Amphiphilic Copolymwers by Atom Transfer Radical Polymerization

Hindsgaul, Claus: Disintegration of beech wood char during thermal conversion

Larsen, Morten Boberg: Alternative Fuels in Cement Production

Larsen, Thomas Ricco Ølholm: Tribological studies of polymer-matrix composites

Lin, Yi: Development of an equation of state for solutions containing electrolytes

Lohse, Brian: Molecular Materials for Optical Data Storage

Løj, Lusi Hindiyarti: Gas Phase Sulfur, Chlorine and Potassium Chemistry in Biomass Combustion

Nielsen, Jens Kromann: Synthesis and Extensional Rheology of Linear and Branched Polymer Melts

Petersen, Trine Lütken: Post translational modifications of proteins: Novel in vitro methods for their study and scale-up

Rasmussen, Christian Lund: Direct Partial Oxidation of Natural Gas to Liquid Chemicals

Rasmussen, Jan Kamyno: Fed-Batch Process Modelling for Monitoring, Optimisation & Control. (incl. A Continuous Time Stochastic Modelling Framework)

Sloth, Jacob: Formation of Enzyme Containing Particles by Spray Drying, Department of Chemical Engineering

Zeuthen, Frederik Jacob: The Formation of Aerosol Particles during Combustion of Biomass and Waste

Emission control research at DTU Chemical Engineering covers the domestic field as well as the industrial. Particle emission from wood-burning stoves found in private homes accounts for approximately 40 % of particle emission in Denmark.

EDUCATION

MASTER AND BACHELOR COURSES

The Department participates in a 3½ year education for the Bachelor of Engineering Degree, a 3 year education for Bachelor of Science and a 2 year education for the Master's Degree. Below, course numbers and names are shown. For 2007 the number of students attending shown in brackets.

SPRING-SEMESTER

28012 Chemical and Biochemical Process Engineering (19) (B)
28015 Mathematical models for chemical and biochemical systems (31) (B)
28021 Unit Operations of Chemical Engineering (7) (B)
28022 Unit Operations of Chemical Engineering and Biotechnology (26) (B)
28110 Chemical and biochemical product analysis (24)
28121 Chemical Unit Operations Laboratory (20)
28160 Mathematical models for chemical systems (40)
28212 Polymer Chemistry (27)
28221 Chemical Engineering Thermodynamics (17)
28231 Laboratory in Chemical and Biochemical Engineering (16)
28244 Combustion and High Temperature Process (5)
28312 Computer-Aided Product Design (15)
28315 Colloid and Surface Chemistry (3)
28321 Chemical Engineering Thermodynamics (20) (B)
28322 Chemical Engineering Thermodynamics (29) (B)
28341 Chemical Reaction Engineering (21) (B)
28350 Process Design: Principles and Methods (22)
28351 Process Control (24) (B)
28375 Air Pollution Control (21) (B)
28410 Design and test your own product ideas (2)
28415 Oil and Gas Production (18)
28423 Phase Equilibria for Separation Processes (21)
28434 Membrane Technology (21)
28443 Industrial Reaction Engineering (19)
28451 Optimizing Plantwide Control (7)
28530 Transport Processes (5)
28852 Risk Assessment in Chemical Industry (22)
28863 Introduction to Fortran Programming (8)
28864 Introduction to Matlab Programming (35)
28885 Technology and Economy of Oil and Gas Production (10) (B)

Course given in co-operation with other departments:

12411 Petroleum Engineering (5)
26010 Introductory Project in Chemistry (1)
26316 Analysis and Chromatography (15)
27944 Biotechnology and process design (23) (B)
41015 Mechanics and Materials (7)
42110 Materials Science (182)
42983 Corrosion and Materials Selection (26)
42984 Materials Science (22) (B)

FALL-SEMESTER

28001 Introduction to chemistry and chemical engineering (62)
28012 Chemical and Biochemical Process Engineering (43) (B)
28013 Chemical and Biochemical Process Engineering, I (11) (B)
28014 Chemical and Biochemical Process Engineering, II (7) (B)
28015 Mathematical models for chemical and biochemical systems (34) (B)
28020 Introduction to Chemical and Biochemical Engineering (36)
28021 Unit Operations of Chemical Engineering (6) (B)
28022 Unit Operations of Chemical Engineering and Biotechnology (27) (B)
28120 Introduction to Chemical and Biochemical Engineering (3)
28121 Chemical Unit Operations Laboratory (3)
28140 Introduction to Chemical Reaction Engineering (27)
28150 Introduction to Process Control (21)
28153 Process Design (8) (B)
28213 Polymer Technology (30)
28241 Chemical Kinetics and Catalysis (30)
28244 Combustion and High Temperature Process (31)
28310 Chemical and Biochemical Product Design (35)
28315 Colloid and Surface Chemistry (31) (B)
28321 Chemical Engineering Thermodynamics (19) (B)
28322 Chemical Engineering Thermodynamics (27) (B)
28341 Chemical Reaction Engineering (17) (B)
28351 Process Control (14) (B)
28361 Chemical Engineering Model Analysis (22)
28420 Separation Processes (18)
28515 Enhanced Oil Recovery (21)
28530 Transport Processes (31)
28811 Polymers in Processes and Products (23)
28845 Chemical Reaction Engineering Laboratory (11)
28851 Chemical Plant Operation (15)
28863 Introduction to Fortran Programming (3)
28864 Introduction to Matlab Programming (48)
28894 Catalytic and Advanced Reaction Engineering (19)

Courses given in co-operation with other departments:

10336 Fundamentals Problems in Fluid Dynamics (14)
12411 Introduction to Petroleum Technology (24)
26010 Introductory Project in Chemistry (33)
27004 Health, Diseases and Technology (23)
27006 Design of biotechnological and environmental processes (86)
27009 Pharmocokinetics (Introductory project work – Food and Drug Technology) (20)
27406 Biotechnology Purification Methods (23)
41015 Mechanics and Materials (54)
42981 Materials Science (38) (B)
42983 Corrosion and Materials Selection (14) (B)

EDUCATION (CONTINUED)

Master of Science Degrees

Adrah, Dennis Setorwu
Modeling of phase equilibria for petroleum-alcohol mixtures

Alvarez Villanueva, Maria Antonieta
Fed-Batch Cultivation Control

Andersen, Kasper Ørum
Antibody Production – Process Analysis

Andrade, Paloma
Optimizing Plantwide Control

Avlund, Ane Søgaard
Octanol-water distribution of chemicals in oil industry

Bentzen, Line Lone Hestkjær
Oxyfuel combustion of methane and propane

Boesen, Rasmus Risum
Development of a Reactor Model for Trickle-Bed Hydrodesulfurization Units

Brix, Jacob
Modelling of entrained flow gasification of solid fuels for syngas production

Casanovas Melià, Mercè
Ozonation of fly ash

Christensen, Jakob Munkholt
Catalytic conversion of syngas to mixed long chain alcohols

Darde, Victor Camille Alfred
Environmental aspects of CO2 capture from flue gas

De Matos, Daniela
Fermentation process monitoring using dynamic principal component analysis

Garrido, Nuno
Modelling of multifunctional chemicals used in oil industry with the CPA equation of state

Ghiyati Ibn Ziyad, Yassir
Understanding and modelling of recombination reactions of olefins and hydrogen sulfide

Gilsenan, Paula Marie
Chromatographic scale-up studies using model protein systems

Giselsson, Trine Mosgaard
Experimental and theoretical optimization of oxyfuel combustion

Giménez Lôpez, Jorge
Oxidation of soot precursors (C2H2/C2H4) and their interaction with NO at high pressure

Guo, Fengxiao
Nanoporous Polybutadiene

Javakhishvill, Irakli
Strategies for preparation of functional polymers with mucoadhesive properties

Jensen, Lars
Gas Hydrates – formation and inhibition

Jensen, Mette Krog
Flow and diffusion of large molecules in microfludic systems

Kofod, Jonas Lyberg
Modelling of phase equilibria for mixtures of relevance to the PTA process

Kristensen, Jakob
Polymers in Refrigeration Plants using Carbon Dioxide as Refrigerant

Labrenz, Agnieszka
Modelling of Biofuel Related Transesterification Reactions

Larsen, Steen
Production of decadmiated phosphate by crystallization and ion exchange

Laursen, Christopher Berglund
CO2 injection in low permeable chalk – a potential EOR method

Leivas Bentos, Rogerio
Fermentation process monitoring using multi-way principal component analysis

Lencastre Fernandes, Rita
Development of microbioreactors for continous yeast cultivations

Llaneza Carceller, Angel
Osmotic pressure of proteins

Lund, Christoffer Buhl
Optimization of the sugar yield in sugar production by using organic solvents to treat molassis

Lundsgaard, Rasmus
Modelling of the migration of phthalates in PVC

Mieiro, Arlindo
Determination of solid-liquid equilibrium using conductivity measurements

Moos, Kristoffer
Whisker Carbon from Methane Decomposition over Reforming Catalysts

Mortensen, Louise Kristine
Experimental and theoretical optimization of woodburning stoves

Neidel, Bjarke
Water-soluble polymer fluid bed coatings

Novakovic, Aleksandra
Release in the system: K-Ca-P(Mg) – The effect of the Ca/P ratio

Nørgaard, Kristian Petersen
Experimental and modelling investigation of gas phase freeboard reactions in a pilot scale reactor

Olaso Pradère, Cristina
Aerosol formation from gas cooker

Potluri, Amarnadh
Fly ash deposition in SCR monolith reactors

Pedersen, Desislava Angelova
Novel polymers for medical decices

Rado Rubio, Oscar Andres
Single cell protein fermentation- modelling, control and optimization

Pueyo, Sonia
Deactivation of SCR Catalysts by Additives

Rafiq, Muhammad Hamid
Design and Analysis of Bio-diesel Process

Rasmussen, Martin Hagsted
Optimized Cement Production

Scheiding, Fleur Desireeé Blanc
Kinetic investigation of a Buchwald-Hartwig amination reaction

Steinsen, Steinunn Dögg
Release of inorganic metals, S and Cl from waste fractions

Sønder, Klaus Bloksgaard
Foaming in FGD plants

Tschentscher, Roman
Aerosol routes to catalytic materials

Wu, Hao
Solids ignition and burn-out in modern combustors

Yu, Kaijia
Preparation of bioacceptable block copolymers by ATRP and "click chemistry"

Zheng, Yuanjing
Potassium capture by coal minerals in a high temperature fixed bed reactor

Bachelor of Engineering

Awad, Hassan
Epoxy binders and their influence on properties and performances of anticorrosive paints

Bergmann, Stine Bothmann and Yasin, Soniasara
Prediction of gas hydrate inhibition using the CPA equation of state

Hansen, Martin Frank
Dimensional stability and internal stress of epoxy coatings during curing

Hauerberg, Niklas Linnemann
Preparation and test of methanation catalysts

Ikram, Shahid
Batch distillation design and analysis

Jensen, Michael Tvedebrink
Modeling of wax depositions in pipelines

Jørgensen, Tommy Lykke
Oxidation of SO2 to SO3

Kudal, Jacob Dermo
Impregnation of large extrudates to desulfurization catalystats

Qayyum, Saddia
Deactivation processes for the Buchwald-Hartwig amination reaction in the production of pharmaceuticals

Rehal, Zainab Kaur and Mukhtar, Amina
Char reactivity at oxy fuel conditions

Weltersbach, Peter
Gas Exportation from SIRI

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Hansen, Natanya	20.06.07
Hindiyarti, Lusi	19.06.07
Hindsgaul, Claus	18.01.07
Hu, Guilin	26.03.07
Larsen, Morten Boberg	23.02.07
Larsen, Thomas Ølholm	30.03.07
Lohse, Brian	16.03.07
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Petersen, Trine Lütken	08.06.07
Rasmussen, Jan Kamyno	22.10.07
Rasmussen, Christian Lund	06.09.07
Sloth, Jakob	17.12.07
Yi, Lin	08.06.07
Zeuthen, Jacob	24.05.07

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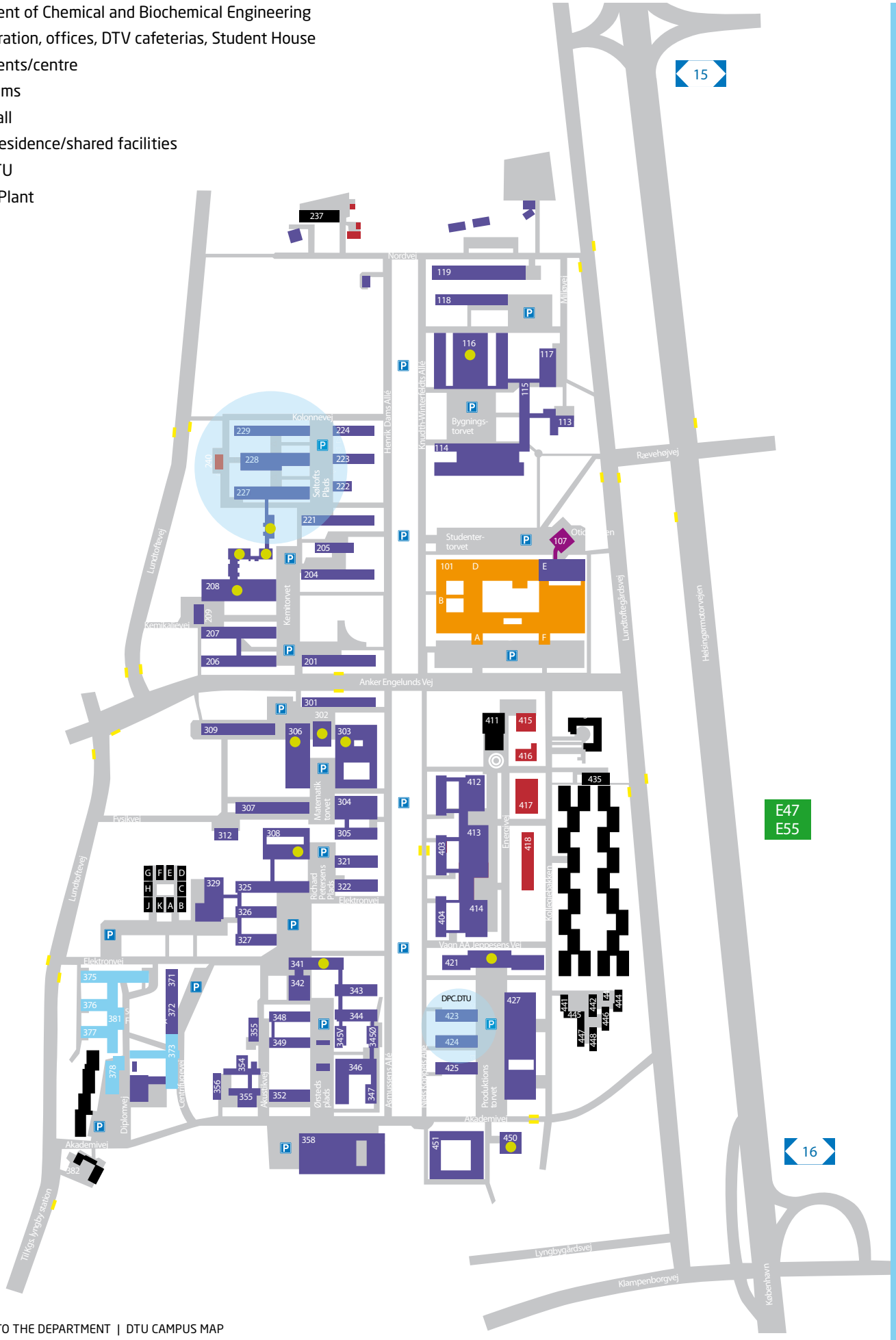
- Departments/centre
- Auditoriums
- Oticon Hall
- Halls of residence/shared facilities
- SCION.DTU
- Physical Plant
- Parking
- Bus stop



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This Annual Report 2007 may be ordered from the reception at the Department of Chemical and Biochemical Engineering, DTU

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