Technical University of Denmark

Annual Report **2008**

DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

Annual Report 2008
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Head of Department

Rapeseed is the preferred feed stock for biodiesel production in most of Europe.
Several projects at DTU Chemical Engineering are dedicated to the production of liquid fuel from biomass.

HEAD OF DEPARTMENT

ACCLIMATIZING CHEMICAL ENGINEERING FOR GLOBAL CHANGES

Kim Dam-Johansen
Professor, Head of Department

The rapid changes in both local and international economies in late 2008 underlined to what extent we live in a truly globalized world. The academic sector conceded to this reality years ago, and DTU Chemical Engineering has a solid history as a Danish university department deeply rooted in international orientation and cooperation. Within our department, employees and students represent all corners of the globe.

Our international focus will continue to increase during the coming years. DTU Chemical Engineering will enhance international programs aimed at facilitating the further development of chemical engineering as a discipline characterized by a strong commitment to quick and efficient adaption of scientific insights into products for practical use. This global arena addresses the challenges within product design, process design, and production within the fields of chemistry and biotechnology as well as the food-, pharmaceutical-, and energy-related industries – all in hopes of benefiting people throughout the world.

In 2008, our international commitment was reflected in multiple programs within the department. In addition to hosting international summer schools and PhD courses, we actively recruited faculty members, PhD fellows, and MSc students from a wide variety of countries. Moreover, the planning and organization of an international, industry-oriented Elite Masters Program within the field of Chemical and Biochemical Engineering has been successful; the program will start September 1, 2009. The Elite Masters Program will be open to a few, especially talented students from around the globe who will get an MSc education with a sharp focus on the interplay between academic research and development within the industry. Upon completion of the program, these students will be able to hold the best positions within industrial research, innovation, process design, operation, and management.

Building new bridges in the catalysis field

With approximately ninety percent of the world's industry-related chemical processes based on catalysis, this particular field has always been of vital importance in chemical engineering. Years ago, we decided to give special attention to the combination of chemical and biochemical catalysis. Then, in 2008, a major step in this direction was taken when a group of five full

professors and one adjunct professor was formed in order to establish significant activity covering enzymatic and heterogeneous catalysis and process technology. The group includes the professors Jan-Dierk Grunwaldt, John Woodley, Anne S. Meyer, Anker Jensen, Jørn Dalgaard Mikkelsen, and adjunct professor Claus Hviid Christensen.

New challenges – New organization
Catering to the challenges of a growing international outlook and increasingly multidisciplinary approach, the planning of a new organizational structure of the department has taken place during the last part of 2008. This new structure is to be implemented in early 2009 and will be composed of disciplinary groups and cross-disciplinary groups covering: Catalytic and Product Engineering (Professor Jan-Dierk Grunwaldt), Engineering Thermodynamics (Docent Georgios Kontogeorgis), Reaction and Transport Engineering (Professor Anker Degn Jensen), Process Technology and Unit Operations (Professor John Woodley), Systems Engineering (Professor Rafiqul Gani), Polymer Technology (Professor Ole Hassager), Petroleum Engineering (Professor Erling Stenby), Combustion and Environmental Engineering (Professor Kim Dam-Johansen), and Bio Engineering (Professor Anne Meyer).

Recognition from the world around us
Widening the international outlook, sharpening the scientific profile, and improving the organizational structure is, in itself, not enough to guarantee excellent results – the effort and dedication of each individual is inestimable, and I am proud to say that 2008 was a year where both faculty and students from DTU Chemical Engineering received an exceptional amount of recognition from the outside world. Professor Anne S. Meyer received the Grundfos Prize 2008; Professor Martin E. Vigild was awarded the Dana Lim Prize 2008; DTU Chemical Engineering students, Jon Christiansen and Bjørn Maribo-Mogensen, won first prize for the project "Internal Steam Reforming in Solid Oxide Fuel Cells"; PhD student Philip Loldrup Fosbøl received the Peter Gorm Petersen Grant.

During 2008, the focus on climate issues drew more headlines in global news than ever before, and in December of 2009, Denmark will host the United Nations Climate Change Conference, COP15. In connection to this, DTU Chemical Engineering will host a workshop on Combustion, Carbon Capture and Storage with the aim of gathering recommendations for future technological development in this field. Both the increasing concern about emission of greenhouse gasses like CO_2 and the global need for cleaner, cheaper, more energy-efficient production methods call for innovative, internationally oriented, and multidisciplinary chemical engineering. At DTU Chemical Engineering we have decades of experience in all of these fields. We look forward to cooperation with our old and new local and international partners in industry and academia on current as well as future challenges.

I wish you a pleasant read.

Kim Dam-Johansen
Professor, Head of Department

HIGHLIGHTS 2008

Since the acid rain debate raged in the 1980s , Denmark has succeeded in reaching its ambitious goals for SO_2 reduction, going from 155 thousand tons in 1992 to 26 thousand tons in 2006. Research done at DTU Chemical Engineering has been a key for these succesful results. In addition, this knowledge can now be applied to research focused on reduction of CO_2 emission.

HIGHLIGHTS 2008

Rektor of DTU, Lars Pallesen, congratulates Professor and Head of Department Kim Dam-Johansen with his 25 years at DTU

JANUARY 1

Professor Jan-Dierk Grunwaldt new Professor at DTU Chemical Engineering

Professor Jan-Dierk Grunwaldt started work at DTU in January 2008 after having received the "Haldor Topsøe Chair in Catalysis and Chemical Engineering."

JANUARY 22-25

Evaluation of DTU Chemical Engineering's research program

A six-member international panel completed an evaluation of the research program within DTU Chemical Engineering. The conclusions posted in the evaluation report issued by the panel were very positive.

JANUARY 31

Departmental seminar by Dr. Tue Johannessen

A departmental seminar was given by Dr. Tue Johannessen, CTO of Amminex A/S, Denmark, entitled, "Industrialization of the hydrogen 'pill' – getting from research to revenue."

FEBRUARY 1

Professor and Head of Department Kim Dam-Johansen 25 years at DTU

On February 1, 2008 it was 25 years since Kim Dam-Johansen, Professor and Head of Department of DTU Chemical Engineering, started his carreer at DTU by being employed as a PhD student. DTU celebrated the jubilee with a reception having a very high attendance of Dam-Johansen's many associates from DTU, private companies, and the public sector.

FEBRUARY 13

Departmental seminar by Professor Gerhard Wegner

A departmental seminar was given by Professor Gerhard Wegner, the Max-Planck-Institute for Polymer Research, entitled, "Managing Photoexcited States in Polyconjugated Macromolecules."

FEBRUARY 22

Departmental seminar by Professor George Jackson

A departmental seminar was given by Professor George Jackson, Department of Chemical Engineering, Imperial College, London, UK, entitled, "Molecular based group contribution approaches for the prediction of the thermophysical properties of fluids."

MARCH 10

DTU Chemical Engineering in research collaboration with Lundbeck A/S

DTU Chemical Engineering reached an agreement with Lundbeck A/S on a research collaboration to convert production of active pharmaceutical ingredients into continuous operations.

22 chemical engineering students from the US university Virginia Tech spent their summer in Denmark

Martin Vigild receives the Dana Lim Award 2008

MARCH 27

Departmental seminar by Professor Jan-Dierk Grunwaldt

A departmental seminar was given by Professor Jan-Dierk Grunwaldt, DTU Chemical Engineering, entitled, "Nanomaterials at work ."

APRIL 1

Jørn Dalgaard Mikkelsen Danisco-LMC professor

Jørn Dalgaard Mikkelsen achieves a professorship sponsored by Danisco A/S and connected to the activities of the Center for Advanced Food Studies (LMC) at the Department of Chemical and Biochemical Engineering. The professorship and the related research activities will concentrate on developing new techniques for producing complex carbohydrates – better known as dietary fiber.

APRIL 30

Departmental seminar by Professor Alain Ponton

A departmental seminar was given by Professor Alain Ponton, Matiêre et Systêmes Complexes, Université Paris Diderot, France, entitled, "Structure and dynamics of complex fluids: from sol-gel systems to smart materials."

MAY 21

DTU Chemical Engineering gets share in major grant for bio-diesel research

The Danish National Advanced Technology Foundation awarded a three and a half year grant of 18 million DKK for research in bio-diesel. The research project comprises three research groups at DTU including DTU Chemical Engineering where John Woodley is the project anchor. The industrial parties in the project are the University of Aarhus and the Danish companies Novozymes A/S and Emmelev A/S.

MAY 22

Departmental seminar by Mr. Neville L. N. Brewis

A departmental seminar was given by Mr. Neville L. N. Brewis, Astra Zeneca, UK, entitled, "Integration of chemical engineering science into pharmaceutical process research and development."

JUNE 9-11

CAPEC Annual Meeting 2008

The CAPEC Annual Meeting 2008, held at Hotel Frederiksdal, Lyngby, had 77 participants. Out of these, 31 were member company representatives, 12 were invited guests, and the rest were CAPEC co-workers.

HIGHLIGHTS 2008

The CAPEC Annual Meeting 2008, held at Hotel Frederiksdal, Lyngby

Professor Anne S. Meyer receives the 2008 Grundfos prize

JUNE 13

Martin Vigild receives the Dana Lim Award 2008

The Dana Lim Prize worth 250.000 DKK was awarded to Reader Martin E. Vigild, DTU Chemical Engineering. The prize will enable Martin Vigild to acquire equipment for pioneer research in the field of nanoporous materials.

JUNE 16-18

IVC-SEP Discussion Meeting 2008

Every year the Center for Phase Equilibria and Separation Processes (IVC-SEP) invites its consortium members for a discussion meeting. The event took place at the conference hotel KolleKolle in Værløse. Seventy-three people participated in the meeting and 22 of these were participants from outside DTU Chemical Engineering.

JUNE 24

Departmental seminar by Professor Lutz Mädler

A departmental seminar was given by Professor Lutz Mädler, Foundation Institute for Material Science, University of Bremen, Germany, entitled, "Gas phase synthesis of functional nanoparticles and nanostructured films."

JULY 18

Departmental seminar by Professor Nazmul Karim

A departmental seminar was given by Professor Nazmul Karim, Texas Tech University, USA, entitled, "One-step Cellulosic Ethanol Production: A Novel Bio-based Concept."

JULY-AUGUST 2008

Summer school for American students

Twenty-two chemical engineering students from the US university, Virginia Tech, spent their summer in Denmark participating in a unit operations summer school arranged by DTU Chemical Engineering.

AUGUST

High School student Alexander Gese visits DTU Chemical Engineering following top placement in the International Chemistry Olympiad

DTU Chemical Engineering was the host for one of Germany's most talented youths in the field of Chemistry during the month of August. Alexander Gese from the Carl-Friedrich-Gauss-Gymnasium in Frankfurt (Oder), placed among the six best in the 2008 German leg of the chemistry competition "International Chemistry Olympiad".

Students, faculty and staff gathered at the departmental Christmas Seminar

SEPTEMBER 3

Thirty public school teachers visit DTU Chemical Engineering

Thirty chemistry and physics teachers from the Danish Public School system visited DTU Chemical Engineering to participate in a polymer course arranged by Danmarks Fysik- og Kemilærerforening and Plastindustrien.

SEPTEMBER 25

Departmental seminar by Dr. Niels Fabricius

A departmental seminar was given by Dr. Niels Fabricius, Shell Global Solutions, London, UK, entitled, "XTL technologies in Shell."

SEPTEMBER 25

DTU Chemical Engineering students win McKinsey Prize

Jon Christensen and Bjørn Maribo-Mogensen, both students at DTU Chemical Engineering, won the first prize in the annual McKinsey & Co. competition for the best bachelor project at DTU. Their winner project was about environmentally friendly fuel cell technology.

SEPTEMBER 30

Professor Anne S. Meyer receives the 2008 Grundfos prize

The Grundfos Prize 2008 was awarded to Professor Anne S. Meyer from DTU Chemical Engineering in recognition of her contribution in research and development concerning new products and processes for using nature's own enzymes and finding new uses for plant material.

OCTOBER 7

CHEC annual meeting: Innovation with an international aim

CHEC held its annual meeting in the Congress Center Søhuset in Hørsholm. Ninety-eight people participated, 40 of whom were external partners.

OCTOBER 23

Departmental seminar by Professor Juan J. de Pablo

A departmental seminar was given by Professor Juan J. de Pablo, Department of Chemical and Biological Engineering, University of Wisconsin-Madison, USA, entitled, "Field Driven Assembly in Nanotechnology."

NOVEMBER 6

Departmental seminar by Professor Rajni Hatti-Kaul

A departmental seminar was given by Professor Rajni Hatti-Kaul, Department of Biotechnology, Lund University, Sweden, entitled, "Industrial biotechnology for production of chemicals and polymers."

NOVEMBER 1

Major grant from the Danish Strategic Research Council given to new DTU Chemical Engineering Project

The project, "Towards robust fermentation processes by targeting population heterogeneity at microscale," was granted 15.9 million DKK funding from the Danish Strategic Research Council to Associate Professor Krist V. Gernaey.

HIGHLIGHTS 2008

In December, 200 public school pupils visited DTU where the winner of the OilSim competition 2008 was announced. Earlier in the year, 600 students from Danish public and technical schools competed in their classrooms to find oil in virtual reality.

NOVEMBER 21

Annual Polymer Day

Forty researchers, PhD students and representatives from industry met at DTU for the 2008 Polymer Day arranged by the Danish Polymer Center.

NOVEMBER 23

Kim Dam-Johansen is the most cited researcher in the combustion field

The global information company, Thomson Reuters, published an analysis of the amount of quotations in the field of 'Energy and Fuels'. The analysis placed the Head of Department at DTU Chemical Engineering, Professor Kim Dam-Johansen, as the world's most cited researcher in the field of "Combustion."

DECEMBER 2

OilSim winners announced at DTU

Two hundred public school students visited DTU where the winner of the 2008 OilSim competition, organized by DTU Chemical Engineering, was announced.

DECEMBER 4

Departmental seminar by Dr. Bjerne S. Clausen

A departmental seminar was given by Dr. Bjerne S. Clausen, Haldor Topsøe A/S, Denmark, entitled, "Fundamental insight in industrial catalysts using advanced in-situ techniques."

DECEMBER 12

Christmas Seminar

Head of Department, Professor Kim Dam-Johansen, reported on the status of 2008 at the departmental Christmas Seminar. The event also featured presentations by the groups forming the new organizational structure at the department beginning in 2009.

DECEMBER 17

Novozymes BioProcess Academy Day

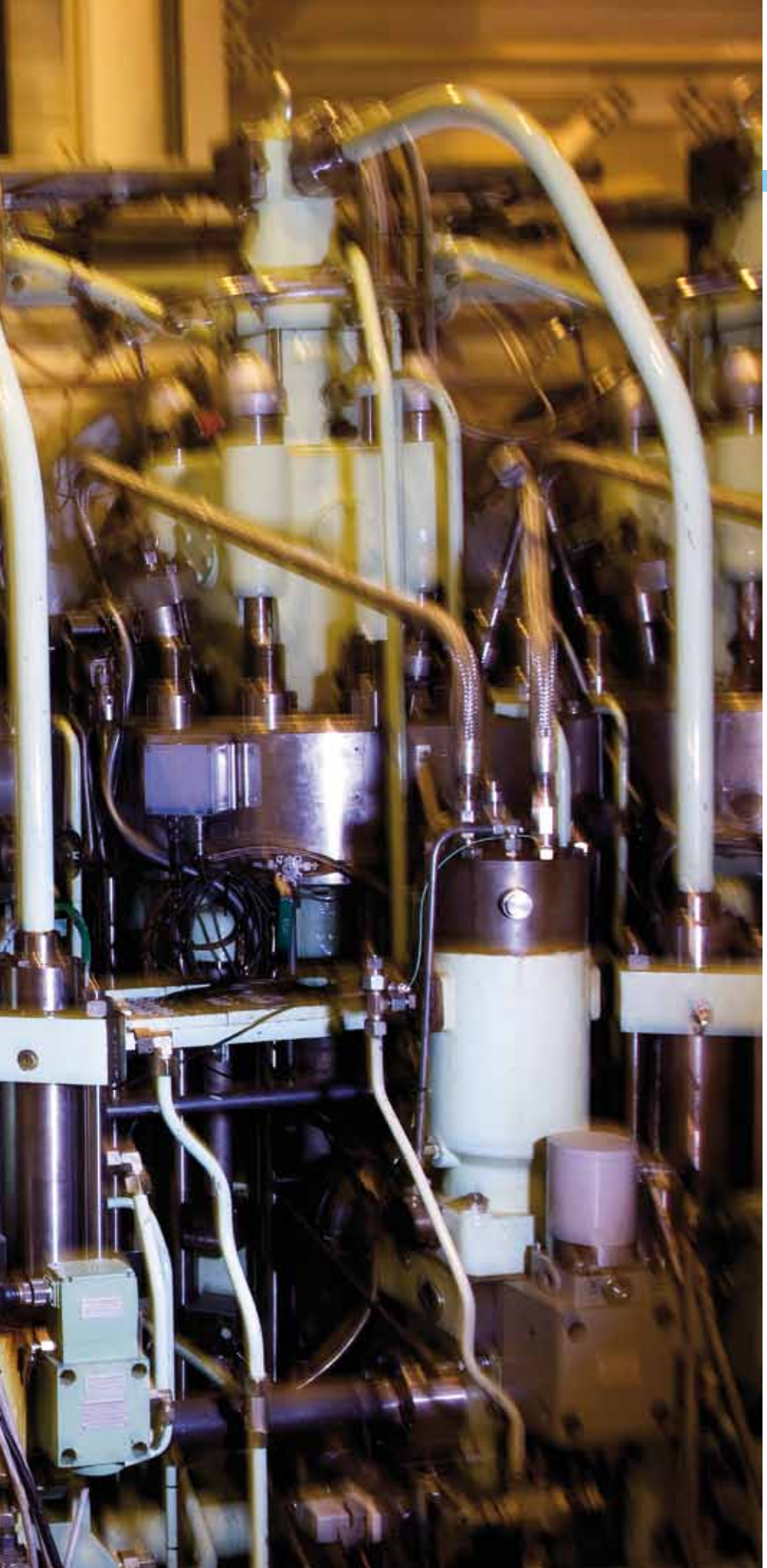
The Novozymes BioProcess Academy Day was held in the BioEng Center and seven PhD students presented their work on the subject.

DECEMBER 17

MSc student, Lars Johansen, receives Carlsbergs Mindelegat

MSc student at DTU Chemical Engineering, Lars Johansen, received Carlsbergs Mindelegat for his exam project.

In 2007, the Danish Minister for Climate and Energy, Connie Hedegaard, initiated the '1 tonne less' campaign, urging individual citizens to reduce their personal energy consumption as a means of fighting global warming locally. Connie Hedegaard has expressed full support to the ambitious EU goal of a 30 % reduction in the emission of greenhouse gases for industrialized countries by 2020. In December of 2009, Denmark will host the United Nations Climate Change Conference, COP15. In connection to this, DTU Chemical Engineering will host a workshop on Combustion, Carbon Capture, and Storage with the aim of gathering recommendations for future technological development in this field.



RESEARCH & INNOVATION

Diesel combustion frozen at 18000 pictures per second

Building a successful future for an oil-free polymer industry

A platform for future cement production technology

Probing the options for CO_2-neutral power plants

PhD student Hanne Hostrup Nielsen is the first researcher to take snapshots inside the giant cylinder of a large marine diesel engine – in pursuit of cleaner and more energy efficient combustion.

DIESEL COMBUSTION FROZEN AT 18000 PICTURES PER SECOND

A thundering noise from a research engine the size of a three storey building fills the test plant at MAN Diesel SE 's headquarters in Copenhagen. Using sign language and equipped with ear plugs, PhD student Hanne Hostrup Nielsen takes us to the top of the four monstrous cylinders. She points to the valve hole serving as the entrance for the mechanical 'eye' which for the first time allows scientists to literally take a closer look at the combustion process inside a large marine diesel engine.

In a separate and much quieter room she shows us the 'eye' itself, a photron high speed camera mounted on a dummy valve. When placed in the valve hole at the top of the cylinder the camera takes detailed snapshots of the combustion process. A similar approach has been used on small diesel engines but the dimensions, risks and heat strain in a large diesel engine has made visual investigation impossible – until now.

"We have learned an enormous amount by putting this window inside the engine and looking in different directions," says Hanne Hostrup Nielsen. "We can see when the flame ignites and evolves, what happens to the soot, and much more."

"What we actually see inside the cylinder is the natural luminescence from the soot formed during the non-premixed turbulent combustion. It is a turbulent and very complex flame where the fuel-to-air ratio is distributed very inhomogeneously," Nielsen explains. "By looking at the pictures, I get a better understanding of the complex mechanisms inside the engine. Sometimes the fuel injection is delayed a millisecond, and I try to find out what these variations mean and how, for example, the injector geometry affects the combustion."

Precise predictions

Hanne Hostrup Nielsen's PhD project is entitled, 'In-situ investigations of the combustion in large, two-stroke Diesel engines', and its purpose is to better understand the inner workings of ship engines in order to minimize emission of NO_x and improve energy efficiency. With MAN Diesel SE covering 80 % of the market for ship engines, even small improvements in engine efficiency can lead to significant worldwide reductions in fuel consumption and pollution.

The data collected by the camera is compared and applied to mathematical models which have so far been the primary tool for describing the processes which take place inside the cylinders.

"We need to know exactly what is going on locally inside the engine in order to validate our model. Once we have a well-functioning numerical model we can change the parameters in the model in order to optimize the combustion process and improve

Most of Hanne Hostrup Nielsen's 'snapshots' inside the engine cylinder are taken at a framerate of close to 17000 pictures per second. When studying smaller sections inside the cylinder, framerates can be as high as 50000 pictures per second.

energy efficiency, thereby minimizing the emission of pollutants like NO_X and soot," Nielsen says.

"More specifically I am trying to prove if the model can be used to predict how much soot is formed. These numbers are used to calculate how much light the soot emits, how it will emit light at a certain temperature and with a certain amount of particles present. Eventually I am hopeful that I will be able to fine-tune the mathematical models by comparing them to the physical images."

Reducing NO_X often leads to higher energy consumption so it is always a trade-off between high energy efficiency or formation of pollutants.

"Roughly speaking, the only way to minimize CO_2 emissions is by having a more energy-efficient engine, meaning you have to burn less fuel to get the same amount of energy for the propeller," says Nielsen.

250000 pictures a second

Taking photos inside a large diesel engine is no picnic – a whole range of practical problems had to be solved before this kind of research was possible at all.

"We spent the first two years finding a way to mount the window so it keeps in place without breaking, and without being destroyed by heat and pressure or covered by soot or calcium residues from the lubrication oil," Nielsen says.

Professor Peter Glarborg, DTU Chemical Engineering, was supervisor on the project and senior scientist Sønnik Clausen from Risø DTU was closely involved in the development of the optical access, featuring a maximum capacity of 250000 pictures a second. It operates within the visual range of the electromagnetic spectrum.

"The optical access only allows us to see a limited part of the combustion chamber. But, after all, this is a first try – there is plenty of space for further development. At a later point we might apply some of the laser technologies for diagnosis that have been used on small engines," says Hanne Hostrup Nielsen who will continue her research within the framework of a large European EU-funded program named Hercules.

In the future, biomass could substitute petro-chemicals in the chemical industry.

BUILDING A SUCCESSFUL FUTURE FOR AN OIL-FREE POLYMER INDUSTRY

In the Bio-Petrochemicals Research Project, DTU Chemical Engineering, DTU Chemistry, and Novozymes A/S join forces to pave the way for large-scale production of renewable polymers. With a looming oil shortage in a world where it is estimated that 4 % of the world's annual oil production is used as feedstock for polymers, this research could have large implications for both the environment and the plastic industry.

Bio-petrochemicals are chemicals that are produced from biomass and will increasingly substitute petrochemicals in tomorrow's chemical industry. If production methods are aptly optimized, these materials could, in theory, replace oil-based feedstock in the polymer industry. The goal of the Bio-Petrochemicals Project is to improve the existing processes for converting sugars and biomass into bio-petrochemicals – a renewable source for common plastic products like textiles and beverage bottles. Potentially, bio-petrochemicals could replace the use of oil as a raw material in these processes while at the same time reducing release of CO_2.

The process begins with carbohydrates – preferably glucose – coming from starch or biomass.

"We base the process on glucose, which can easily be obtained from the hydrolysis of starch or biomass. Several other researchers are working on how to degrade biomass into monosaccharides, so we are focusing on how to transform the monosaccharides into the desirable chemicals. By using a combination of enzymes and inorganic catalysts, we get a new chemical, 2,5-furandicaboxylic acid (FDA), which has similar properties as terephthalic acid (TPA) and thus may be used as a building block for industrial polymers," explains Wenjing Fu, PhD student at DTU Chemical Engineering.

"A lot of research has been done already at the laboratory scale but so far not at an industrial scale. Our aim is to make the process inexpensive enough for industrial applications," adds Jacob Skibsted Jensen, postdoc at DTU Chemical Engineering.

The crucial step

"The issues of scaling up from laboratory to industrial scale have not yet been addressed properly," says Jacob Skibsted Jensen. "This important part of the process is almost never described in the publications within this field. The major focus so far has been to understand the chemistry on a small scale; so what we are keen to find out is how it works on a larger scale. This is the crucial step if the products are to be applied in industry and reach the market."

The Bio-Petrochemicals Project is anchored in the biorefinery concept – the establishment of production units and plants which convert biomass to fuels, bio-petrochemicals, and new materials.

"It is quite a journey to come from identifying the catalysts, which give

PhD student Jacob Skibsted Jensen and Postdoc Wenjing Fu are on the look-out for innovative approaches to large-scale production of polymers based on biomass instead of oil.

Many similar projects are expected to be launched at DTU Chemical Engineering in the future. Professors engaged in this area are Jan-Dierk Grunwaldt, John Woodley, Anne Meyer, Anker Jensen, Jørn Dalgaard Mikkelsen and adjunct Professor Claus Hviid Christensen.

the desired selectivities, to actually make a process which will in the end produce multiple tons of material," Jacob Skibsted Jensen says.

Multidisciplinary approach

Fifteen researchers are engaged in the research platform spanning DTU Chemical Engineering, DTU Chemistry and Novozymes A/S. What DTU Chemical Engineering in particular can add to the research is knowledge on the scale-up and the design of the chemical and enzymatic processes. However, the tight cross-disciplinary collaboration between the two departments at DTU and the industrial partner Novozymes A/S is essential in making all the pieces come together.

The strategy from the outset has been to try to get everyone to sit in one place.

"We come with different backgrounds and each party adds their expertise to the mutual research efforts," says Jensen. "Novozymes knows all about the enzymes, DTU Chemistry works with inorganic catalysts, and DTU Chemical Engineering has the knowledge about the chemical and enzymatic processes and reactors. All are focusing on the middle part of the process and a little bit on the polymerization, in regards to testing if the final product is good enough for making polymers."

Wenjing Fu received her bachelors degree in China and her master's degree at DTU Environmental before she started her current PhD work. Jacob did his master's at DTU Chemistry and his industrial PhD at DTU Chemical Engineering before entering the Bio-Petrochemicals Project as a postdoc. One of Wenjing and Jacob's future challenges is to build a laboratory scale plant.

"We are in the design phase for the reactor used in the process we carry out. In the first part of the process we use enzymes to convert glucose to fructose, followed by a dehydration reaction to a middle compound and finally an oxidationstep to get to FDA. The hardest step is the dehydration step – it has been studied for many years, but it has always been a problem to make it to the industrial scale," Fu says.

"And it is not an option to use extremely expensive materials or equipment," Jacob adds. "We have a very narrow limit for funding the process."

Wenjing Fu concludes that, "If we are successful the prospect is that the chemical industry of tomorrow will feature glucose as an important feedstock and substitute many processes that require oil."

DTU Chemical Engineering and FLSmidth A/S join forces in a large research effort to develop cleaner and more energy efficient methods for cement production.

A PLATFORM FOR FUTURE CEMENT PRODUCTION TECHNOLOGY

Cement is the world's most widely used building material. When we see tower blocks rise to the sky and bridges crossing rivers, lakes, and valleys, it is worth a thought that up to one-third of the cement used today outside China is produced in plants developed and designed by Danish engineers. However, cement is produced in a process which is both energy consuming and also a source of harmful emissions. This is the background for the New Cement Production Technology Project, a research platform where DTU Chemical Engineering, FLSmidth A/S, and the Danish National Advanced Technology Foundation join forces to develop cleaner and more energy efficient cement production methods, as well as finding ways to enhance those processes which currently operate in production plants.

The project was granted 25 million DKK by the Danish National Advanced Technology Foundation in 2007 and started its five year research schedule in 2008, focusing on four main areas: Energy efficiency, Alternative fuels/fuel flexibility, Clinker burning and Harmful emissions.

Eight research projects have been outlined under these headlines and the first five of these were launched in 2008. The initial mathematical modeling and process experiments take place at laboratories and the pilot plants at DTU Chemical Engineering. These will subsequently be tested in collaboration with research engineers from FLSmidth, partly in FLSmidth's test center at Dania close to Mariager, and partly in full scale plants in cooperation with FLSmidth's customers.

A win-win research project

Reduction of air pollutants and greenhouse gases as well as the growing energy prices are major technical challenges. However, at the same time they offer significant business opportunities for the most innovative companies, making the collaboration between FLSmidth and DTU Chemical Engineering a win-win project. FLSmidth gains a competitive edge by being able to recruit highly skilled engineers and researchers, and DTU Chemical Engineering educates skilled graduates and researchers while creating new realisations, process concepts, and knowledge for the benefit of society.

"The collaboration between DTU Chemical Engineering and FLSmidth has been tested within a number of sub areas in smaller projects before the platform was launched. They proved beneficial to both the fundamental research and the industrial development and paved the way for this significant venture," says Professor and Head of Department at DTU Chemical Engineering Kim Dam-Johansen.

"The research will give us a head start by securing the competitive edge in more energy efficient and less environmentally-demanding cement production plants, thus meeting the present and future demands of our customers worldwide," says Kimmo

The New Cement Production Technology Steering Committe as of September 2008. From left: Hanne Bengaard and Carsten Gaarn-Larsen from The Danish National Advanced Technology Foundation, Professor and Head of Department at DTU Chemical Engineering Kim Dam-Johansen, the former Vice President of Research and Development at FLSmidth A/S, Kim Pandrup Christensen, Project Manager Jytte Illerup, and Vice President of Research & Development at FLSmidth A/S, Kimmo Vesamäki. At the end of 2008 Kim Pandrup Christensen left the committee and was replaced by Erik Birch, Senior Vice President at FLSmidth A/S.

Vesamäki, Vice President of Research & Development at FLSmidth A/S.

Making good ideas grow and spread

With Jytte Boll Illerup as the project coordinator, the research platform is organized and managed by a six-member steering committee which will ensure optimum cooperation and synergy within the platform. Steering committee members from FLSmidth A/S and DTU Chemical Engineering are joined by representatives from The Danish National Advanced Technology Foundation.

"To The Danish National Advanced Technology Foundation it is an important objective to strengthen the ties between industry and university," says director of The Danish National Advanced Technology Foundation Carsten Gaarn-Larsen. "The cement platform combines a high level of technical skills in combination with substantial business opportunities, and the prospect of reducing CO_2 emissions in cement production adds societal relevance even on a global scale. DTU Chemical Engineering can be proud of the skillful outlining and highly professional management of this project. It can add enormous value in the cement production field and the Foundation will follow the project from initial idea to final result by keeping a constant dialogue with the platform leader and the steering committee."

The acquired insights will be useful in several contexts and research will therefore regularly be communicated to other interested companies and researchers within the energy and environmental fields. A special advisory board made up of representatives from the DONG Energy, Haldor Topsøe, and Vattenfall will ensure that information about developments within power plants and the chemical process industry will also be put into play in the cement industry. At the same time the advisory board members will obtain ideas from the cement industry to be used in their industries in order for the results of the research to be known as quickly as possible.

PhD-student, Leila Faramarzi, traces the properties of aqueous alkanolamines for use in a Carbon Capture and Storage process.

PROBING THE OPTIONS FOR CO_2-NEUTRAL POWER PLANTS

While climate changes have strengthened global consensus that emission of greenhouse gasses like CO_2 need to be dramatically reduced, it remains a fact that the world's demand for energy and heat will depend on fossil fuels for many years to come. One of the urgent challenges in today's energy sector, therefore, is to find new (and further enhance already known) ways to reduce CO_2 emission from power plants. Carbon Capture and Storage (CCS) is one possible route and PhD student Leila Faramarzi's PhD project, 'Post-Combustion Capture of CO_2 from Fossil Fueled Power Plants', covers the potential use of aqueous alkanolamines, one of several traditionally applied ways of capturing CO_2 in the post-combustion phase.

Alkanolamines such as monoethanolamine and methyldiethanolamine are chemical compounds that carry hydroxyl (-OH) and amino (-NH_2, -NHR, and -NR_2) functional groups on an alkane backbone. In a solution with water, alkanolamines react with and absorb CO_2 – making them a potential agent for post-combustion capture of CO_2 on a large scale.

"Alkanolamines have been used for over 70-80 years for other purposes," Leila Faramarzi explains. "It is a very old technique for separating acid gases like CO_2 and SO_2 from natural gas. Now it is being tried for an environmental purpose, but we don't know yet how applicable it will be on an industrial scale. That is one of the things my project could help to clarify."

Broad experience in the petroleum field

In the first part of the project Leila Faramarzi's task has been to meticulously sort through data about the process that is available in open literature. When sufficient reliable data sets are harvested they are applied to mathematical models describing the capture process. Once an adequate model is available it becomes much easier to assess the optimal process conditions.

"I have been doing thermodynamic modeling of the solubility of CO_2 into alkanolamines. We were looking solely for the best possible conditions; what temperature and what pressures to choose in order to maximize the amount of CO_2 that we can separate from the flue gas," explains Faramarzi.

Before endeavouring into the CCS field, Leila Faramarzi had already gained broad experience in the field of petroleum research. She received her Bachelor of Petrochemical Engineering in Iran and worked as a piping engineer for a year before she started work on her MSc in Natural Gas Transmission. It was during this work that she had her first professional encounter with alkanolamines,

Carbon Capture and Storage (CCS) defines technology for removing CO_2 from power plant emission in the post-combustion phase. While still on the experimental level, CSS technology is expected to become an important tool for reduction of CO_2 emission from power plants in the future.

The first part of the CCS process is the capture of CO_2 followed by sequestration. Sequestration – the transport and storage of captured CO_2 – presents an array of research challenges, e.g. pressurizing the captured CO_2 and transporting it to reservoirs such as saline aquifers or pockets under seabeds. Another storage option is injection of CO_2 into partially depleted oil reservoirs, thus gaining a higher recovery percentage of oil, while removing CO_2 from the atmosphere. A full scale implementation of CCS is planned to be operational at the Mongstad Power Station in Norway in 2014 and CSS using alkanolamines is currently being tested in DONG Energy's CCS pilot plant in Esbjerg, Denmark.

using them for separating CO_2 from natural gas. Later she did research at a petroleum research institute for a year and went on to work as a research assistant at DTU Chemical Engineering for six months prior to commencing her PhD project.

A range of projects dedicated to CCS

Leila Faramarzi's research into post-combustion capture of CO_2 using alkanolamines is one of several methods currently being investigated at the IVC-SEP research center at DTU Chemical Engineering. Faramarzi is working closely with the Professors Erling H. Stenby, Georgios Kontogeorgis and Kaj Thomsen as well as postdoc Philip Loldrup Fosbøl. The post-combustion team includes Victor Darde, who, in his own industrial PhD study, is looking into aqueous ammonia's abilities for post-combustion CO_2-capture and Benedicte Mai Lerche whose PhD study is focused on the potential of aqueous solutions of amino acids as CO_2 absorbents. Furthermore, Professors Erling H. Stenby and Kaj Thomsen are engaged in a cooperative research effort with DTU Chemistry, supported by the Danish Council for Strategic Research and the power companies, DONG Energy and Vattenfall, concerning the possible use of ionic liquids for CO_2 capture.

Only the future can tell which CCS approaches and methods will prove to be the most environmentally and economically viable. One important overall advantage of CCS, however, is that it can be applied to already existing power plants whereas pre-combustion technologies generally require a redesign of the power plant structure.

"Personally I believe the optimal CO_2 capture system is likely to be a combination of pre-combustion and post-combustion techniques," says Leila Faramarzi, who in a later stage of her project will do mathematical modeling related to the CO_2 absorption device – the apparatus which would eventually perform the actual CO_2 capture from power plants.

EDUCATION

Two new professors at DTU Chemical Engineering in 2008

Searching for oil and gas in virtual reality

Besides emission control research related to power plants, DTU Chemical Engineering covers research in domestic wood stoves which account for approximately 40 % of particle emission in Denmark.

Professors Jan-Dierk Grunwaldt and Jørn Dalgaard Mikkelsen both joined DTU Chemical and Biochemical Engineering in 2008.

TWO NEW PROFESSORS AT DTU CHEMICAL ENGINEERING IN 2008

Two new professors joined DTU Chemical and Biochemical Engineering in 2008. Jørn Dalgaard Mikkelsen was appointed to a Professorship in the field of BioProcess Technology sponsored by Danisco A/S and Jan-Dierk Grunwaldt was awarded the Haldor Topsøe Chair in Catalysis and Chemical Engineering.

Professor Jan-Dierk Grunwaldt began his Professorship in January 2008. His work deals mainly with catalysis and focuses on the synthesis of materials e.g. making powders in flames or with hydrothermal methods, the hot topic of biomass conversion, and reactions in innovative solvents like supercritical fluids. Instead of using 'trial and error' methods, he ideally wants to design them systematically by gaining an understanding of the structure of the catalysts using *in situ* studies where the catalysts are recorded while they are 'in action.'

Jørn Dalgaard Mikkelsen took his seat as a Professor on April 1st 2008 and his research activities will concentrate on developing new techniques for producing complex carbohydrates (better known as dietary fibres), improving our understanding of how carbohydrates influence our health.

OilSim sent hundreds of Danish students on a virtual conquest for energy resources in a fictitious country.

SEARCHING FOR OIL AND GAS IN VIRTUAL REALITY

Six hundred students from Danish high schools and technical schools competed against each other in the online simulation game, OilSim, in November 2008.

Organized by the company Simprentis and DTU Chemical Engeering, OilSim is a virtual conquest for oil and gas in a fictitious country. The contesting teams engaged in virtual geological surveys, made bids for licenses, joined in shared licenses with other teams, performed test drillings, and hired proper service companies. Prior to the OilSim games, teachers from the participating schools gathered at a facilitator training at DTU Chemical Engineering where Professor Erling H. Stenby explained the importance of the discovery and recovery of oil and gas and the role of the science in that context.

OilSim 2008 was rounded off with an 'Education and Oil' day at DTU in December. More than 100 students participated and were offered presentations by the OilSim sponsors: Mærsk Olie & Gas, Dong Energy and Chevron. Students were also given guided tour of DTU Chemical Engineering's laboratory and test plant facilities.

ORGANIZATION

CHEC

IVC-SEP

CAPEC

DPC.DTU

BioProcess Engineering

Administration & Technical Support

Professor and Head of Department Kim Dam-Johansen at the podium during the Departmental Christmas Seminar 2008.

The pilot plant facilities at DTU Chemical Engineering

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 a 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, Head of CHEC

www.chec.kt.dtu.dk

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

CHEC

COMBUSTION AND HARMFUL EMISSION CONTROL – THE CHEC RESEARCH CENTER

CHEC is a research center mainly in the field of Chemical Reaction Engineering and Combustion, emphasizing 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. They are used to analyze and extrapolate the experimental data as well as providing 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 such as granular enzymatic products, and controlled release systems, in many different fields like 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 conducted there is directed towards pyrolysis of biomass, oxyfuel combustion, gasification, methanol and bioethanol production, as well as fuel cell 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
- Topsøe Fuel Cell

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

Professor Erling H. Stenby (second from left, front row) with members of the IVC-SEP group during a session in the new 3D Virtual Reality facilities at DTU Chemical Engineering

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 international research organizations, the scientific results from IVC-SEP are implemented in industrial products and processes. This 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, Head of IVC-SEP

www.ivc-sep.kt.dtu.dk
Head of IVC-SEP, 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 modeling. With six tenured faculty members the center covers several topics with both experimental and theoretical research.

Currently, the main activities of the center 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 center 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 research and education at DTU Chemical Engineering. Many companies financially support research projects as well as hold the membership. For instance the Chemicals in Gas Processing project (CHIGP) which is extensively sponsored by industrial partners (Total, Statoilhydro, 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.

A rapidly growing activity is the research concerning post-combustion CO_2 capture. Within this area IVC-SEP has recently initiated several projects in collaboration with DONG Energy and Vattenfall. The focus is the high energy penalty associated with the established technologies for CO_2 capture. New solvents such as chilled ammonia, amino acid solutions, and ionic liquids are among the potential solutions under investigation.

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

In 2008 the Consortium of IVC-SEP consisted of the following members:

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

At the Danish Polymer Center 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, Head of DPC

www.kt.dtu.dk/dpc
Head of DPC, Professor Ole Hassager | oh@kt.dtu.dk | Phone: +45 4525 2973

DPC

THE DANISH POLYMER CENTER

The Danish Polymer Center is devoted to fundamental research in polymers, soft materials, and complex fluids. They also seek 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 to 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 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 Master's 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 DPC.

Research Consortium in Polymers at DTU
The basic purpose of this consortium, established in 2006, is to ensure both stability and continuity of contact and communication between the Polymer Center at DTU and the parts of Danish industry that commercially use polymers. The consortium will run a number of smaller research projects and will serve as a greenhouse for conceiving ideas and innovating plans for future research and educational initiatives.

Graduate School Program in Polymer Science
Initiated in 2003, the Graduate School of Polymer Science is a research education network between the Department of Chemical and Biochemical Engineering at DTU, the Department of Chemistry at Aarhus University, Risø National Laboratory, and other associated industrial companies. Financial support to the DPC 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 Graduate School in Polymer Science are as follows:

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

Members of the Research Consortium in Polymers are as follows:

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

Briefly, the research objective of CAPEC is to develop computer-aided systems for process simulation, process/product synthesis, design, analysis, and control/operation that is principally suitable for the 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 model the underlying phenomena and behavior of the processes and operations.

Rafiqul Gani, Head of CAPEC

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Head of CAPEC, Professor Rafiqul Gani | rag@kt.dtu.dk | Phone: +45 4525 2882

CAPEC

COMPUTER AIDED PROCESS-PRODUCT ENGINEERING CENTER (CAPEC)

The CAPEC research center 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 center constitutes a very distinct group of professors and associate professors, researchers, postdocs, and PhD students that contribute to the joint activities of DTU Chemical Engineering. Additionally, CAPEC usually hosts around ten MSc and BSc students plus a varying number of visiting students and international visitors.

In 2008 CAPEC was supported by the following industrial consortium:

- Akzo-Nobel (NL)
- Alfa Laval A/S (DK)
- AstraZeneca (S)
- BASF (D)
- Bayer AG (D)
- Borealis Polymers Oy (SF)
- ChemProcessTechnologies (USA)
- ConocoPhilips Company (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)
- Invensys SimSci-Esscor (USA)
- Kongsberg Maritime (NO)
- Mitsubishi Chemical Corp. (JPN)
- Neste Oil (SF)
- Novozymes A/S (DK)
- Optience (USA)
- Petrobras (Brasil)
- Processium (F)
- ProSim (F)
- SCG Chemicals Co. Ltd. (TH)
- Syngenta (UK)
- Unilever (USA)
- VTT Technical Research Centre of Finland (SF)

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 products. At the same time the objective is to hatch top-qualified MSc and PhD candidates through research based teaching and supervision. We hope that this twofold strategy will contribute to fullfilling the potential of biotechnology to substantially impact industrial production and hereby contribute to development of new, ingenious, and sustainable processes and products.

Anne S. Meyer, Head of BioProcess Engineering

www.bioeng.kt.dtu.dk
Head of BioProcess Engineering, Professor Anne S. Meyer | am@kt.dtu.dk | Phone: +45 45252909

BIOPROCESS ENGINEERING

The Center for BioProcess Engineering is a multidisciplinary research center 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. Biologically based processing also challenges classical chemical engineering by providing new problems and new solution potentials to a wide application area which spans from pharmaceuticals, food ingredients, and fine chemicals to biofuels. 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 biocatalytic processes. The Center for BioProcess Engineering hosts the following 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.

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 address 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 biocatalytic events. This research effort will run for at least five years and educate at least five PhD, one postdoc, and ten MSc candidates.

The 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 plant polysaccharides present in industrial byproduct streams. The objective is to design high value carbohydrate products having potential health benefits.

The Center for BioProcess 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 while accompanying them throughout all phases of their work.

ADMINISTRATION

Efficient support from our people in administrative functions plays an important role within our department. We provide services in many different areas, including project administration, contracts, facility management, education, personnel, and general administration.

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 they play a major role in ensuring that a wide range of internal processes run smoothly.

WORKSHOP

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

CORPORATE COMMUNICATION

Our web-editor ensures that our website meets our high standards with respect to design and business communication as well as writing up the latest company news in our corporate website and annual reports.

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.

LABORATORIES

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

PRODUCTIVITY & STAFF

Reduction of CO_2 emission from power plants is a major research focus area at DTU Chemical Engineering. Zero emission is the ultimate goal.

ADVISORY BOARD

LARS BANG

EXECUTIVE VICE PRESIDENT · H. LUNDBECK A/S

Scientific research at the university level is a prerequisite for the development of Lundbeck's chemical activities in Denmark. We have had a beneficial cooperation with DTU Chemical Engineering 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 DTU Chemical Engineering's scientific staff as advisors.

KIM PANDRUP CHRISTENSEN

The close cooperation with DTU Chemical Engineering has ensured significant results within emission technology which will benefit a lot of industries. Long-term focus on development and innovation is necessary to meet the ever changing rules and legislation that most industries will have to comply with. DTU Chemical Engineering ensures a high level education and important research projects that will lead to the technologies of the future.

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 DTU Chemical Engineering 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 both their own and the company's development.

PER FALHOLT

EXECUTIVE VICE PRESIDENT · NOVOZYMES A/S

In terms of industrial collaboration, DTU Chemical Engineering is at the front line and our cooperation 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 within society are found. DTU Chemical Engineering 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 DTU Chemical Engineering and the Danish energy sector, creating stability and competitiveness while allowing for fine-tuning of research in new areas benefiting both Dong Energy and DTU Chemical Engineering. This collaboration ensures an ongoing dialogue between researchers and employees in the energy sector. In addition, it has significantly optimized efficiency in the sector.

ULLA RÖTTGER

MANAGING DIRECTOR · AMAGERFORBRÆNDING

Close cooperation with specialists in the university is essential to Amagerforbrænding achieving the high standards we set for our business and in further develop our core competencies. Working closely with DTU Chemical Engineering provides us with the opportunity to continuously improve our work and to enhance our environmental performance.

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. DTU Chemical Engineering's contributions in these fields are important for society in general and instrumental for the continuing development of Cheminova.

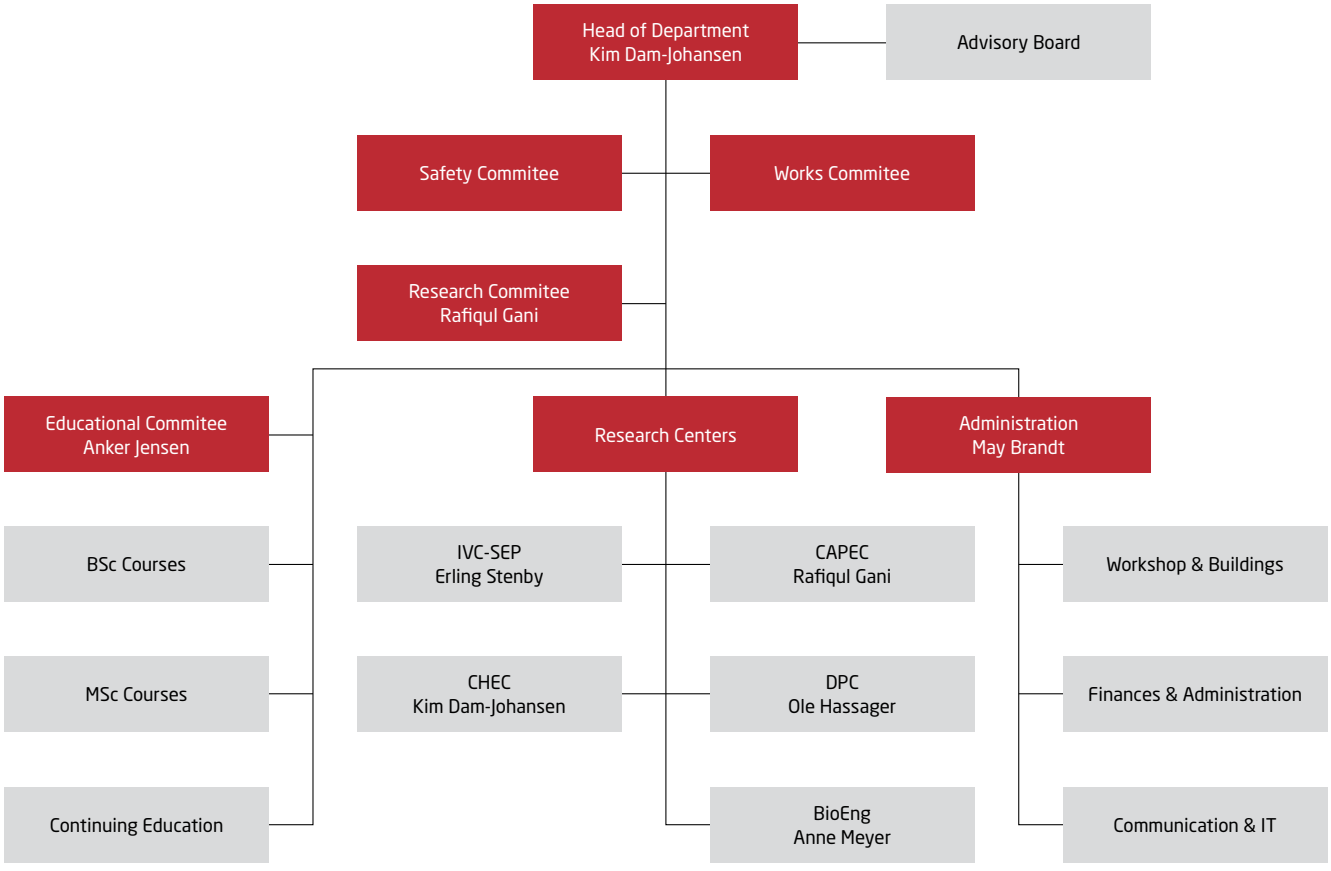
STUDENT COMMITTEE

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

KTStudents is the student organization at DTU Chemical Engineering. The purpose of the organization is to create opportunities and great experiences for the students at the department. We do this through industry events, social gatherings, and KTStudent involvement within the department. We give the students an opportunity to network with other students interested in chemical engineering.

Thomas Petersen, President, KTStudents

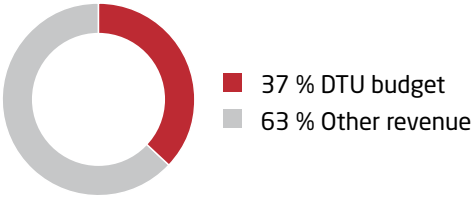
2008 ORGANIZATION



KEY FIGURES: FINANCES AND STAFF 2008

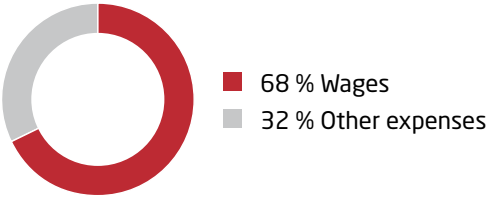
REVENUE 2008

(Total 137,173 mill. DKK)



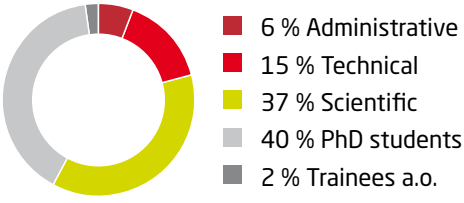
EXPENDITURES 2008

(Total 100,204 mill DKK)



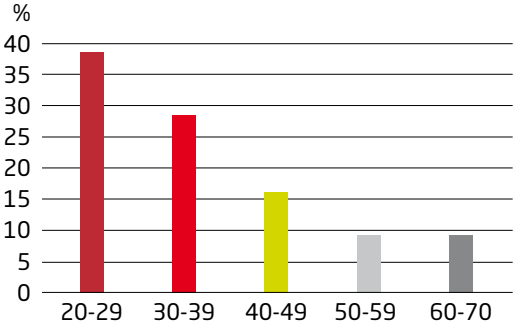
TYPE OF STAFF

(Total 186 persons)



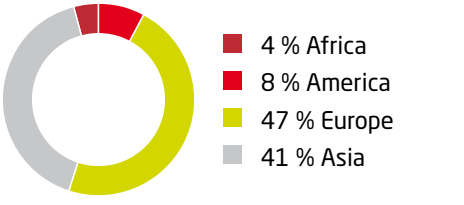
STAFF DISTRIBUTED BY AGE

(Total 186 persons)



FOREIGN SCIENTIFIC STAFF

(Total 77 persons)



PRODUCTIVITY

TEACHING & EDUCATION 2008

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	**48**
Total course units	**92**

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

RESEARCH & INNOVATION 2008

Scientific publications with referee	**124**
Contributions to refereed conference proceedings (not indexed in ISI)	**24**
PhD theses	**24**

PUBLICATIONS

Articles in Journals

Albaek, Mads O.; Gernaey, Krist V.; Stocks, Stuart M. Gassed and ungassed power draw in a pilot scale 550 litre fermentor retrofitted with up-pumping hydrofoil B2 impellers in media of different viscosity and with very high power draw. Chemical Engineering Science, vol: 63(24), p. 5813-5820 (2008)

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Carvalho, Ana; Gani, Rafiqul; Matos, Henrique A. Systematic methodology for process analysis and generation of sustainable alternatives. ESCAPE-18. Lyon, France, 1-4 June, 2008

Christensen, Martin Ellegaard; O'Connell, John P.; Abildskov, Jens. New method for correlating and predicting solubilities in mixed solvents. ESAT 2008. Cannes, France, 29 May – 1 June, 2008

Christensen, Martin Ellegaard; O'Connell, John; Abildskov, Jens. Recent Developments in Excess Solubility Estimations - Solute-Free Nonideality. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Conte, Elisa; Morales Rodriguez, Ricardo; Gani, Rafiqul. The Virtual Product-Process Design Laboratory. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Damstrup, Marianne; Jensen, Anker Degn; Kiil, Søren; Sparsø, Flemming Vang; Xu, Xuebing. Continuous glycerolysis in an immobilized enzyme packed reactor for industrial monoacylglycerol production. AOCS 99th Annual meeting. Seattle, USA, 2008

Eliasson Lantz, Anna; Ödman, Peter; Petersen, Nanna; Olsson, Lisbeth; Gernaey, Krist V. Applying spectroscopic methods and chemometrics to get a snap-shot of physiology in fermentation processes. 7th European Symposium on Biochemical Engineering (ESBES7), Faro, Portugal, 7-10 September, 2008

Eliasson Lantz, Anna, Ödman, Peter; Petersen, Nanna; Olsson, Lisbeth; Gernaey, Krist V. Practical aspects with applying near-infrared spectroscopy for monitoring of filamentous microorganism fermentations. 3rd PanEuropean Process Analytical Technology Science Conference (EUPAT3), Göteborg, Sweden, 7-8 October, 2008

Forcén, P, L. Oriol, C Sánchez, R. Alcalá, S. Hvilsted, K. Jankova: Photoinduced Anisotropy and Volume Holographic Recording in Liquid Crystalline Diblock Copolymers with Azobenzene Units. 2nd International Workshop on Liquid Crystals for Photonics – LCP2008, Cambridge, UK, 21-23 July, 2008

Fosbøl, Philip Loldrup. Capture and Storage Projects at IVC-SEP, DTU Chemical Engineering. DTUEnergy Conference. Technical University of Denmark, Copenhagen, DK, 2008

Fosbøl, Philip Loldrup; Thomsen, Kaj; Stenby, Erling Halfdan. Phase Equilibria and CO_2 Corrosion - A new approach to corrosion modelling. SPE meeting. Copenhagen, Denmark, 2008

Frederiksen, K.; von Solms, Nicolas; Neela, Vasu. Which Polymers should be used in Heat Pumps and Refrigeration Systems that use CO_2 as Refrigerant. 8th IIR Gustav Lorentzen Conference on Natural Working Fluids. Copenhagen, Denmark, 2008

Fuhlendorff, R.; Rype, J.-U.; Garde, A.; Vrang, A.; Jonsson, Gunnar Eigil; Madsen, S. Combining Membrane Separation and Fermentation Processes for improved performance. 11th Nordic Filtration Symposium. IDA, Copenhagen, Denmark, 25-26 August, 2008

Gani, Rafiqul; Singh, Ravendra; Gernaey, Krist V. A model-based framework for design and analysis of PAT systems. 1st European Conference on Process Analytics and Control Technology. Frankfurt am Main, Germany, 22-25 April (Plenary Lecture), 2008

Gani, Rafiqul. A Model-Based Systems Approach for Integrated Chemical Product-Process Design. Process Development Symposium 2008. Jiminy Peak Resort, The Berkshires, Hancock, MA, USA, 22-25 June (Plenary Lecture), 2008

Gani, Rafiqul. A process systems engineering approach for managing the complexity. ChemPor 2008, 10th International Chemical and Biological Engineering Conference. Braga, Portugal, 4-6 September, 2008

Gani, Rafiqul; Woodley, John. Development of sustainable chemical processes. International Symposium on Chemical Industry and Waste. Barcelona, Spain, 2008

Gani, Rafiqul. From property prediction to process and product design. MASI (Data, Information and Knowledge in Chemical Technology). Helsinki, Finland, 6 March, 2008

Gani, Rafiqul. Models, modelling and Chemical Engineering – What Next? ICChE (International Congress of Chemical Engineering) 2008. Dhaka, Bangladesh, 31 December 2008 – 1 January 2009

Gani, Rafiqul. Property Model Analysis for Use In Process-Product Development. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Gani, Rafiqul; Jimenez-Gonzalez, Concepcion; Constable, David; Shafique Bashir, Muhammad. Solvents In Organic Synthesis: Replacement and Multi-Step Reaction Systems. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Gani, Rafiqul. The Need and Use of Thermophysical Databases in Property Modeling and for Applications in Process-Product Design. CALCON 2008. Hyatt Regency Jersey City on the Hudson, Jersey City, New Jersey, USA, 2-6 July (Plenary Lecture), 2008

Gani, Rafiqul. Use of Property Models in Chemcial Process – Product Development – Which, When and How? ESAT 2008. Cannes, France, 29 May – 1 June, 2008

PUBLICATIONS CONTINUED

Gani, Rafiqul. Use of property models in chemical process-product development – which, when & how? ESAT-2008. Cannes, France, 29 May - 1 June (Plenary Lecture), 2008

Genné, I.; Buekenhoudt, A.; Wyns, K.; Jonsson, Gunnar Eigil; Zwijnenberg, H.J.; Nyström, M.; Deratani, A.; Causserand, C. Towards standardisation of cut-off measurements of UF and NF membranes. Proceedings of Engineering with membranes. Algarve, Portugal, 25-28 May, 2008

Gernaey, Krist V.; Sin, Gürkan; Albo, Erez; Woodley, John; Singh, Ravendra; Gani, Rafiqul. Application of mechanistic models within a PAT framework. ISPE conference. Malmø, Sweden, 1 October, 2008

Gernaey, Krist V.; Albo, Erez; Woodley, John; Sin, Gürkan. Mechanistic models for evaluation of alternative fermentation control strategies within a PAT framework. European Symposium on Biochemical Engineering Science, Faro, Portugal, 7-10 September, 2008

Gonzalez Villalba, Hugo Edson; Abildskov, Jens; Gani, Rafiqul; Khan, Tariq; Sen, Sabyasachi. Computer-Aided Phase Equilibria Predicition for Organic Systems: Automatic Generation of Group Interaction Parameters for Original UNIFAC and UNIFAC Dortmund. ESAT 2008. Cannes, France, 29 May – 1 June, 2008

Gonzalez Villalba, Hugo Edson; Abildskov, Jens; Gani, Rafiqul. Computer-aided Phase Equilibria Prediction for Organic Systems: UNIFAC-CI. Analysis, Revision and Extension. ESAT 2008. Cannes, France, 29 May - 1 June, 2008

Gonzalez Villalba, Hugo Edson; Abildskov, Jens; Gani, Rafiqul. Computer-aided Phase Equilibria Prediction for Organic Systems: UNIFAC-CI. Analysis, Revision and Extention. ChemPor 2008, 10th International Chemical and Biological Engineering Conference. Braga, Portugal, 4-6 September, 2008

Gonzalez Villalba, Hugo Edson; Abildskov, Jens; Gani, Rafiqul; Khan, Tariq A.; Sen, Sabyasachi; Bluck, David. Increased Application Range of Property Models without New Experimental Data. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Grunwaldt, J.-D.; Kimmerle, B.; Baiker, A.; Boye, P.; Schroer, C.G. Catalysts in Action: From Integral to Spatially Resolved X-ray Absorption Spectroscopy. Workshop on time-resolved and in-situ of heterogeneous catalysts and catalytic processes using X-rays: Current Possibilities and Future Prospects, ESRF, 7 February, 2008 (invited)

Grunwaldt, J.-D.; Kimmerle, B.; Baiker, A.; Boye, P.; Schroer, C.G. In situ Spectroscopic Studies over Flame-Made Noble Metal Catalysts during the Partial Oxidation of Methane. 41. Jahrestreffen Deutscher Katalytiker, Weimar, 27-29 February, 2008

Grunwaldt, J.-D. Watching Catalysts at Work. UK Synchrotron Meeting, Daresbury, 11-12 September, 2008 (invited)

Grunwaldt, J.-D.; Kimmerle, B.; Baiker, A.; Boye, P.; Schroer, C.G. Catalysts at Work: In situ Spectroscopic Studies over Flame-Made Noble Metal Catalysts during the Partial Oxidation of Methane. 14th Nordic Symposium on Catalysis, Göteborg, 6 October, 2008

Grunwaldt, J.-D. Monitoring Nanomaterials at Work in Catalysis. Nano-Day at DTU, 2 December, 2008 (invited)

Guo, Fengxiao; Jankova, Katja; Vigild, Martin E.; Ndoni, Sokol. Hydrophilic nanoporous 1,2-polybutadiene via Surface-initiated Atom Transfer Radical Polymerization. ACS 236th National Meeting, Philadelphia, Pennsylvania, USA, 17-21 August, 2008

Haider, Peter; Kimmerle, Bertram; Krumeich, Frank; Kleist, Wolfgang; Grunwaldt, Jan-Dierk; Baiker, Alfons. Gold-catalyzed aerobic oxidation of alcohols: Effect of gold particle size on catalytic performance in different solvents. SCS Fall Meeting, Zürich, 11 September, 2008

Halim, Iskandar; Carvalho, Ana; Srinivasan, Rajagopalan; Gani, Rafiqul; Matos, Henrique A. S. Sustainability Analysis of Chemical Process Plants Using a Hybrid Heuristic and Indicator Model. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Huusom, Jakob Kjøbsted; Hjalmarsson, Håkan; Poulsen, Niels Kjølstad; Jørgensen, Sten Bay. Improving Convergence of Iterative Feedback Tuning using Optimal External Perturbations. 47th IEEE Conference on Decision and Control, Cancun, Mexico, 9-11 December, 2008

Hvilsted, S. Design of Biocompatible Amphiphilic Block Copolymers Targeting Drug Delivery and Therapeutic Applications. International Conference on Advances in Polymer Science & Technology (POLY-2008), New Delhi, India (Invited lecture), 28-31 January, 2008

Jankova, Katja. Self-assembled Block Copolymers with Various Architectures Designed by ATRP. International Symposium on Engineering Micro-/Nano-Materials based on Self-Assembling and Self-Organization ISEM2008 Returns, Tokyo, Japan, 8-10 December, 2008

Jankova, Katja. Designing polymer surfaces with covalently attached functionalities. Seminar "Technologies for manufacture of MIDs: Miniaturized moulded interconnect devices", DTU, Denmark, 26 November, 2008

Jankova Atanasova, Katja; Islam, Mohammad Aminul; Hansen, Hans Nørgaard; Tang, Peter Torben. Surface tension of polymer melts - experimental investigations of its effect on polymer-polymer adhesion. Nordic Polymer Day NPD 2008, Stockholm, Sweden, 11-13 June, 2008

Jensen, Anker. Heterogeneous Fixation of N2: Investigation of a Novel Mechanism for Formation of NO. 32th Symposium (International) on Combustion, Montreal, Canada, 3-8 August, 2008

Jensen, Anker. CFD activities at DTU Kemiteknik. Danish 10 year anniversary meeting, Birkerød, Denmark, 8-9 October, 2008

Jensen, Pernille Erland; Pedersen, Anne Juul; Kirkelund, Gunvor Marie; Ottosen, Lisbeth M. Electrodialytic treatment of fly ash. EnergyDTU 2008 Internal Conference. Technical University of Denmark, 2008

Jiang, J.; Wu, Z.; Benter, M.; Jankova, K.; Toboryski, R.; Bechgaard, K. Plasma polymerisation by Softplasma™. Nordic Polymer Day NPD 2008, Stockholm, Sweden, 11-13 June, 2008

Jonsson, Gunnar Eigil. Dynamics of the ultrafiltration process. 11th Nordic Filtration Symposium. IDA, Copenhagen, Denmark, 25-26 August, 2008

Jonsson, Gunnar Eigil. Modelling aroma stripping under various forms of membrane distillation processes. International Conference on membranes and membrane processes: ICOM2008. Hawaii, USA, 12-18 July, 2008

Jonsson, Gunnar Eigil. Tuning of the cut-off curves by dynamic microfiltration. International Conference on membranes and membrane processes: ICOM2008. Hawaii, USA, 12-18 July, 2008

Jutz, Fabian; Grunwaldt, Jan-Dierk; Baiker, Alfons. Investigation of the Mn(Salen) Br-catalyzed synthesis of cyclic organic carbonates by in situ X-ray absorption spectroscopy at the Mn-K and Br-K edge. SCS Fall Meeting, Zürich, 11 September, 2008

Jørgensen, Sten Bay. Reactor Modelling for Monitoring and/or Multivariable Control - a Process Analytical Tool. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Koukkari, Pertti S.; Pajarre, Risto; Gani, Rafiqul. Use of the Constrained FREE Energy Method for Multiphase Chemical REACTOR Simulation. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Kovacs, Linda; Mallat, Tamas; Grunwaldt, Jan-Dierk; Krumeich, Frank; Baiker, Alfons. Nature of the Active Species in the Gold Catalyzed Aerobic Oxidation of Dibenzylamine. SCS Fall Meeting, Zürich, 11 September, 2008

Lek-utaiwan, Pimporn; Gani, Rafiqul; Suphanit, Bunyaphat; Mongkolsiri, Nakarin. Integrated design of solvent-based extractive separation processes. ESCAPE-18. Lyon, France, 1-4 June, 2008

PUBLICATIONS CONTINUED

Lundsgaard, Rasmus; Kontogeorgis, Georgios M.; Kristiansen, Jørgen K.; Jensen, Torkil F. Estimation of migration and diffusion coefficients of GRINDSTED® SOFT-N-SAFE from PVC into iso-octane. ILSI 4th International Symposium on Food Packaging, Prague, Czech Republic, November 19-21, 2008

Monsalvo, Matias Alfonso; Shapiro, Alexander. Behavior of Fluid Mixtures in Porous Materials. SPE Meeting. Hellerup, Denmark, 2008

Monsalvo, Matias Alfonso; Shapiro, Alexander. Phase Behavior in Confined Systems. NanoDay 2008. University of Copenhagen, Copenhagen, Denmark, 2008

Morales Rodriguez, Ricardo; Gani, Rafiqul. A Systematic Multiscale Modelling Framework for Product-Process Design and Development. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Morales Rodriguez, Ricardo; Gani, Rafiqul. Systematic Modelling Framework in Chemical product-Process Design and development. ChemPor 2008, 10th International Chemical and Biological Engineering Conference. Braga, Portugal, 4-6 September, 2008

Nopens, Ingmar; Benedetti, Lorenzo; Jeppsson, Ulf; Pons, Marie-Noëlle; Alex, Jens; Copp, John B.; Gernaey, Krist V.; Rosen, Christian; Steyer, Jean-Pierre; Vanrolleghem, Peter A. Benchmark Simulation Model No 2 – Finalisation of plant layout and default control strategy. 6th IWA World Water Congress and Exhibition 2008, Vienna, Austria, 7-12 September, 2008

Novakovic, Aleksandra; Frandsen, Flemming; Holgersen, Lilian Beenfeldt. Release of Potassium from the Systems K–Ca–Si and K–Ca–P. Impacts of Fuel Quality on Power Production and the Environment. Banff, Canada, 2008

Olsen, Stefan Møller. Developing an enzyme-based antifouling coating part II, the coating system. 14th International Congress on Marine Corrosion and Fouling. Kobe, Japan, 2008

Pedersen, Mads; Viksø-Nielsen, Anders; Meyer, Anne S. Influence of substrate particle size and wet oxidation on physical surface structures and enzymatic hydrolysis of wheat straw. European Symposium on Biochemical Engineering Science. Faro, Portugal, 2008

Petersen, Nanna; Gernaey, Krist V.; Cervera Padrell, Albert; Eliasson Lantz, Anna; Ödman, Peter; Stocks, Stuart (2008) Analyse af NIR data fra Streptomyces coelicolor fermenteringer. Den første danske kemometri-konference (DSK.2008), Nyborg Strand, Denmark, 10-11 January, 2008

Prado Rubio, Oscar Andres; Jørgensen, Sten Bay; Jonsson, Gunnar Eigil. Integrated Bioreactor and Membrane Separation Processes. ISGSB-08. Helsingør, Denmark, 17-20 August, 2008

Prado Rubio, Oscar Andres; Jørgensen, Sten Bay; Jonsson, Gunnar Eigil. Modelling of Electrically Driven Membrane Separation Processes. BEC08. Supetar, Croatia, 17 September, 2008

Prado Rubio, Oscar Andres; Jørgensen, Sten Bay; Jonsson, Gunnar Eigil. Modelling of Ion Transport across Anion Exchange Membranes Under Current Reversal Conditions. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Rosen, Christian; Aguado, Daniel; Comas, Joaquim; Alex, Jens; Copp, John B.; Gernaey Krist V.; Jeppsson, Ulf; Pons, Marie-Noëlle; Steyer, Jean-Pierre; Vanrolleghem, Peter A. Inhibition and toxicity modelling within the long-term control benchmark model (BSM1_LT) framework. 6th IWA World Water Congress and Exhibition 2008, Vienna, Austria, 7-12 September, 2008

Rossing, Netta Liin; Lind, Morten; Jensen, Niels; Jørgensen, Sten Bay. A Goal Based Methodology for HAZOP Analysis. CSEPC conference, Harbin, China, 8-10 September, 2008

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul; Tsolou, Georgia; Mavrantzas, Vlasis. Atomistic Simulation of the Diffusion of Small Gas Molecules in Polyisobutylene. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul. Computer Aided Polymer Design using Group Contribution plus Property Models. ESCAPE-18. Lyon, France, 1-4 June, 2008

Satyanarayana, Kavitha Chelakara; Abildskov, Jens; Gani, Rafiqul; Tsolou, Georgia; Mavrantzas, Vlasis. Computer Aided Polymer Design Using Multiscale Modeling. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Schäpper, Daniel; Fernandes, Rita L.; Gernaey, Krist V., Eliasson Lantz, Anna; Stocks, Stuart; Szita, Nicolas. Development of continuous culture microbioreactors. AIChE Spring National Meeting / 10th International Conference on Microreaction Technology (IMRET-10), New Orleans, Louisiana, USA, 6-10 April, 2008

Schäpper, Daniel; Gernaey, Krist V.; Eliasson Lantz, Anna; Stocks, Stuart; Szita, Nicolas. Development of continuous culture microbioreactors. 7th European Symposium on Biochemical Engineering (ESBES7), Faro, Portugal, 7-10 September, 2008

Shafique Bashir, Muhammad; Gani, Rafiqul. A Systematic Methodology for the Selection of Green and Non-Reactive Solvents for Multistage Organic Reactions. CAPE-Forum. Thessaloniki, Greece, 6-9 February, 2008

Sin, Gürkan; Eliasson Lantz, Anna; Gernaey, Krist V. Evaluating prediction uncertainty of fermentation models. 7th European Symposium on Biochemical Engineering (ESBES7), Faro, Portugal, 7-10 September, 2008

Sin, Gürkan; Gernaey, Krist V. Practical identifiability of complex fermentation models: a systematic approach. 7th European Symposium on Biochemical Engineering (ESBES7), Faro, Portugal, 7-10 September, 2008

Sin, Gürkan; Gernaey, Krist V.; Neumann, Mark; van Loosdrecht, Mark C.M.; Gujer, Willi. Uncertainty analysis in WWTP model applications: a critical discussion of issues using a design example. 1st IWA/WEF Wastewater Treatment Modelling Seminar (WWTmod2008), Mont-Sainte-Anne, Québec, Canada, 1-3 June, 2008

Singh, Ravendra; Gernaey, Krist V.; Gani, Rafiqul. A Model-Based Framework for Systematic Product Quality Monitoring and Control. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Singh, Ravendra; Gernaey, Krist V.; Gani, Rafiqul. A Software Tool for Design of Process Monitoring and Analysis Systems. AIChE Annual Meeting 2008. Philadelphia, PA, USA, 16-21 November, 2008

Singh, Ravendra; Gernaey, Krist V.; Gani, Rafiqul. Off-line design of PAT systems for on-line applications. ESCAPE-18. Lyon, France, 1-4 June, 2008

Tindal, Stuart; Archer, Ian; Farid, Suzanne; Hailes, Helen C; Woodley, John. Stability of immobilised amino acid oxidase from Trigonopsis variabilis. European Symposium on Biochemical Engineering Science, Foro, Portugal, 7-10 September, 2008

Us, Tolga; Jensen, Niels; Lind, Morten; Jørgensen, Sten Bay. Fundamental Principles of Alarm Design. CSEPC conference, Harbin, China, 8-10 September, 2008

van Lith, Simone Cornelia; Frandsen, Flemming; Montgomeery, M; Vilhelmsen, T.; Jensen, S.A. Lab-Scale Investigation of Deposit-Induced Chlorine Corrosion of Superheater Materials under Simulated Biomass-Firing Conditions. The European Corrosion Congress. Edinburgh, UK, 2008

van Lith, Simone Cornelia; Frandsen, Flemming; Montgomery, Melanie; Vilhelmsen, Tommy; Jensen, S.A. Lab-Scale Investigation of Deposit-Induced Chlorine Corrosion of Superheater Materials under Simulated Biomass-Firing Conditions. Impacts of Fuel Quality on Power Production and the Environment. Banff, Canada, 2008

PUBLICATIONS CONTINUED

von Solms, Nicolas; Neela, Vasu; Kristensen, Jakob. Measuring and Modeling the Solubility, Diffusivity and Permeability of Carbon Dioxide in Polymers Used as Packing and Sealing Materials in Carbon Dioxide Refrigeration Plants. AIChE Annual Meeting. Philadelphis, PA, USA, 2008

von Solms, Nicolas; Jensen, Lars; Michelsen, Michael Locht; Kontogeorgis, Georgios. Modelling Hydrogen-Bonding Fluid Mixtures Using Insight Gained from Spectroscopy. AIChE Annual Meeting. Philadelphis, PA, USA, 2008

Wedberg, Rasmus; Peters, Günther H.j.; Abildskov, Jens. Isothermal Compressibility from Fluctuation Solution Theory. ESAT 2008. Cannes, France, 29 May – 1 June, 2008

Woodley, John. Design tools to evaluate the implementation of biocatalysis in pharmaceutical processes. BioFine USA - Chemical Process Design. Sanibel Island, FL, USA, 2-3 December, 2008

Woodley, John. Industrial biocatalysis - a new era. Biotrends 2008 - SusChemEng. Dortmund, Germany, 5-6 November, 2008

Woodley, John. Scale-up issues for chemoenzymatic processes. Cascade Chemoenzymatic Processes. Como, Italy, 18-20 September, 2008

Woodley, John; Gernaey, Krist V. Scale-up of biocatalytic processes. Industrial Biotechnology. Malmø, Sweden, 8 October, 2008

Woodley, John. Tools for implementing biocatalytic processes. IBOS annuaal meeting. Lunteren, The Netherlands, 24-25 September, 2008

Woodley, John. Multi-enzyme reaction engineering. Oral presentation at Biocat 2008, Hamburg, Germany, 31 August – 4 September, 2008.

Wu, Mengzhe; Jørgensen, John Bagterp; Jørgensen, Sten Bay. A Dynamic Model for a Cupola Furnace. AIChE Annual Meeting 2008

Zhenning, Wu; Jiang, Juan; Benter, Maike; Larsen, Niels B.; Jankova, Katja. Novel polymer coatings based on plasma polymerized 2 - methoxyethyl acrylate. Nordic Polymer Day NPD 2008, Stockholm, Sweden, 11-13 June, 2008

MASTER'S AND BACHELOR COURSES

The department participates in a 3 1/2 year educational program for the bachelor's degree, a 3 year educational program for the Bachelor of Science, and a 2 year education for the Master's degree. Below, course numbers and names are shown for 2008 with the number of students attending shown in brackets. Courses for the bachelor's degree are marked with (B). The other courses are Master's courses or common courses.

SPRING-SEMESTER

28001 Introduction to Chemistry and Chemical Engineering (51)
28012 Chemical and Biochemical Process Engineering (19) (B)
28014 Chemical and Biochemical Process Engineering II (4) (B)
28015 Mathematical Models for Chemical and Biochemical Systems (34) (B)
28020 Introduction to Chemical and Biochemical Engineering (59)
28022 Unit Operations of Chemical Engineering and Biotechnology (42) (B)
28110 Chemical and Biochemical Product Analysis (21)
28121 Chemical Unit Operations Laboratory (20)
28156 Process and Product Design (27) (B)
28160 Mathematical Models for Shemical Systems (49)
28212 Polymer Chemistry (23)
28221 Chemical Engineering Thermodynamics (27)
28231 Laboratory in Chemical and Biochemical Engineering (26)
28241 Chemical Kinetics and Catalysis (21)
28312 Computer-Aided Product Design (5)
28321 Chemical Engineering Thermodynamics (3) (B)
28322 Chemical Engineering Thermodynamics (29) (B)
28342 Chemical Reaction Engineering (37) (B)
28345 Chemical Reaction Engineering (17)
28350 Process Design: Principles and Methods (10)
28352 Chemical Process Control (34) (B)
28415 Oil and Gas Production (17)
28423 Phase Equilibria for Separation Processes (11)
28434 Membrane Technology (23)
28443 Industrial Reaction Engineering (21)
28451 Optimizing Plantwide Control (2)
28852 Risk Assessment in Chemical Industry (26)
28855 Good Manufactoring Practice (44)
28863 Introduction to Fortran Programming (9)
28864 Introduction to Matlab Programming (25)
28885 Technology and Economy of Oil and Gas Production (12) (B)

Course given in co-operation with other departments:

26010 Introductory Project in Chemistry (1)
26316 Analysis and Chromatography (17)
27944 Biotechnology and Process Design (59) (B)
31525 Physiological transport phenomena (14)
41015 Mechanics and Materials (4)
42110 Materials Science (141)
42983 Corrosion and Materials Selection (10)
42984 Materials Science (34) (B)

EDUCATION CONTINUED

MASTER'S AND BACHELOR COURSES

FALL-SEMESTER

28001 Introduction to Chemistry and Chemical Engineering (52)
28012 Chemical and Biochemical Process Engineering (42) (B)
28013 Chemical and Biochemical Process Engineering, I (5) (B)
28015 Mathematical models for chemical and biochemical systems (28) (B)
28020 Introduction to Chemical and Biochemical Engineering (8)
28022 Unit Operations of Chemical Engineering and Biotechnology (36) (B)
28120 Introduction to Chemical and Biochemical Engineering (3)
28121 Chemical Unit Operations Laboratory (9)
28140 Introduction to Chemical Reaction Engineering (34)
28150 Introduction to Process Control (28)
28213 Polymer Technology (39)
28233 Recovery and Purification of Biological Products (15)
28244 Combustion and High Temperature Process (26)
28246 Applied Enzyme Technology and Kinetics (25)
28247 Advanced Enzyme Technology (9)
28310 Chemical and Biochemical Product Design (45)
28315 Colloid and Surface Chemistry (37) (B)
28316 Laboratory Course in Colloid and Surface Chemistry (10)
28321 Chemical Engineering Thermodynamics (9) (B)
28322 Chemical Engineering Thermodynamics (32) (B)
28341 Chemical Reaction Engineering (25) (B)
28351 Process Control (18) (B)
28361 Chemical Engineering Model Analysis (19)
28410 Design and test your own product ideas (4)
28420 Separation Processes (21)
28515 Enhanced Oil Recovery (11)
28530 Transport Processes (19)
28811 Polymers in Processes and Products (22)
28845 Chemical Reaction Engineering Laboratory (10)
28851 Chemical Plant Operation (9)
28863 Introduction to Fortran Programming (1)
28864 Introduction to Matlab Programming (23)

Courses given in co-operation with other departments:

10336 Fundamentals Problems in Fluid Dynamics (6)
11425 Arctic Technology - Introductory course (11)
12411 Introduction to Petroleum Technology (15)
26010 Introductory Project in Chemistry (52)
27004 Health, Diseases and Technology (32)
27006 Design of Biotechnological and Environmental Processes (87)
27009 Pharmocokinetics (Introductory project work – Food and Drug Technology) (15)
27944 Biotechnology and process design (20) (B)
41015 Mechanics and Materials (60)
42983 Corrosion and Materials Selection (25) (B)
42984 Materials Science (25) (B)

MASTER OF SCIENCE DEGREES

48 students finished their research projects for the M.Sc. Degree. The project titles and names of the students are listed below.

Abaigar, Maria
Process design for ethanol production

Ajish, John
Novel environmentally friendly compound for antifouling protection

Al-Haque, Naweed
Bio-refinery: Evaluation of process design alternatives

Andersen, Kenneth
Water uptake of interpenetrating polymer network of hydrophilic polymers and silicone

Andersen, Stefan Sylvester
Medium Temperature Sorbents for H_2S

Bradley, Ryan
Regulated Ammonia Desorption from Metal Ammines by the Controlled Use of Automotive Waste Heat

Bøgh, David
Using spectroscopy data for developing association equations of state

Cervera Padrell, Albert
Fermentation process monitoring using NIR transmittance and reflectance

Christensen, Martin Ellegaard
Mixed Solvent Solubility – Modeling

Cui, Yang
Simulation of the dewatering process in wet flue gas desulphurisation

Huang, Shengli
Measurements and Modelling of CO_2 Solubility in Water and CO_2-saturated Water Density at High pressures

Jakobsen, Mathilde Rosendal
Injectable microparticles

Jampana, Rama Krishna Raju
Experimental Studies of CO_2 Injection for Enhanced Oil Recovery

Jannerup, Julie
Hydrodemetallization in Vacuum Gas Oils

Jensen, Anja Zarah
Reduced Emission of CO_2 from Cement Production

João, Terra
Analysis of a sustainable "model" bio-refinery

Johnsen, Martin Moser
Substrate percolation through nano-porous membranes based on block copolymers

Justesen, Stine
Improving the performance of exterior wood coating systems

Kaasi, Andreas
Bioreactor design for tissue engineering of heart valves

Kuchipudi, Vijaya Kumar
Structure/Property Relations. Data Reduction, Parameter Variance and Prediction Intervals

Li, Li
Surface Modification of Nanoporous 1,2-Polybutadiene Matrices by Near UV-Induced Photooxidation

Lindholdt, Asger
Thermodynamic Modelling of H_2S Solubility in Salt Solutions

Lyhne, Anders
Simulation of elastic breakup in uniaxial extension of entangled polymer melts

Madsen, Anne Louise Berg
Plasma Polymerization of Hexamethyldisiloxane

Malmos, Maria Christine
Water borne wood stains for exterior wood

Mangru, Vickram
Modelling of liquid-liquid equilibria of polymer solutions with the PC-SAFT equation of state

EDUCATION CONTINUED

MASTER OF SCIENCE DEGREES

Martinez, Luis Maria
Novel materials for Optical Storage

Mogensen, David
Mathematical Modelling of Solid Oxide Fuels Cells

Ndumbe Ngale, Kenneth
Tranport in light gas reservoire

Neela, Vasu
Refrigeration Plants using Carbon Dioxide as Refrigerant: Permeability of Carbon Dioxide in Polymers used as Packing and Sealing Materials

Nwadigo, Okechukwu Bruno Kizito
Modelling of Environmental and Toxicological Properties

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

Ratnam, Ashok
Complex liquids

Riaz, Muhammad
Design and Analysis of Extractive Separation Processes using Ionic Liquids

Sagar, Kaushal Shashikant
Liquid-core wave guides based on nanoporous materials

Sandersen, Sara
Absorption processes for CO_2 capture

Shafique Bashir, Muhammad
Solvent based separations and organic synthesis

Sharifi, Elham
Surfactants for removal of particle contamination in liquid CO_2-cleaning/extraction of silicone rubber

Sørensen, Casper Hadsbjerg
Thermodynamic modelling of hydrocarbonn mixtures with the PC-SAFT model

Trespalle Vidal, Gemma
Optimization of anticorrosive coatings

Tybjerg, Peter Christian Vestager
Distribution of polar inhibitors in oil-water mixtures

Us, Tolga
Functionality based Abnormal Situation Management

Vognsen, Maria
Mixing by rotary jetheads in newtonian and pseudoplastic liquids

Wissing, Louise
Oxidation of SO_2 to SO_3 in marine engines

Wu, Mengzhe
Towards Simulation of Cupola Furnace for Model Based Control

Wu, Zhenning
Analysis and Optimization of Poly (ethylene oxide) Coatings Produced by Low-energy Plasma Polymerization

Zahid, Adeel
Gas injection in heavy oil reservoirs

Øzer, Fatima
Film Transfer Coefficients in Monolith Catalysis

BACHELOR OF ENGINEERING DEGREES

15 students finished their research program for the B.Eng. Degree. The project titles and names of the students are listed below.

Frost, Michael and Anders Møllegaard Knage-Rasmussen
Thermodynamics of aqueous systems with association models

Hansen, Niels Feilberg and Carsten Petersen
Design and construction of a CO_2 absorber-stripper pilot plant for removal of CO_2 from combustion flue gases

Hansen, Peter Vind
Particle emission from a wood burning stove

Hansen, Philip Amlani and Kasper Tingsted Bay Klausen
Optimization of laccase mediator system for bleaching of Kraft pulp

Hejlgaard, Katja
Flue Gas Desulfurization at oxy-fuels conditions

Jakobsen, Martin
Kinetics for methane steam reforming on a rhodium type reforming catalyst

Meek, Mette
Synthesis and characterisation of a polymer formed from condensation of 3,3',4,4'-benzophenonetetra carboxylic acid dianhydride with a poly (ethylene glycol)

Olsen, Brian Kjærgaard
Catalytic Combustion in a Palladium Coated Monolith

Olsen, Runi Frodi Leif
Vapor pressure of ethanol-water-sugar-protein solutions

Osted, Philippa Weirup
Characterisation of polymer materials for irradiation sterilisation

Sørensen, Anne Grumstrup
Pretreatment and hydrolysis of straw: influence of grinding and enzyme composition

Thøgersen, Hans Jerik Folmer
Refrigeration Plants using Carbon Dioxide as Refrigerant: Solubility of Carbon Dioxide in Polymers used as Packing and Sealing Materials

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Elmøe, Tobias D.	23.06
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Guide to the department

- Department of Chemical and Biochemical Engineering
- Administration, offices, DTU cafeterias, Student House
- Departments/centers
- Auditoriums
- Oticon Hall
- Halls of residence/shared facilities
- SCION.DTU
- Physical Plant
- Parking
- Bus stop

USEFUL INFORMATION

This Annual Report 2008 may be ordered
from the reception at the Department of
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