

ROOTS

PROFILE 2013

DEPARTMENT OF
ENGINEERING

EDUCATION - RESEARCH - INNOVATION



DAILY MANAGEMENT AND ADMINISTRATION 2013

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CONTENT

An ever-increasing Value creating Academia.....	4
▶ ENGINEERING PROJECTS.....	6-57
Hello Wind Turbine - How's it going	8
Ear Computer predicts Hypoglycaemia	10
A World of Computer Systems	12
The Perfect Energy Mix.....	14
Smart IT Platform for Healthcare	16
3D Camera spots Sick Pigs	18
Researchers can now learn more about B12 Vitamin Deficiency.....	20
Sensors report on the State of the Building	22
A 12-Storey Energy Laboratory	24
Green Magnets	26
Manufacturing Research	28
Researchers Scrutinise Cracks in Composite Materials	30
Printing Cartilage Implants in 3D	32
5900 Kilometres on a Single Litre of Petrol	34
Cancer Diagnosis with a Simple Blood Sample	36
New and Efficient Energy Conversion in Membranes	38
Lipids for All Purposes	40
New Cholesterol Lowering Substance	42
A Major Bioproducts Adventure	44
Drone spots Game in the Field	46
Agricultural Machinery with Computer Brains	48
Computer Model brings Field to the Farmers Desktop	50
Reduced Odour from Pig Farms	52
Scarecrows that speak Bird	54
Computer Model will reduce the Risk of Terrorist Attack	56
▶ INFRASTRUCTURE.....	58-59
▶ TALENT DEVELOPEMENT	60-61
▶ PHD PROJECTS.....	62-80
▶ PUBLICATIONS 2013.....	81-87
▶ KEY FIGURES	88



Photo: Aarhus University

The research success of the past decades at Aarhus University has set a high standard, but we can do even better by thinking anew and by turning even more of the best of our discoveries and thoughts into actions.


The establishment of a new engineering science department in July 2011 is a significant strategic step in this direction, emphasising the Aarhus University ambition of excellence in basic, applied and strategic research.

Solutions to the most challenging global problems of the 21st century can only be achieved when engineers join their

colleagues from the sciences and humanities to apply engineering principles within the context of the human experience. Whether the challenge is to build a bio-based society orchestrated around sustainable energy technologies, handling the food and water demands of a rapidly growing global population or ensuring a global convergence of ICT with respect to security or healthcare, a truly collaborative effort across all disciplines is required.

Interdisciplinary collaboration is a cornerstone of the university strategy and a principle we fully embrace at the Depart-

AN EVER- INCREASING VALUE CREATING ACADEMIA



■ We are in extremely exciting times. Globalization more than ever affects the conditions of research. If we want to stay on the cutting edge of engineering, the need for an ever-increasing value creating academia is of utmost importance. ■

ment of Engineering. Our students and faculty are encouraged to connect with their peers both across engineering disciplines and across departments and campuses in general. An engineering department driving interdisciplinary collaboration through tight links with the well-established world class neighboring departments completes the innovation value chain from basic science to actual innovation.

In our laboratories, we are developing new technologies within diverse domains like healthcare, agriculture and manufacturing — each with the end goal of leading collaborative ef-

forts toward solutions to bring knowledge to bear on the world's great challenges and to improve the human condition.

I am animated and exhilarated about the challenges we are facing and very proud of being able to highlight our researchers activities in this first Department of Engineering, 2013 Profile magazine.


Thomas Skjødeberg Toftegaard
Head of Department of Engineering

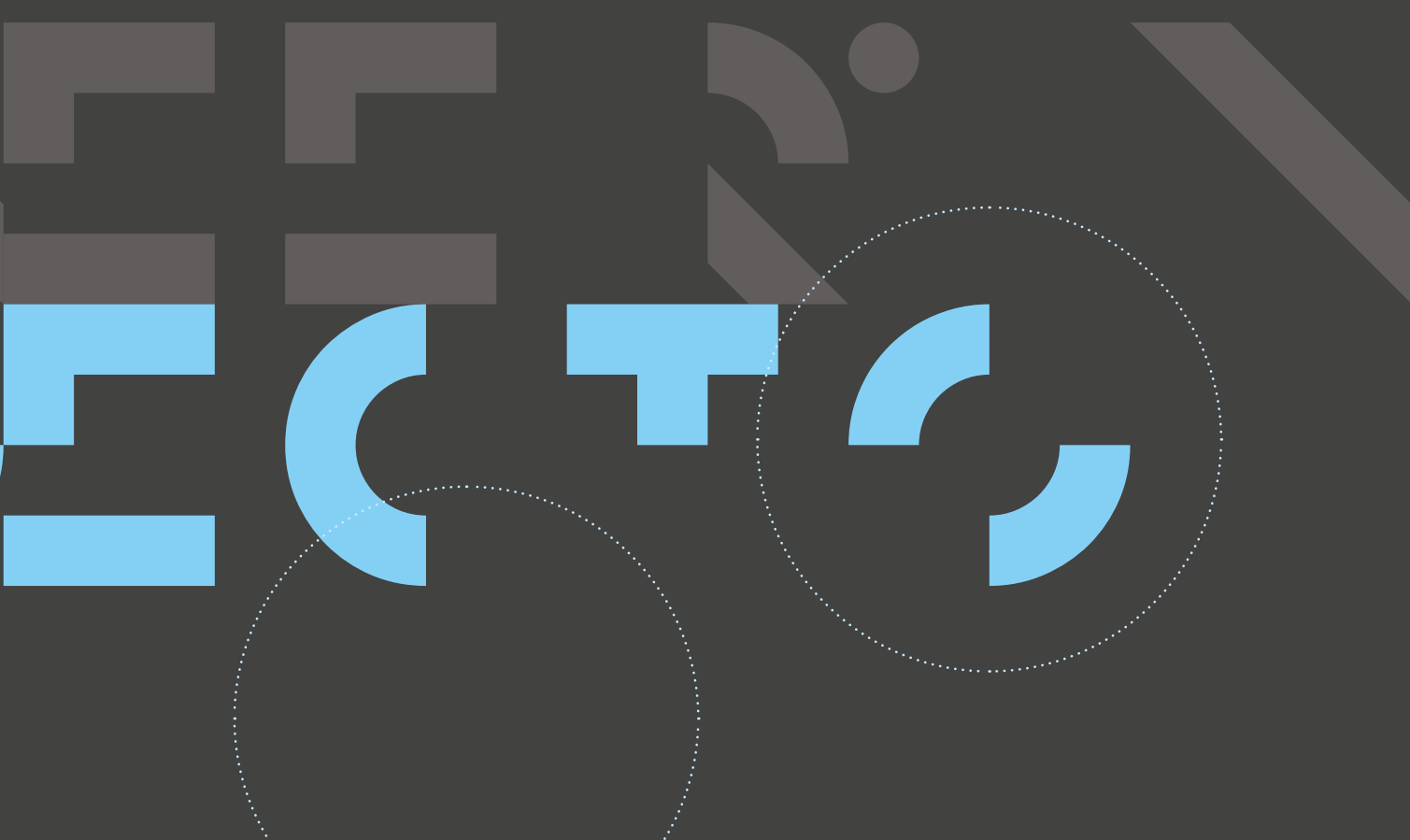


ENGINEERING PROJECTS



Aarhus University conducts engineering research of a high international standard and is at the forefront with the development of new knowledge and technology-based solutions. Solutions that can improve quality of life, create a greener environment, strengthen the competitiveness of Danish companies or in other ways enhance the value of research in society.





FOUR ENGINEERING DISCIPLINES

- 1 Biological and Chemical Engineering
 - 2 Civil and Architectural Engineering
 - 3 Electrical and Computer Engineering
 - 4 Mechanical Engineering
-



Photo: Colourbox

An international research team will develop an intelligent platform that is able to monitor and control the use of electricity. The purpose is to provide electricity and utility companies with detailed information about the current electricity production and the electricity usage within a limited geographical area. In this way, it will be easier for the individual households to consume electricity when electricity production is high and prices are low.

"The goal is to develop a complete prototype of an intelligent system that is able to control the electricity consuming units in the home based on supply and demand," explains Rune Hylsberg Jacobsen, associate professor at Aarhus University.

Electricity must be consumed the moment it is produced; otherwise it is wasted. Society as a whole can therefore make large savings with an intelligent solution that adapts electricity use and consumers' behaviour to the actual electricity production.

Wind turbines and washing machines must communicate

Researchers at Aarhus University will contribute to the project by developing software for a so-called intelligent gateway for the home that is able to control energy use on the basis of ope-

rating information from the utility companies and the individual household's electricity requirements.

"One could say that our task is to design an infrastructure for communication between electrical devices in the home and the utility companies. We need an energy system that is much more efficient and that is able to contribute to even out the imbalance between the energy production and the energy consumption," says Rune Hylsberg Jacobsen.

No more overproduction of electricity

Denmark's current energy system is based on demand-controlled energy production that always has the capacity to meet the most extreme user demands. This means that we often have an excess of energy that we have to waste or export to other countries at a price that might be lower than the production costs.

In the smart energy system of the future, it will be possible to create an automated control between the units on the electrical grid and thereby move the energy use to those periods where the energy is most available.

"If it is windy at night then that is when it is most appropriate to charge the electric car or use the washing machine," explains Rune Hylsberg Jacobsen.

HELLO WIND TURBINE - HOW'S IT GOING?

- Is it possible to get the wind turbine to communicate with the washing machine? And is it possible to predict the energy demand of consumers? Researchers from Aarhus University will help Europe take an important step towards the intelligent electrical grid of the future.

The electrical grid of the future predicts user behaviour

Within the next couple of years, we will experience a significantly increased European demand for electricity from renewable energy sources due to the political decision to reduce the emission of greenhouse gases. There is therefore a need for new intelligent solutions to ensure an optimal use of the existing green electricity production from sources such as wind turbines and solar cells.

One of the greatest technical challenges faced by the researchers in this context not only concerns the development of a communication platform that automatically transmits information about access to electricity to the individual households and their electrical devices. They will also need to develop a calculation system that is able to predict patterns in electricity use in limited geographical areas and return prognoses to the utility companies.

"Our goal is to make the electrical grid of the future more intelligent to keep it one step ahead of the development in consumer behaviour. So it will be able to predict when the supply of electricity will be largest, and consequently, when it will be most appropriate to charge the electric car," says Rune Hylsberg Jacobsen

The system will be pilot tested in 100-200 homes and will be adapted to ensure the highest possible level of user friendliness and impact on energy behaviour.

PROJECT FACTS

Title: Energy Demand Aware Open Services for Smart Grid Intelligent Automation.

Financial framework: 3.3 million EUR, EU's 7th Framework Programme for Research

Schedule: 2012 – 2015

Project partners: Sapienza University of Rome (Italy), IMDEA Energía (Spain), A. V. Luikov Heat and Mass Transfer Institute of the National Academy of Sciences of Belarus (Belarus), ATANVO GmbH (Germany), GridManager A/S (Denmark), Panoramic Power (Israel), Solintel (Spain), SEAS-NVE (Denmark), Kalundborg Municipality (Denmark), Minskenergo (Belarus)

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Photo: Aarhus University

- A small device in the ear protects diabetes patients from hypoglycaemia. Small electrodes measure electrical brain signals and warn the patient if their blood sugar drops to a critically low level.

A small device in the ear protects diabetes patients from hypoglycaemia. Small electrodes measure electrical brain signals and warn the patient if their blood sugar drops to a critically low level.

Diabetes is one of the most wide-spread, rapidly spreading and expensive diseases in the world. One of the most serious complications of the disease is hypoglycaemia, also called insulin shock, which occurs when the blood sugar drops to a level where the brain no longer functions normally. This is a serious condition with a risk of both coma and death.

Researchers from Aarhus University have therefore started working on a device that prevents hypoglycaemia by warning the patient so that they can take preventative action. The vision

is to help people with diabetes by providing better treatment and a better quality of life.

Measuring electrical activity in the brain

The device detects the risk of hypoglycaemia by measuring the electrical activity in the brain by means of small electrodes in the ear.

In case of low blood glucose levels, characteristic changes appear in the electrical signals from the brain. These signals can be measured and analysed by using advanced algorithms, which makes it possible to detect low blood sugar levels before hypoglycaemia occurs.

The device functions via three small electrodes and a micro-

Brain-computer interface (BCI), one of today's most fascinating technologies. Lately, researchers have come a long way in the development of micro-computers and advanced algorithms that can interpret electrical activity in the brain cells and thereby reveal the mental states of human beings. The photo shows Professor (Docent) Preben Kidmose, a specialist in in-the-ear EEG. An insulin shock detector is just one of the many potential applications of the technology.



The researchers have produced the first prototype of a small, discreet ear computer that can prevent insulin shock in diabetics by measuring their brain activity.



Photo: Aarhus University

EAR COMPUTER PREDICTS HYPOGLYCAEMIA

computer that decode the activity in the brain. The design of the device will be similar to the design of a traditional hearing aid and it will be very comfortable for the user and almost invisible in the ear canal.

Little and discreet

The technology for measuring electrical activity in the brain is called EEG monitoring. While EEG technology is already well-known, the experiment with electrodes in the ear is new. The device has great potential because it is non-invasive and discreet, and at the same time the measurements are very precise. "The patient has to wear the device 24 hours a day so user-friendliness is crucial for the product's potential for commercialisation. Today, EEG measurement takes place via electrodes on the head, which requires a form of helmet. Ear EEG will give the technology completely new applications," says Preben Kidmose.

Around 20 percent of all patients with insulin-requiring diabetes are not able to sense when they have low blood sugar levels. Some patients may not even wake up if their blood sugar levels drop during the night. And other diabetics have deliberately increased blood sugar values to avoid hypoglycaemia.

There is no equipment currently available that can warn patients when they are going into insulin shock so the ear EEG technology has major clinical and commercial potential.

The success criteria for the project are to establish a technical and clinical proof-of-concept for an Ear EEG-based hypoglycaemia alarm.

The main technical challenge addressed by the project is the development of a platform consisting of dry electrodes and corresponding electronic instrumentation to provide high quality EEG recordings from the ear. To meet the requirements for high accuracy, noise immunity, low power consumption and physical size that allow the device to be placed in the ear canal, the electronic instrumentation will be implemented in an

application specific integrated circuit (ASIC) using state-of-the-art chip technology. The characterisation of EEG signals and the detection of hypoglycaemia episodes require advanced signal processing techniques and the development of dedicated signal processing algorithms.

ADVANCED SIGNAL PROCESSING

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The characterisation of EEG signals and the detection of hypoglycaemia episodes require advanced signal processing techniques and the development of dedicated signal processing algorithms.

PROJECT FACTS

Title: Ear EEG-based Hypoglycaemia Alarm

Financial framework: 20.35 million DKK, The Danish National Advanced Technology Foundation

Schedule: 2013 – 2017

Project partners: Widex A/S, The Endocrine Research Unit (EFE), Odense University Hospital, Hyposafe A/S

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A WORLD OF COMPUTER

■ Aarhus University is participating in a major international research collaboration between universities and businesses to develop new modelling technology for advanced software. Danish Bang & Olufsen is one of the companies participating in the COMPass project, and they have already harvested the first fruits of the project's research.

COMPASS – NEW TECHNOLOGY FOR THE MODELLING, TESTING AND VERIFICATION OF INTERACTIONS BETWEEN IT SYSTEMS

Modern system architecture consists of a number of different independent computer-based systems. These systems may very often share properties, such as a television that shows photos taken with a mobile phone. Or it could be the ambulance control system that communicates with the patient records system. In both cases, these are so-called systems of systems.

COMPass is an international research project with a large consortium of universities and companies. The objective is to develop model-based techniques and tools for the design, operation and control of systems of systems. These techniques may lead to completely new standards for how we test and verify software. This is of vital commercial importance, particularly in companies that spend a lot of resources on quality assurance, and in companies that develop mission critical software for aircraft, trains and military equipment.

Bang & Olufsen is one of two companies involved in the project testing the new technologies with case studies.



Photo: Aarhus University

▶ When two or more different computer systems cooperate and share resources, a so-called system of systems arises. And this provides major challenges for software engineers around the world because they are currently difficult to handle. Researchers are, however, well on the way to developing the first model-based techniques and tools that can be used to design, operate and control systems of systems. The photo shows the software engineering group at Department of Engineering.

SYSTEMS

How do we make sure that the computer-based systems sold in the shops today – for example televisions or stereos – do not quickly become obsolete? And how can we guarantee that the existing media products can communicate with the systems of the future? A major European research project is shedding light on this.

The speed of technological development of media products is constantly increasing. More than ever before, manufacturers need new theories, methods and techniques that enable them to continuously and quickly adapt their existing systems to new systems, media and future consumer needs.

When systems pair with each other, anything can happen

The objective is to develop new methods, tools and modelling languages that make it easier to develop and optimise the interaction between different independent IT-based systems and thereby achieve functions or services that would not be achievable by using a single IT-based system in isolation.

Bang & Olufsen have already benefited from the first version of the modelling language in the company's work with technology development and control. They are now able to analyse the characteristics of the systems that arise when their own systems are paired with their competitors' systems with their special formats, distribution methods and rights. This allows B&O to ensure the quality of their products better and faster.

PROJECT FACTS

Title: Comprehensive Modelling for Advanced Systems of Systems (COMPASS)

Financial framework: 6 million EUR, funded by EU's 7th Framework Programme for Research

Schedule: 2012 – 2014

Project partners: Newcastle University (UK), University of York (UK), Bremen University (Germany), Universidade Federal de Pernambuco (Brazil), Bang & Olufsen (DK), Insiel (Italy), Atego (UK)

Contact: Professor Peter Gorm Larsen, pgl@eng.au.dk



THE PERFECT ENERGY MIX

- Climate change, the prospect of fossil fuels shortages and political demands to reduce CO₂ emissions mean new, major demands for knowledge that can help to optimise our overall energy production and enable us to better utilise the Earth's green energy sources. Researchers from Aarhus University have developed the most comprehensive model based on 100 percent renewable energy to date.



How many solar cells are required compared to wind turbines if you wish to reduce excess production of electricity? Or, in other words: What is the technically optimal mix of solar and wind in the fossil free energy supply of the future?

This is the question that researchers from Aarhus University have found the answer to. They have studied current European consumption in detail based on more than 70,000 hours of weather and fuel consumption data and 2,600 different geographical measurement points.

The study is one of the world's largest time series analyses of consumption and power availability, and it provides a good starting point for predicting the requirements for energy storage, transmission and reserve capacity in the renewable energy system of the future.

The researchers have calculated how many solar cells would be required compared to wind turbines to reduce the excess production of electricity or, more specifically, the mix of solar energy and wind energy which would provide precisely the energy production that best matches the consumption pattern and, at the same time, gives the most optimal conditions for utilising the energy.

On the road to lopsided production of renewable energy

The formula for this correct mix is an important intermediate result in the planning of fossil free energy supplies. Because if we extrapolate our current production of electricity to 2020, then Denmark alone will produce a surplus of 700 GWh of renewable energy. However, with the technically optimal ratio, this surplus production would instead be 300 GWh.



Photo: Aarhus University

THE OPTIMAL MIX

According to the researchers, the optimal energy mix between solar and wind power is around 20 percent solar energy and 80 percent wind energy. With this mix, approximately five percent more renewable energy can be integrated into our energy system.

An optimal energy mix reduces the production of surplus energy and thus the need for energy storage, which in Denmark alone is equivalent to between a half and one million electric car batteries. Or that each and every family changed their consumer habits and did all of their hot wash laundry all year round when it was windy and there was a surplus of energy.

This is connected to the fact that solar energy is produced in a pattern that complements wind energy well – both in relation to daily and seasonal fluctuations.

In a sustainable energy system on a continental scale, these intermediate results could save enormous amounts of surplus energy.

▲ Professor Martin Greiner is the man behind the most comprehensive model so far of the continental scale sustainable energy system of the future.

PROJECT FACTS

Title: CONSENSYS COMplex Networks of Smart ENergy SYStems

Financial framework: 1 PhD and 1 Industrial PostDoc

Schedule: From 2010

Project partners: DONG Energy A/S

Contact: Professor Martin Greiner, greiner@eng.au.dk

No more technological chaos in the care of the elderly. Today the ECG monitor, sphygmomanometer and the intelligent pill dispenser operate on different systems. The researchers Stefan Wagner (left) and Finn Overgaard Hansen have contributed to the development of a joint European digital marketplace for welfare applications.



Photo: Aarhus University

Automatic door openers, fall detectors, intelligent sphygmomanometers, medication systems and blood sugar alarms. These are just a few examples of the electronic devices that have been introduced in home care in recent years, each connected to their own isolated computer system and unable to communicate with one another.

Technological chaos at home with the elderly

This gives rise to such a large technical burden that the municipalities opt out of many of the solutions.

"During the last few years there has been a boom in the development of tele-medicine solutions that are capable of making the individual citizen more self-sufficient. These solutions are necessary elements in a technology based care and nursing sector. But right now it looks more like a chaotic mix of devices and control systems that neither the elderly nor the care assistants have any chance of operating," says Stefan Wagner, assistant professor at Aarhus University.

But now help is on the way. In close collaboration with the IT company Sekoia ApS, researchers have developed a new open source platform for technological welfare apps. Named CareStore, it gathers all electronic aids so that they are able to communicate with one another across systems and providers.

Digital market place for welfare apps

The first prototype of the platform has been successfully tested in Denmark. The goal is now to develop a digital marketplace for the entire European nursing sector where businesses will be able to offer applications for their tele-medicine products in accordance with a common digital standard in the future.

The key to a well-functioning, technology based nursing sector is to have systems that are capable of handling several electronic units in a simple way.

"Instead of ten isolated systems, we can now make do with one single system. This makes it far more simple for the elderly person. The nursing staff can look forward to more efficient

SMART IT PLATFORM FOR **HEALTHCARE**



- Employees in the care and nursing sector will receive a helping hand for everything from medication and distribution of tasks to tele-medicine with a new, open software platform for welfare apps.

ABOUT CARESTORE

Today there are between three and ten different welfare technological appliances in a normal assisted care home and that number is expected to increase. Each appliance operates on its own system and is not designed to communicate with other appliances. This makes it hard to exploit the full potential of the technology.

CareStore offers a solution to this problem. It is a system and an open platform that bring together all the tele-medicine product applications.

In the future, companies will be able to offer new applications for their products in accordance with a common standard similar to those that we already know from e.g. iTunes.

In practice, the system only requires the installation of a touch-screen with built-in computer in the individual assisted care home. It then recognises and installs the different devices and connects the equipment to the person who lives there automatically.

working procedures and the local authorities can expect an optimal utilisation of their investments in new electronic equipment”, says Stefan Wagner.

CONTACT

Title: CareStore

Financial framework: 13 million DKK, EU's 7th Framework Programme for Research

Schedule: 2012 – 2014

Project partners: Institut de Recherche en Systemes Electroniques Embarques (France), University of Minho (Portugal), Sekoia (Denmark), Deosite (Poland) og plejecentret Rommerskirchen (Germany).

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3D CAMERA SPOTS SICK PIGS

- Researchers have built the first prototype of a combined RFID and camera solution as part of a two-year development project funded by a grant from EU's 7th Framework Programme for Research. The special camera will make it possible to identify sick pigs in the agricultural sector's huge pigsties.

Modern pork production is concentrated in fewer and larger farms, and the number of animals per herd has increased significantly over the past few years. This makes it more difficult for the farmer to make routine health checks on the individual animal. In order to solve this problem, researchers have developed a new system with electronic ear tags (RFID) and a 3D camera which can monitor the animals' well-being in the pigsties and detect illness at an early stage.

Monitoring at an individual level

The ear tags are familiar RFID equipment which is used e.g. for labelling clothes to prevent shoplifting from stores. The cameras are based on Kinect sensor technology which is familiar from the Microsoft Xbox 360 console. Together the two technologies are able to monitor many hundreds of pigs in a herd with the help of a computer which is preprogrammed to recognise and follow the individual animal's feeding pattern.

The system sends an alarm to the farmer if one of the pigs begins to change its behaviour to a degree that exceeds a defined threshold limit value for feeding frequency and length of feeding on an individual basis.

Feeding pattern reveals distress and illness

The 3D cameras being used in the project are able to see in the dark so it is possible to follow the animal's feeding pattern 24 hours a day. They can also check that the ear marking technology is working as it should.

A computer logs the time and duration of each pig's consumption of feed in a database and builds up a behavioural profile for the individual animal in the herd. Subsequently, it can alert personnel working in the pigsty about animal distress far earlier than would be possible via daily inspection. This is because an animal feeding less often than it usually does, or feeding for a shorter time is a clear sign of illness, explains Associate Professor Torben Gregersen.

"We can log the time and duration of the pig's consumption of feed in a database and in this way obtain detailed know-

ledge of the individual animal's feeding pattern. Deviations from the normal feeding pattern are an important indicator of distress and the system therefore quickly alerts the personnel and indicates which of the animals it is," explains Torben Gregersen.

Where is pig number 428?

Today pork production is concentrated in fewer and larger farms all over Europe and tracking a single animal can therefore be somewhat of a challenge. Here the camera technology offers another smart solution. It "looks" down on the pigsty and follows the pigs as unique graphic objects so that it can retrieve information on the location of the individual animal at all times.

The farmer can also be equipped with a control unit such as a mobile phone. Here he keys in "find 428" and the location of the pig in the pigsty is displayed on a digital map. At the same time, the computer controls a spotlight which shines a light on pig number 428. This makes a significantly improved and more systematic supervision of each animal's welfare possible and also solves a major problem:

FEWER ANTIBIOTICS IN THE TEST PIGSTY

At the researchers' test pigsty in Belgium, they have succeeded in discovering illnesses in the slaughter pigs up to four days before the farmer would otherwise be able to register distress. This makes it possible to quickly commence on a course of treatment and thereby reduce the risk of infection.

Thanks to this early automatic identification of sick pigs, the farmer only has to treat the sick pig instead of treating large numbers or even the whole herd with antibiotics.

This can significantly reduce the total consumption of antibiotics.





Photo: Aarhus University

"It is clear that as pig herds grow bigger and bigger so does the need for new technology that can make it easier to monitor and identify the animals," says Torben Gregersen from Aarhus University.

Aarhus University has established a test pigsty with the prototype of the monitoring system in Merelbeke in Belgium. The first results show that the technology makes it possible to identify sick pigs very quickly and thus reduce the risk of infection in the herd and subsequent financial losses for the farmer.

PROJECT FACTS

Title: PigWise – Optimizing performance and welfare of fattening pigs using High Frequency Radio Frequency identification (HF RFID and synergistic control on individual level)

Financial framework: 4.8 million DKK, EU's 7th Framework Programme for Research, ICT-Agri

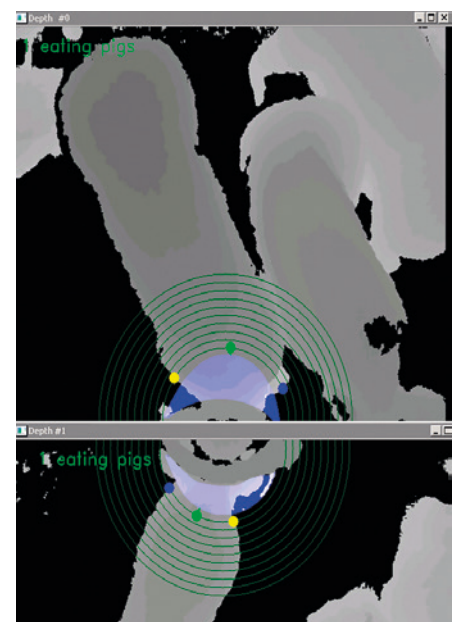
Schedule: 2011 – 2013

Project partners: Georg-August-University Göttingen GAUG, Germany; Institute for Agricultural and Fisheries Research ILVO – Technology and Food Science Unit – Agricultural Engineering – Livestock Precision Farming; Katholieke Universiteit Leuven KUL, Belgium; Institut Superiore Mario Boella ISMB, Service and Application Laboratory, Italy

Contact: Associate Professor, Torben Gregersen, tg@iha.dk



The 3D-camera "looks" down on the pigsty and follows the pigs as unique graphic objects. In that way it retrieves information on the location of all individual animal at all times. This makes it possible for the farmer to improve a systematic supervision of animal welfare.



RESEARCHERS CAN NOW LEARN MORE ABOUT **B12 VITAMIN DEFICIENCY**

Photo: Colourbox



- Researchers have succeeded in producing a copy of the B12 vitamin that is completely without effect and which can outperform the naturally occurring vitamins in our diet. For the first time it is therefore possible to create selective B12 vitamin deficiency in laboratory animals. This is a critical step towards a deeper understanding of the consequences of vitamin deficiency.

Researchers estimate that approx. 20-30 percent of all persons above the age of 60 have some degree of B12 vitamin deficiency. As we grow older, production of a special protein in the body is weakened. This protein has the task of absorbing the vitamin from our diet.

Despite an otherwise good nutrition and preventive dietary supplements, a large part of the elderly population very often have vitamin deficiency. There is no comprehensive overview of the consequences of this, but we know that the B12 vitamin includes a group of vital chemical substances which are also significant for the formation of red blood cells and for the maintenance and regeneration of the nerves.

B12 deficiency suspected of contributing to dementia

A deficiency of the B12 vitamin is also suspected of being one of the most important causes of dementia and other examples of lasting damage to the brain and nervous system. But so far it has not been possible for the researchers to acquire sufficient knowledge of the deficiency's complications, explains Sergey Fedosov, senior researcher at Aarhus University.

"B12 has a very complex chemical structure and we do not yet have a fully detailed understanding of the importance of the vitamin for all of the body's functions. But we suspect that a lack of the vitamin can be part of the explanation for a number of different pathological phenomena connected with the nervous system."

The B12 vitamin is the general term for a group of chemical substances under the name cobalamins.

First laboratory animals with strong B12 vitamin deficiency

The primary reason for the researchers' lack of knowledge about B12 vitamin deficiency is that it has not been possible to create a controlled vitamin deficiency in laboratory animals.

"It is impossible to put together a diet lacking in B12 without also causing other types of deficiencies. This makes it difficult to isolate the significance of the B12 vitamin for the symptoms that we can identify in laboratory animals. Neither is it possible to test new treatment methods," says Sergey Fedosov.

For this reason, he and his colleagues from the University of Innsbruck in Austria put their heads together five years ago and

began to experiment with the preparation of a so-called anti-vitamin to B12. Today, they have succeeded in designing a molecule that is almost identical with the real vitamin in its chemical structure, but which is completely without effect.

In the laboratories at Aarhus University Hospital, the researchers completed the first experiments and exposed animals to a diet rich in anti vitamins, with positive results.

Anti-vitamin outperforms B12 from our diet

What is so smart about the anti vitamin is that it outperforms other types of B12 vitamin in the battle to be absorbed in the body. The anti-vitamin is designed so that it can be absorbed in the intestinal system but, at the same time, is unable to perform the B12 vitamin's normal reactions in the body.

"When the real B12 vitamin from the diet is absorbed through the intestinal system, it is transported to the cells that are equipped with a special enzyme. The enzyme converts the vitamin into a catalytic form where it is able to carry out the reactions that are necessary for the body's functions. When an anti-vitamin to B12 is absorbed in the body and meets the cell's enzyme, its molecule becomes completely ineffective," explains Sergey Fedosov.

So far the researchers have produced two different chemical variants of the anti-vitamin to B12.

Fluorescent molecules provide researchers with new knowledge

They have also developed a third form of the B12 vitamin with a chemical composition that gives it fluorescent properties. This means that the vitamin becomes visible when you illuminate it so that the researchers can follow how it is transported inside the body and determine how it fares in competition with the anti-vitamins.

The technique to make the vitamin molecule luminous can also be used in connection with the natural occurrence of B12 vitamins in the food we eat, opening up for completely new studies of its functions in cells and tissues.

In the long term, Sergey Fedosov hopes that this access to new data can be used by doctors to develop efficient methods for the treatment of vitamin deficiency.

◀ Researchers have developed a special type of anti-vitamin that can outperform the B12 from our diet in the battle to be absorbed in the body. This makes it possible to study the consequences of vitamin deficiency which are suspected of causing lasting damage to the nervous system and dementia.

CONTACT

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- Small sensors can collect information about vibrations in buildings and predict damage and collapse with greater accuracy than ever before.



SENSORS REPORT ON THE STATE OF THE BUILDING

By registering micro-vibrations with sensors, a research group from Aarhus University has developed a new method for monitoring the condition of buildings and other structures. The method is internationally ground-breaking and it could be of major significance for the construction industry in the future.

"Vibrations in a building can provide quite a lot of information about the properties of the construction. By using small sensors to gather information, we are able to predict how a building is doing a long time before the visible damage symptoms occur," explains Rune Brincker, professor at Aarhus University.

It is the first time that researchers have developed a secure and reliable method for a so-called vibration based condition monitoring of buildings.

Analysis of vibrations reveals damage to the construction

Small vibrations occur all the time in all buildings. They are caused by general seismic activity in the ground surface and, by wind and they contribute to a continuous degradation of the construction.

So far researchers have not been able to monitor degradation and thereby predict the durability of a building, explains Rune Brincker.

"Fundamentally we know very little about how buildings are doing and therefore it is very difficult to predict their durability. We carry out inspection and maintenance programmes and, naturally, we carry out repairs when we discover visible damage. But we do not have any procedures for ensuring that we find that damage," he says.

The durability mystery

Most of the buildings in the world were built within the last 50-100 years during a historic building boom. But nobody has been able to solve the mystery of their durability, explains Rune Brincker.

"Our bridges, dams and houses are relatively new. Many of them are still doing well but we know for certain that they will not last forever. The question is: how long will they last? That would be very valuable information," says Rune Brincker.

With the new monitoring method and by analysing a building's vibration pattern or its so-called vibration characteristics, the researchers are able to evaluate the building's condition and predict its durability.

Detects cracks, frost damage and rust

The researchers have developed the first prototype of a system that is able to register the vibrations in a building via sensors. A computer with specially designed software collects and analyses data from the sensors and identifies incipient damage very precisely.

This damage may be cracks or other significant deteriorations of the construction such as frost damage in concrete. But it can also be rust in reinforcing bars or bridge wires that lead to the beginning of loss of bearing capacity.

The system can also be used for bridges as well as wind turbines and large structures.

Could provide large savings in the building industry

The researchers' new method for monitoring buildings focuses primarily on safety. But the technology also has significant potential for savings in the building industry in that it contributes to reducing the use of materials.

"Today we have to oversize our buildings to prevent failure and fatigue in the construction. It is a strategy that we have used because we have lacked anything better but it has an extreme effect on raising the price of construction," explains Rune Brincker.

The researchers expect that they will be able to reduce the use of materials by half or more in the long term and instead carry out continuous repairs and maintenance.



Engineers from Aarhus University are the first in the world to predict the durability of buildings and detect construction damage before it becomes visible to the naked eye.

CONTACT

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A 12-STOREY ENERGY LABORATORY

- Researchers have begun using a new hall of residence as a full-scale energy laboratory. Over the next three years they will carry out the most radical monitoring programme in the world. They log the energy consumption in the 159 apartments with a few seconds interval 24 hours a day. The aim is the building with its own Virtual Power Plant.

The first residents moved into the new Grundfos Dormitory residence hall on the waterfront in Aarhus in 2012. Apart from the magnificent views of the bay that the 198 students who live there can enjoy from their apartments, at first glance you would not notice anything at all out of the ordinary about the modern-looking apartment building.

But that would be a mistake. The grey concrete building actually contains integrated electronic hardware for millions of DKK, and researchers are now setting out on what might be the world's largest full-scale experiment with intelligent control of energy consumption.

A Virtual Power Plant

The hall of residence is probably the most thoroughly monitored building ever seen. The researchers log temperature, levels of humidity, CO₂ emissions and the flow of water, heating and electricity every six seconds for 24 hours a day, providing them with access to a very detailed data basis.

They need the data basis to be able to look at correlations, explains Assistant Professor Steffen Petersen.

"Once we have a sufficient amount of data we can begin to take a look at correlations. Are there any particular peak periods? And are we able to control the energy consuming behaviour in relation to the actual supply of electricity in an energy supply system based on renewable energy."

The amount of collected data provides the building with its own so-called Virtual Power Plant which coordinates the overall demand-response potential of all controllable energy use in order to ensure the balance between electricity production and consumption.

On the road to intelligent control of energy consumption

The researchers will further develop intelligent control of the energy consumption, which can help to give the building's users an appropriate energy behaviour without them even thinking

about it. The building must itself know whether it needs cooling or heating up in the morning and it must calculate the most appropriate and cheapest time to consume electricity.

Furthermore the intention is that the building will receive weather prognoses on temperature, wind conditions and the direction of the sun, and the researchers are already experimenting with how this information can be used to automatically regulate the building's total heating and ventilation requirements with the lowest possible energy consumption and the most optimal comfort level for the young people living in it.

Future buildings make predictions

If you forget to turn off the light or other equipment, the apartment must be able to help you either by turning off the light itself or by asking you for permission to do so. Or perhaps it lowers the temperature when you are out and turns up the heat in good time before you return in order to save energy. These are the researchers' development scenarios, explains Steffen Petersen:

"We must further develop intelligent energy use control that is able to help the users of a building develop desirable energy behaviour without them noticing it. I think that this will be the case in a few years. There is a huge energy saving potential in automating certain processes. The building itself must know if



In the basement of the Grundfos Dormitory Lab technical equipment monitors the energy use in the 159 apartments every few seconds. The photo shows Assistant professor, Steffen Petersen (right) and Michael Dahl Knudsen, PhD student, Department of Engineering.

Photos: Aarhus University



it will have a cooling or heating requirement tomorrow and it must calculate when it is most appropriate to use more energy,” says Steffen Petersen.

In the long term the intelligent control of the energy use will provide the individual apartments with increased possibilities for using electricity when the electricity production is high and the price is low. The difficult thing about electricity is that it must be used when it is produced - otherwise it is wasted.

“We want to see how far we are able to adapt buildings of this type to a future with fluctuating energy. The goal is to develop a finished prototype of an intelligent system that is able to control the electricity consuming units in the home based on supply and demand. If it is windy during the night, this will be the most appropriate time to use the laundry machine,” says Steffen Petersen.

The future electrical system will be significantly different from the electric system we know today. It must be able to integrate and utilize the large quantity of renewable energy sources to a much greater extent than we have the capabilities of today.

Therefore the researchers’ largest technological challenge is to develop a communication system that not only automatically registers information about the amount of available electricity but also predicts patterns in the electricity use of the dormitory’s residents.

“Once we have collected information about the energy use in the dormitory during a specific period, we can begin to predict what will most likely happen at a given time under the given weather conditions. And this is very valuable in that we can start working on the design of intelligent buildings which automatically respond to the users’ needs in the most sustainable way,” says Steffen Petersen.

The research project at Grundfos Dormitory Lab is a feasibility study on how to use larger building complexes as an integrated part of smart cities via technological smart grid functions. The results will be used to develop recommendations on how to construct future buildings and how to improve existing buildings by adding the smart grid technologies.

PROJECT FACTS

Title: Virtual Power Plant for Smart Grid Ready Buildings and Costumers

Financial framework: 9.4 million DKK, ForskEL-programme

Schedule: 2013 – 2016

Project partners: Aarhus Kommune, Alexandra Institutet A/S, Grundfos Holding A/S, Develoco A/S, DONG Energy A/S

Contact: Project Manager Peter Harling Lykke, ply@eng.au.dk

At first sight, people might not think there is anything unusual about the typical apartment building on the waterfront in Aarhus. But they are mistaken. The 12-storey concrete building contains advanced integrated smart grid technology for millions of kroner, and researchers have started a full-scale experiment on balancing the electricity production and consumption



GREEN MAGNETS

- There's a good chance that green magnets could become an energy efficient alternative to electromagnets in the particle accelerators of the future which are used for basic research, manufacture of materials and the treatment of tissue diseases.

ABOUT GREEN MAGNET TECHNOLOGY

Magnets are used everywhere where particle acceleration is required. This can be in very large accelerators for basic research but also to a large extent in smaller accelerators used for modification of materials for the electronics industry or for the production of isotopes for PET/CT scanners.

Green magnets are based on permanent magnet technology and compared to electromagnets they have the advantage of not consuming much electricity and not requiring large water cooling installations.

Electromagnets create a magnetic field by sending electricity through a coil that bends and focuses the particle beam in the accelerator. This is an expensive business and the electricity bill can run into millions.

Green magnets create a magnetic field with the help of rare earth elements that have special, powerful magnetic properties. They can maintain a constant magnetic field without additional energy.

In fact, green magnets can reduce the energy consumption involved in particle acceleration by up to 99 percent. They also take up less space because they do not need to be fitted with massive cables, coils and cooling installations.

In collaboration with the Danish companies Danfysik and Sintex, researchers have spent the past three years developing a so-called green magnet that can replace the energy guzzling electro magnets that we use today.

In both tests and final installations, the green magnets have functioned to full satisfaction. By reducing electricity consumption by more than 75 percent, they can save companies and universities worldwide millions on their electricity bills while at the same time contributing to minimising environmental impact.



▲ ASTRID2 is located at Aarhus University and is one of Denmark's largest particle accelerators. It is powered by strong magnets that have the disadvantage of consuming enormous amounts of electricity. It just recently had one of the very first of the new green magnets installed and successfully tested. It is now able to maintain a constant magnetic field without consuming energy.

Export adventure just around the corner

The latest prototype has been thoroughly tested and the first customer from a market potentially worth millions has already placed an order with Danfysik. The customer is the technical university ETH in Zurich who will use the magnets for radiocarbon dating of archaeological finds.

Aarhus University is also in the process of installing green magnet technology in the ASTRID2 accelerator.

Using magnets in basic research

At the universities, particle accelerators are employed in the most advanced forms of basic research. The particle accelerators contain large, powerful magnets that create a magnetic field and thereby such powerful acceleration that the electrons are propelled to speeds close to the speed of light. Here they emit some very intense short wave light. This light is called synchrotron radiation and is used by researchers to analyse everything from biological systems to nano-technological connections at the atomic level.

In basic research, particle acceleration provides researchers with a technique for acquiring knowledge about the smallest and perhaps the most important components of humans and the world around us.

Using magnets in medical treatment

Magnets are currently used in ion accelerators for radiation treatment in hospitals. They control the tiny atomic particles used in the treatment of many different types of tissue diseases as for example cancer.

The ion accelerator systems currently use large electromagnets and therefore have very high power consumption. At the same time, they are expensive to manufacture and take up a lot of space. With green magnets, you can develop compact ion equipment that are easier designed into departments or hospitals.

PROJECT FACTS

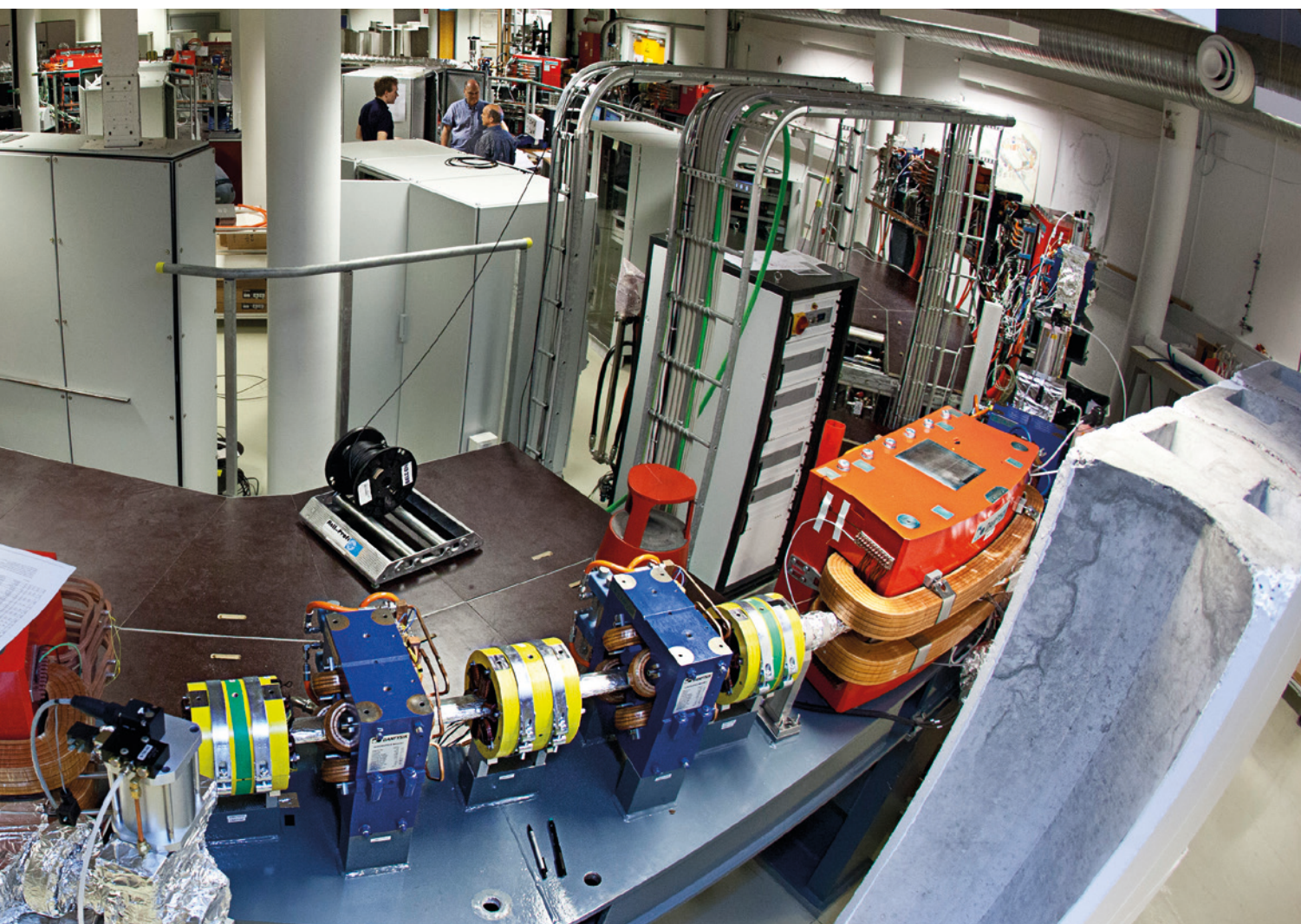
Title: Green Magnets

Financial framework: 18 million DKK, The Danish National Advanced Technology Foundation

Schedule: 2010 – 2013

Project partners: Danfysik A/S, Sintex A/S, ISA Centre for Storage Rings Facilities, Aarhus University, University of Aalborg

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MANUFACTURING RESEARCH

- Many different engineering disciplines will need to come into play in the knowledge collaboration between the universities and companies, if Denmark is to maintain a competitive manufacturing industry.

The Danish manufacturing field is exposed to the growing global competitive pressure. During the last decade in particular more and more companies have outsourced all or part of their production to countries with cheaper labour.

The scientific development within both material and process technology is rapidly moving forward and manufacturing research is today one of the departments new demand-driven research areas. It is an area where research, to a great extent, is financed directly by the companies.

Knowledge must make Companies Competitive

There are high ambitions for the achievements to be made in manufacturing. The aim is for more Danish companies to benefit from state-of-the-art technologies and thereby improve the opportunities for maintaining a competitive, technologically-developed and globalised production within the country.

This requires research across all engineering disciplines. It also requires that the university has a very in-depth understanding of the innovation needs of companies and, at the same time, that we are able to bring highly-specialised skills into play both in multi-national companies with large R&D departments and in small local companies with a speedy development of advanced technology.

Manufacturing is organised as part of our mechanical engineering section and the preliminary external framework is placed in Aarhus University's participation and board activities

in the business cluster DAMRC. We have also entered into the newly established national MADE organisation, where we are involved with the usage of ICT as a part of the manufacturing process.

DAMRC – DANISH ADVANCED MANUFACTURING RESEARCH CENTER

DAMRC is a research and development centre for advanced manufacturing and machining technologies. The core business is to transform the latest knowledge into practical solutions in close collaboration with the universities for the benefit of Danish industrial companies' global competitiveness. The focus is on machining and new materials.



Read more about DAMRC on www.damrc.com

MADE – MANUFACTURING ACADEMY OF DENMARK

MADE is a newly established association linking all Danish universities working within manufacturing with the Danish manufacturing industry with the mission of strengthening the future Danish competitiveness within manufacturing by joining forces on a national scale.



Read more about MADE on www.made.dk



Photo: Aarhus University



The business cluster DAMRC showcases the value of knowledge based collaboration between universities and the industry.

For example one participating company specialised in optimising milling processes has achieved a 30 percent improvement in machining time, and another manufacturing company has gained 15-20 percent reduction of production costs.

CONTACT

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RESEARCHERS SCRUTINISE CRACKS IN COMPOSITE MATERIALS

- Today's computer models can provide detailed information about the strength of constructions under different forms of load. This information is useful input for the design process. But these programmes are often inadequate to deal with a composite material that behaves much differently to a homogeneous material when subjected to stress.

The study of cracks and their significance for the durability of a construction has been going on for decades as classical fracture mechanics. But what actually happens when a modern composite breaks?

In the majority of cases, the problem is found in the joints but we do not have a detailed picture of its causes and effects. For example, how does a crack occur when a single glass fibre separates from plastic? How does it occur when two glass fibres simultaneously separate from the plastic? And what if a collection of fibres breaks? What significance will it have for the construction's formation of cracks under various forms of stress and for its durability?

New theoretical model for the formation of cracks

Researchers from Aarhus University have entered virgin territory. They have already developed an existing theoretical model that can describe a random composite's behaviour during the formation of cracks in two dimensions. Now they are busy expanding the model to three dimensions.



Windmills, tennis rackets, aircraft and windows. These are just some of the examples of where using composites is an advantage. The increasing use of composite products challenges our understanding of classical fracture mechanics. For example, how does carbon fibre react when it is subjected to stress? Researchers are working to develop a theoretical model that will describe the characteristics of materials with a much higher degree of detail than is possible today.



During the next three years, they have to continue feeding data into an existing FEM programme on the fracture mechanics of different composites in different directions during both monotonic and cyclic stress.

If the researchers succeed in developing a preliminary theoretical model, it will be possible for them to describe fatigue in structures far more precisely on the basis of both the formation of cracks and their expansion in the composites. In the future this research has a range of interesting perspectives. It can

both give better perspectives for more precise design processes while at the same time providing basic knowledge about how composites behave.

CONTACT

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PRINTING CARTILAGE IMPLANTS IN 3D

- Cartilage injuries are a growing worldwide health problem. At present there are very few treatment methods, and those that exist are often inadequate. The consequences are pain and discomfort for patients as well as repeated surgeries, which are costly for society. To address this problem, researchers are working to print surgical implants and create new tissue using stem cells. The goal is to develop completely new methods of treatment.

These techniques have worked in clinical trials with rabbits. In a few years, scientists from Aarhus University and Aarhus University Hospital hope to have a completely new method of treatment ready for tissue injuries in humans.

Printing is cheap and efficient

The idea is to build new tissue which can replace damaged areas in the body with the help of so-called mechanical stimulation of stem cells. This means that the implants are designed with specific predefined material properties which can subsequently attract stem cells and stimulate them to grow new cells.

"We print an implant in 3D which in size and shape corresponds to the damaged tissue. The nanostructure of the implant is designed to attract the patient's own stem cells and activate them to create new, specific tissue. The implant then disintegrates as the new, healthy tissue is formed," says Jens Vinge Nygaard, associate professor at Aarhus University.

Scientists have previously had far more advanced and costly methods in play using stem cells which have to be proliferated outside the body prior to implantation. The new printing technology is ground-breaking and significantly cheaper than other regenerative medicine technologies. It can also, in principle, be used to produce bone tissue, fat and skin in a wide range of cases of tissue defects.

In the first instance, the researchers are experimenting with producing cartilage, which could mean that the damaged joints of arthritis patients can be made to function again.

Implant rigidity determines cell type

What is special about the researchers' method for producing artificial tissue is that it is based on new materials technology. Surprisingly enough, the rigidity of the material for the implant turns out to be crucial in determining what type of tissue and cell structures are formed by the stem cells.

This discovery makes it possible to adjust the mechanical properties of the implant – for example how porous or compact it must be – and then print it on a 3D printer so that it matches the individual patient's specific tissue damage.

The researchers from Aarhus University and Aarhus University Hospital are working closely with two Danish biotechnology companies to bring the research results closer to a clinical practice so the technology can be commercialised.

NEW METHODS OF PRODUCING ARTIFICIAL TISSUE

The principle of using the form and mechanical properties of the material to stimulate stem cells is a fundamental change within tissue engineering.

It is possible to adjust the mechanical properties of the implant material and thus grow different types of tissue. Scientists will start by focusing on restoring cartilage.

PROJECT FACTS

Title: CartigenPro

Financial framework: 14 million DKK, The Danish National Advanced Technology Foundation

Schedule: 2013 – 2017

Project partners: Davinci Development A/S and LevOss ApS

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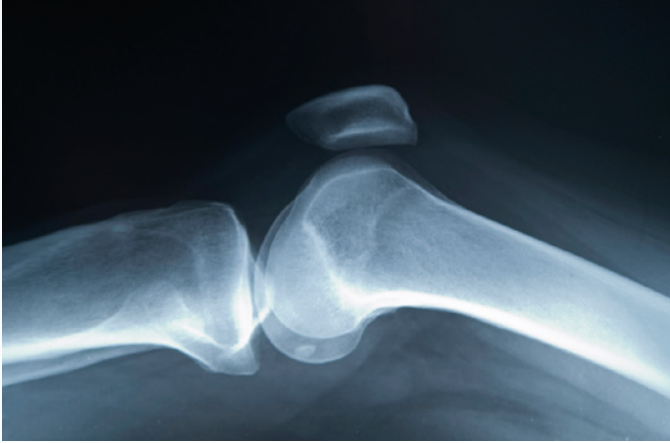


Photo: Colourbox

Age-related damages in the locomotor system have taken the lead as the fastest-growing health problem in the European population. Now researchers are a step closer to finding a new treatment method that catches attention far beyond the borders of Denmark. They will print surgical implants and create new tissue by means of mechanical manipulation of stem cells.



- ▼ Researchers at work on a new method of producing artificial tissue. The photo shows Associate Professor Jens Vinge Nygaard next to a specially constructed machine designed to test the mechanical properties of surgical implants. His research focus is bio mechanics and materials engineering, and he has discovered how it is possible to stimulate the growth of different types of cells by regulating the rigidity of the printing material.

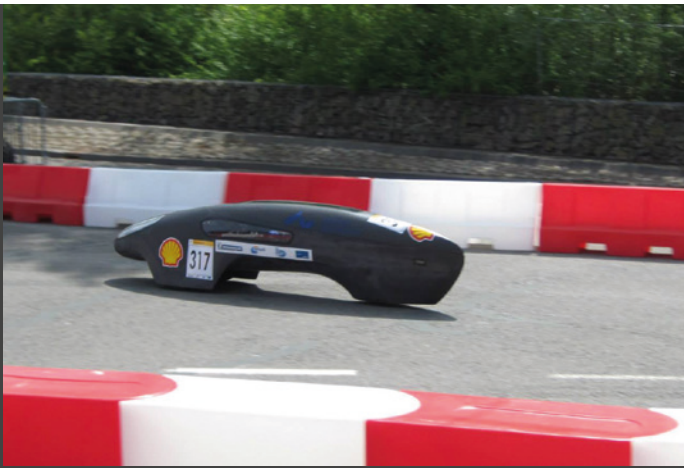


5900 KILOMETRES ON A SINGLE LITRE OF PETROL

- How far can you get a car to run on the equivalent of a single litre of petrol?

This is the annual challenge of the Shell Eco-marathon international race. Aarhus University participated for the first time in 2013 and achieved an overall fifth place.

- Zenith 33 is the name of the car built by researchers and students at Aarhus University. It managed to run 5900 kilometres on the equivalent of one single litre of petrol at the Shell Eco-marathon 2013.



It was a baptism of fire for the group of engineering students from both AU Herning and the Department of Engineering who made up Team AU. A single semester - that was all they had to prepare for Aarhus University's first ever participation in the Shell Eco-marathon.

They started with a general idea, then toiled in the workshop on the design and construction of the extremely efficient vehicle for hundreds of hours before managing to get the car ready at the very last minute. The first test run took place around a parking lot near the track in Rotterdam.

Fortunately Zenith 33, as the car was christened, surpassed all expectations in its class for battery/electric vehicles. It drove a total of 661.80 kilometres per kilowatt hour (kWh), which converts to an efficiency of approximately 5900 kilometres on a single litre of petrol.

Team AU achieved an overall fifth place out of 224 teams from 24 countries.

CONTACT

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ZENITH 33

The car is a self-supporting construction made of carbon fibre which provides greater rigidity and strength in relation to its weight:

- The vehicle's size and shape are the result of a compromise as both weight and air resistance affect performance. Greater length gives a low air resistance coefficient but also more surface area and weight
- Zenith 33 is 2.90 m long, 0.57 m wide and 0.65 m high. The bottom of the car is raised approx. 0.15 m above the ground as this provides lower air resistance
- The driver lies almost completely flat to reduce air resistance.
- Zenith 33 has two front wheels and a rear wheel and integrated solar panels on the roof
- The wheels are light carbon fibre disc wheels with ceramic bearings. They weigh less than wheels with spokes and have a lower air resistance during rotation

ZENITH 33 VERSION 2.0

In the all-new 2014-version, Zenith 33 version 2.0 will be equipped with two motors instead of one: a very small high-efficiency electric motor for driving with a constant speed and a larger motor that only starts running in connection with acceleration.

In total it will be 10 kg lighter which combined with a number of technical improvements will reduce the car's air resistance by 33 percent compared to the 2013 model.



CANCER DIAGNOSIS WITH A SIMPLE BLOOD SAMPLE

- Researchers from Aarhus University are among the world leaders when it comes to developing antibodies for cancer therapy. In the long term, this technology may have a major impact on both diagnostics and treatment. A simple blood sample that can identify the type of cancer cell is one of the examples of the potential applications of the research.

Researchers are well on the way with the development of a so-called micro-fluid chip which will make it possible to isolate cancer cells from healthy cells in a blood sample. If they succeed, this will be a breakthrough for the diagnosis and treatment of cancer.

A blood sample from a cancer patient contains several billions healthy cells and only a few cancer cells. The fundamental challenge is therefore to capture the sick cells, isolate them and transfer them to the laboratory so that it is possible to investigate which treatment will be required to eliminate them.

Chip will capture cancer cells

The researchers have achieved the first promising results, and they expect to have a new method ready within three years that ultimately will form the basis of a far more differentiated diagnosis and treatment of cancer patients than the one we know today.

The key to realising this promising scenario is a small chip that is able to bind the cancer cells on its surface and give the researchers access to study them closely in the laboratory. A close study of the cells can provide the doctors with information about both the type of cancer and how advanced it is and thereby make it possible to tailor optimal treatment for the individual patient.

The chip works according to a simple principle. It contains a canal with fluid through which the patient's blood is injected. There are special antibodies on the inner surface of the canal that are able to capture the cancer cells in the sample. This aspect already functions, and the researchers are now working to generate the most specific and relevant antibodies to be added to the surface of the micro-fluidic chip.

Milestone for cancer diagnostics

Today cancer is usually diagnosed by means of a tissue sample from a tumour. The treatment often consists of an operation and chemotherapy.

In the future, this practice could look very different. With the researchers' micro-chip, doctors will be able to diagnose cancer much more precisely and at a much earlier stage with a simple blood sample. It also has the advantage of being able to ascertain when all of the cancer cells are gone. This will make it possible to avoid unnecessary chemotherapy, explains Associate Professor Peter Kristensen: "With this new technology, it will be possible to diagnose cancer by means of a simple blood sample. As a matter of routine, doctors will be able to characterise the sick cells, design an optimal treatment and follow how the patient benefits from this treatment. Furthermore, it is much easier to avoid unnecessary chemotherapy."

In many cases today, doctors offer patients chemotherapy after a cancer operation in order to be on the safe side and avoid metastasis.

First prototype ready in a few years

The researchers expect to have a complete prototype of a fluid chip that is able to select the dangerous cancer cells from blood samples ready within just three years.

However, it will take longer before patients can benefit from the technology. First it must be optimised for different types of cancer and production costs also need to be reduced.

PROJECT FACTS

Title: Single Cell Proteomics

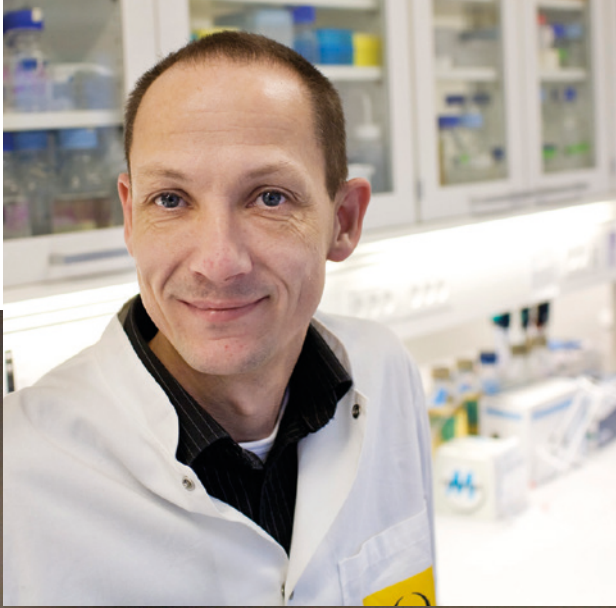
Financial framework: 5 million DKK, Danish Council for Independent

Schedule: 2012 – 2015

Project partners: The University of Cambridge, the Technical University of Denmark, Bispebjerg Hospital, Rigshospitalet

Contact: Associate Professor, Peter Kristensen, pk@eng.au.dk

Photo: Aarhus University



Associate Professor Peter Kristensen published a new method for the selection of artificial antibodies aimed at cancer cells in 2011 in the journal *Nature Protocols*. Today he is building on the existing results to develop a so-called fluid chip that some day will be used to screen blood in daily practice in oncology departments.

Photo: AU Archive

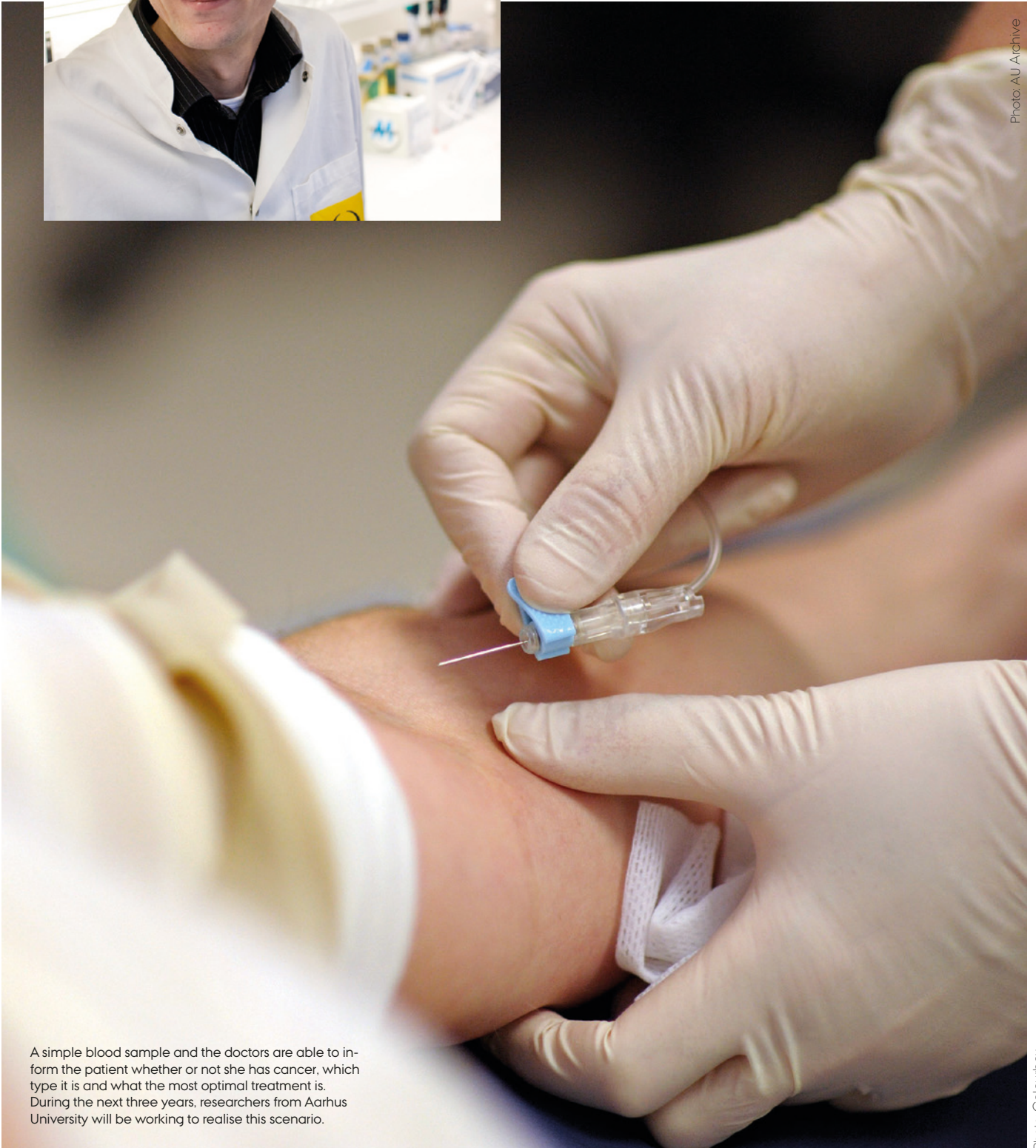


Photo: Colourbox

A simple blood sample and the doctors are able to inform the patient whether or not she has cancer, which type it is and what the most optimal treatment is. During the next three years, researchers from Aarhus University will be working to realise this scenario.



Photo: Aarhus University

It looks like a very thin piece of plastic, but in reality it is an ion conducting membrane which is currently being used in e.g. fuel cells. What is special about the small piece of plastic lying on the table in the chemistry laboratory at Aarhus University is that it has been extensively studied by a small group of researchers over the last few years. They hope that they now have identified a new method for the conversion of energy with a very low loss of energy.

A detailed examination

With specially designed equipment, the researchers have carried out detailed studies of the membrane's properties for the conversion of energy. The study includes electrokinetic conversion where pressure is converted directly into electricity through the membrane or vice versa where electricity is converted into pressure.

A number of parameters affect the efficiency of these energy conversion processes, and the research group has now mapped the properties of ion conducting membranes that are important for obtaining high conversion efficiencies.

The first tests show that the membrane can be optimised to an efficiency of up to 20 percent. This exceeds by far the previous maximum measured efficiency of five percent in silicon-based nanopores.

Membrane-based gas compressor for cooling

One of the major advantages of electrokinetic energy conversion is that it requires no moving parts in contrast to e.g. pumps with motors. For this reason, membrane-based energy conversion systems can compete on both price, efficiency and reduced environmental impact, especially in small systems.

The technology is therefore of commercial interest in a num-

NEW AND EFFICIENT ENERGY CONVERSION IN MEMBRANES

- The latest research findings show that membranes can be used for conversion of pressure into electrical energy with high efficiency. In the long term, this could be the key to more efficient and cost-effective energy conversion.



With custom designed equipment, the researchers are able to map the membrane's properties. This is important for its ability to convert energy from pressure into electricity and vice versa. The photo shows Postdoc Jacopo Catalano in the laboratory.

An ion conducting membrane is often associated with fuel cells or electrical seawater desalination, but the technology has the potential to provide cheap and efficient cooling. Researchers have described the properties of a new type of membrane which can be used for gas compression in fridges and elsewhere.

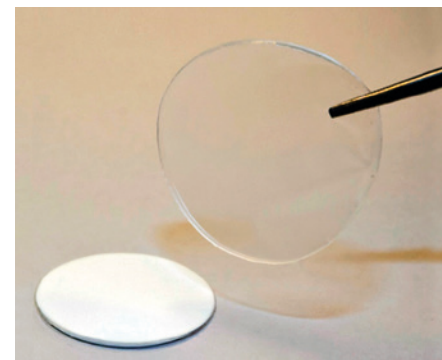


Photo: Aarhus University

ber of different applications. This could be as an energy supply for homes where solar panels can be used to heat a liquid and thereby generate pressure that can be converted into electricity. Or it could be used in relation to cooling. The research group is in the process of developing a membrane-based energy conversion system for gas compression as a substitute for mechanical compressors.

Cheap, simple and efficient

Membrane technology may prove to be cheaper, simpler and far more energy efficient when it comes to cooling in smaller systems such as refrigerators. Working with the existing membranes on the market, the researchers have already achieved remarkable results with electrokinetic energy conversion. By optimising the properties of the membranes, they expect to be able to considerably increase the conversion efficiency.

However, it will take some years before the technology has matured for commercial use.

PROJECT FACTS

Title: Investigations of the membrane thermoelectric effect for solar-heat powered hydrogen production and AU-AUFF Pilot Center: Basic and applied studies of novel membrane materials and processes.

Financial framework: 7.8 Million DKK and 5.5 Million DKK , Villum Foundation and Aarhus University, Research Foundation

Schedule: 2012 – 2017

Project partners: Norwegian University of Science & Technology, Max Planck Institute for Chemical Physics of Solids, Germany

Contact: Associate Professor, Anders Bentien, bentien@eng.au.dk

LIPIDS FOR ALL PURPOSES



- Chefs cannot do without them. Neither can the pharmaceutical, cosmetic and chemical industries. Lipids are an integrated part of our lives and researchers from Aarhus University are busy designing new types.

Aarhus University has one of the world's most recognised laboratories for research in lipids. In recent years, a range of multi-disciplinary research projects have arisen here, conjoining classical basic research in chemistry and biology on the one hand and modern process technology on the other.

The research activities in the laboratory mesh with the business community's innovation requirements and are to a great extent driven by demand, explains the lab's daily manager Zheng Guo:

"Our research focuses on applications and always has a link to a company that will produce something for the market. We develop many new technologies that can be used in industrial processes and production."

The central research areas comprise lipid processing technology, bioresource technology, microbial technology and enzyme technology. With a number of prestigious articles in international journals, the laboratory has generated a high level of global interest in just a few years. The perspectives for applications of the newest lipid technology are very good and address industrial challenges such as food safety, green energy, nutrition and disease prevention.

Multi-functional encapsulation of fish oil

One of the many projects they are working on is the development of a natural antioxidant that can prevent oxidation of fish oil in dietary supplements and thereby protect the content of Omega 3 in them. The researchers have identified different types of encapsulation material which can, via a special composition of antioxidants, neutralise free radicals and help the active substances from the oil pass through the cell membrane and into the bloodstream so that they are better absorbed in the body.

The method is based on enzyme technology that optimises the physical and chemical properties of the antioxidants. Laboratory experiments have also shown that the antioxidants in the fish oil capsule have the positive effect of increasing shelf life and that the taste of fish is better disguised.

An alternative to phthalates

Castor oil has proved to be an excellent means of softening plastic and can thus replace the phthalates that are suspected of causing hormone disruption in humans and animals. Soft-N-Safe, which is produced by DuPont Danisco, is now used instead of phthalates in both toys, medical equipment, cling film and much more.

Unfortunately, it is also an expensive alternative as castor oil is extracted from the seeds of the castor oil plant (*ricinus communis*) which cannot be sufficiently cultured and supplied. Working with researchers from Aarhus University and others, the company has now developed a new and cost-effective plasticiser as an alternative to already known plasticisers. It is based on high oleic rapeseed oil and can be produced efficiently on a laboratory scale. It will, however, require some years of further development and testing before the substance will be suitable for production on an industrial scale.

LIPIDS

Lipids are a group of organic substances that are insoluble in water but soluble in a range of organic solvents and fats.

With such a broad definition, it is hardly surprising that the group comprises many different compounds, including fatty acids, triglycerides, wax, phospholipids, ceramides, cholesterol and other steroids, fat-soluble vitamins and terpenes.

These organic compounds can be divided into a multitude of sub-groups; fatty acids are further categorised as saturated, monounsaturated and polyunsaturated, as well as short chain and long chain fatty acids.

CONTACT

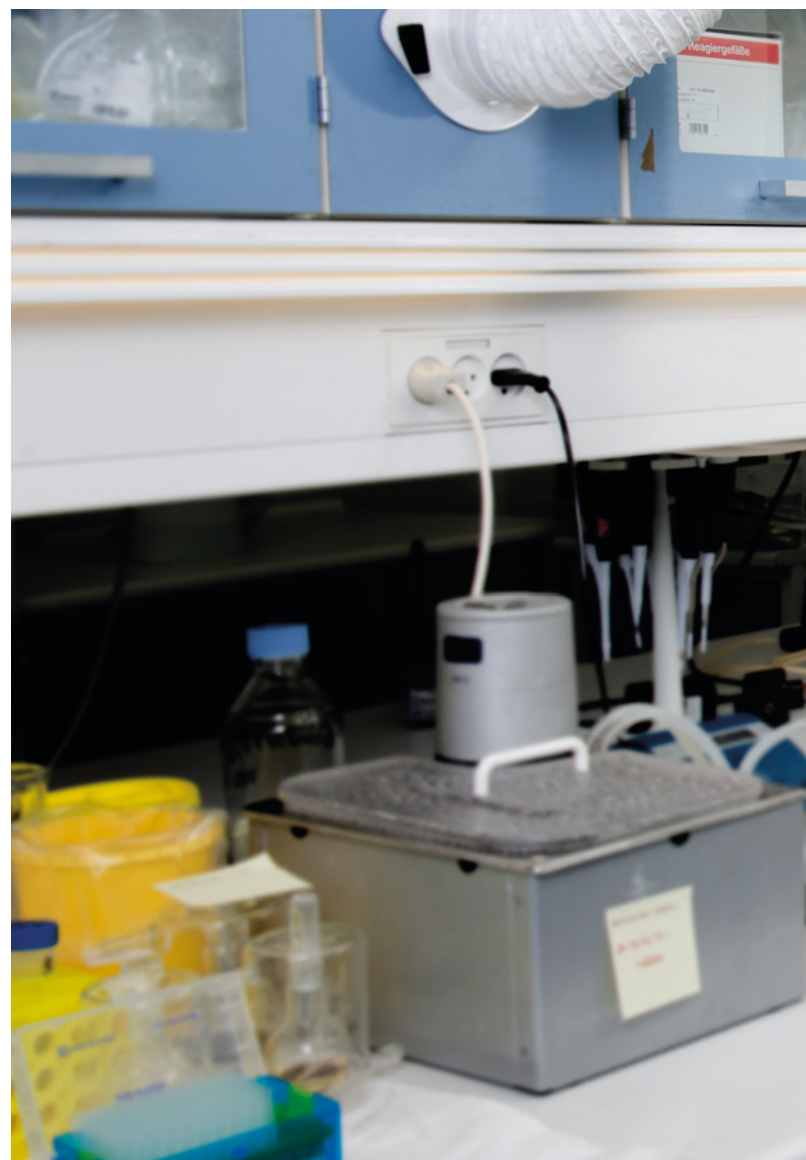
Associate Professor Zheng Guo, guo@eng.au.dk

◀ Associate Professor Zheng Guo is the daily manager of one of the world's leading laboratories for research in lipids. Here researchers are busy designing new types of lipids with new functionalities.

NEW CHOLESTEROL LOWERING SUBSTANCE

■ Plant sterols from e.g. fruit and vegetables hold the key to reducing blood cholesterol.

But the natural content in a typical diet is far from sufficient. In the laboratories at Aarhus University, a young researcher has succeeded in producing a new, highly concentrated and easily absorbed substance with the same beneficial characteristics.



Around 400 tomatoes, 200 carrots or 150 apples – this is how much you need to eat to get the optimal cholesterol lowering effect via the natural content of plant sterols in your food. Therefore, researchers have spent decades working on the development of new chemical syntheses of plant sterol derivatives. Today almost all supermarkets in the West have a selection of good, functional food products that promise to reduce consumers' blood cholesterol level.

The problem is that these products can be expensive. The chemical production of plant sterols is often based on expensive chemicals and usually requires a large amount of energy over a rather long reaction time.

Detective work in the laboratory

To solve these problems, a researcher at Aarhus University decided to try and develop a new, more effective and economically viable substance. Two years later after several hundred test reactions between a large number of different plant sterols, fatty acids and amino acids, she has discovered something that is attracting the attention of the functional food industry.

The new substance is both cheaper and more sustainable to manufacture compared to the known chemical variations of plant sterols. Also, it has a reaction time of just 12 hours, a very low consumption of activation energy during the creation process and a 90 percent utilisation of the substance from the reaction.

Better absorbed by the body

While natural plant sterols have low solubility and therefore are difficult for the intestines to absorb, the new synthetic substance has a molecular structure that ensures that the body has optimal access to it.

"A large part of the natural plant sterols pass through the digestive tract. The new substance is merely synthesised plant sterol with a molecular structure that significantly improves absorption in the body," explains Worawan Panpipat.

She has developed the substance in two synthesised variations. One that is soluble in fat and one that is soluble in water. In this way, it is possible to enrich more types of foods such as soft drinks and dairy products.



Photo: Aarhus University

Defeats dangerous cholesterol

Excessive amounts of cholesterol in the blood expose many people to cardiovascular diseases which are among the most frequent cause of death today. This is because cholesterol can be deposited in the blood vessels when the body contains too much of it.

If the new substance makes it to the market, it can be a real alternative to medical treatment of one of the world's greatest health problems. It works by outperforming the dangerous cholesterol in the battle to be absorbed by the body:

"The new substance binds to the limited number of cholesterol transporters in the cell wall of the intestines and it therefore seems to be able to prevent the so-called bad LDL cholesterol from being absorbed in the body", explains Worawan Panpipat.

Studies have shown that two grams of plant sterols per day lower the content of the bad cholesterol in the blood by around 10 percent. This corresponds to reducing the risk of heart disease by around 20 percent

- ▲ After several experiments in the lab, Worawan Panpipat, a PhD student at the Department of Engineering, has identified a new chemical super compound that has a cholesterol lowering effect. She has just received the International AOCOS (American Oil and Chemists' Society) award for her research.

CONTACT

Associate Professor Zheng Guo, guo@eng.au.dk

A MAJOR BIOPRODUCTS ADVENTURE

- Non-food plants and plant residue can be used for more than just fuel. In addition to fuel, you can produce chemical building blocks for production of plastics as well as high-protein animal feed.

Aarhus University is participating in a new, large research initiative together with other Danish universities and leading companies. Within five years, they will create the knowledge required to strengthen the preconditions for producing a range of green products that are currently either imported or extracted from fossil fuels.

These products could include e.g. new sources of protein for animal feed and raw materials for many different chemicals

and polymers. The biomass from which products must be extracted consists of crop residue, straw, grasses and other plant matter that do not compete with food production.

The research initiative has a budget of historical proportions – DKK 160 million. The aim is to create the technological progress that will enable Denmark to convert to a bio-based society and utilise the full potential of plants.

Every year, Europe imports huge amounts of soya based feed for animals. But is it possible to convert simple grass to digestible high-protein nutrition and thereby partially become self-sufficient?



Pretreatment of biomass is essential for a number of biomass technologies. A promising technology is extrusion where several process steps can be carried out in one instrument.



PROJECT FACTS

Title: BIO-VALUE SPIR

(Strategic Platforms for Innovation and Research)

Financial framework: 160 million DKK, The Danish Council for Strategic Research and The Danish Council for Technology and Innovation

Schedule: 2013 – 2018

Project partners: University of Copenhagen, Technical University of Denmark, Aalborg University, Arla Foods, Hamlet Protein, KMC, Kongskilde, DLG, Haldor Topsøe, Novozymes, Rockwool, Borregaard, Danish Agriculture & Food Council, Agrotech and Inbiom.

Contact: Senior Researcher Anders Peter Adamsen, apsa@eng.au.dk



Photo: Hamlet Protein



FROM GRASS TO HIGH-PROTEIN ANIMAL FEED

When you produce bioethanol, there is the possibility of utilising the plant material to produce animal feed. Grasses and other perennial species of plant contain proteins that can meet the needs for amino acids of most large mammals. The challenge for research is to optimise the separation of the biomass into various components and remove those parts of the plants which are indigestible and which inhibit absorption of protein in the body.

The feed must be manufactured from fresh leaves in order to extract high-quality proteins. They can subsequently be upgraded and used as feed for calves, piglets etc.

Aarhus University has unique facilities for biomass production in Foulum as well as many hectares of land where it is possible to experiment with the cultivation of new crops with optimised properties for animal feed.

Furthermore, with existing facilities for production of feed and livestock as well as world class research in animal nutrition, it is an ideal place to establish a pilot plant for production of protein from green biomasses.

The researchers have already started on the first experiments though the technology will not be commercially ready for a number of years. However, it could then be a real viable alternative to imported soya feeds.

EU countries currently import more than 45 million tonnes of high-protein feed, which accounts for 70 percent of total requirements. The impact on the climate from the production and transport of the animal feed currently used is enormous. A greater degree of self-sufficiency will therefore make a positive contribution to Denmark's environmental accounts.

DRIVE USING MANURE AND FLY USING WOOD

Hydrothermal liquefaction or bio-refining has the potential to become one of the most important energy technologies of the future. It is pivotal in the work being done to develop new methods for producing biofuels and in the conversion of organic materials into products that are presently extracted from fossil fuels.

Researchers from Aarhus University have developed a groundbreaking new process that effectively transforms all kinds of biomass into bio-crude oil that is comparable to crude oil from fossil fuels in all practical respects.

The method is able to exploit 85-90 percent of the energy content in the biomass, which is better than any known technology can achieve. What is more, it is not more expensive.

At the same time, the bio-fuel can be processed relatively easily into diesel, petrol or aviation fuel using the oil industry's existing processing plants, or it can be used without further processing as e.g. bunker fuel in ships. Thus it is not necessary to adapt engines or use additives in the fuel to be able to use it in the transport sector.

The technology also has the advantage of being able to immediately process humid and wet biomass, which forms by far the majority of green resources found on earth such as sludge, fertiliser, wood and straw.

During the next few years, the method will be further developed and the production of oil will be tested in a planned pilot plant at AU Foulum.

DRONE SPOTS GAME IN THE FIELD

- The number of animals killed by machinery on agricultural land is going to be reduced with the use of drones, cameras and algorithms. Researchers at Aarhus University are behind a project that has great potential for both animal and farmer.

Every year thousands of deer, hares and pheasants die in the fields when they get run over by large farm machinery at harvest time. In particular, the accidents occur during the summer when the animals migrate to the edge of wooded areas. But according to the first results from an Aarhus University project to monitor deer, the problem can be greatly reduced by using drones equipped with thermal cameras.

Advanced algorithms are lifesavers

In partnership with two companies, researchers have conducted the first flights over agricultural land using a drone equipped with a thermal camera. In one of the flyovers, the drone managed to find two roe deer fawns despite only covering a few hectares of land.

The prospects for using drones to monitor game are substantial, explains the project's anchorman, Senior Researcher Rasmus Nyholm Jørgensen:

"In the future we will be able to provide a solution for the farmer where wildlife in the field will be pinpointed with great accuracy. The problem today is that the animal will usually lie flat on the ground when an agricultural machine is approaching. Therefore it is extremely difficult to detect the animal and prevent a collision. Even for a hunter with a trained dog, it is an almost impossible task."

He also points to another problem related to wildlife killed in the field, which is that of food quality. The game may be infected with disease-carrying bacteria and contamination of the harvest can lead to bacterial poisoning for whoever ends up eating it.

Bacteria in forage grasses involve a risk of infecting entire cattle herds.

Stressful accidents

Another negative consequence of the many collisions is that the experience is often very unpleasant for the driver of the machine.

"The animals are hit by large agricultural machines that may be driven by an 18-year-old young man who subsequently has to go out to deal with the animal and maybe finish it off. It is bound to affect you psychologically," says PhD student Kim Arild Steen.

Researchers at Aarhus University have recently been looking for solutions to minimise the number of animals run over by agricultural machinery in the field. With the latest use of drones, there is now a good chance of finding an optimal solution that can alleviate the problem of so many animals being killed.

"The advantage of using drones is that an aerial scanning can be very fast. We can already monitor large areas in a very short time," explains Rasmus Nyholm Jørgensen.

Cameras detect body heat

Although researchers have made great strides towards finding a suitable solution, Rasmus Nyholm Jørgensen recognises that there is still a long way to go before they have a market-ready product.

"We have developed algorithms that are capable of detecting the presence of animals in the photos from the thermal camera. However at this relatively early stage of development, we still have problems in distinguishing between objects in the field that have been warmed by the sun and animals that emit heat. Our ambition is to develop a system that is able to distinguish between animals and other objects," he explains.

Rasmus Nyholm Jørgensen hopes that the project will help lead to a workable solution, ultimately reducing the number of animals killed on agricultural land.

"Many farmers experience these fatal situations and would really like to solve the problem. And we would really like to help them and believe that we can do so," says Rasmus Nyholm Jørgensen.



Photos: Aarhus University

▲ An advanced drone is able to monitor wildlife in the field and solve the problem of the many animals killed by agricultural machinery each year.

▲ Here is the drone which uses a heat-seeking camera to detect wildlife from the air.

HOW THE DRONE SPOTS ANIMALS IN THE FIELD

The drone is equipped with a heat-sensitive camera. From the air it is able to detect body heat, for example from game.

The researchers have developed the algorithms that can detect the presence of animals via the camera readings.

Now the challenge is to develop the algorithms that will allow the drone to tell the difference between objects in the field that have been warmed by the sun and animals lying in the grass.

CONTACT

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Project partners: Natur og Landbrug, Sky-watch



Photo: Aarhus University

Driverless tractors programmed to drive with a minimum overlap in the fields give less strain on the soil and a reduced fuel consumption of around 10-15 percent. This is one of the scenarios for farmers if they utilise their intelligent machines more optimally.

In recent years, researchers and companies have come a long way in working to produce intelligent solutions for the large machines employed in the agricultural sector. These solutions make it possible for the machines to communicate with one another and with other systems. This can mean, for example, that a tractor will automatically receive relevant knowledge about the condition of the soil and will be able to act on this. At the same time, the tractor receives messages from other tractors that either are working or have worked on the same field, thereby avoiding overlapping field operations.

Prototype on the way

The potential for a more effective utilisation of agricultural machines is huge and there are many environmental and economic gains to be made, particularly in the work out in the fields which is one of the agricultural sector's major expenses. Here the huge combines and tractors are both expensive to procure

and operate because they require many man-hours behind the wheel.

The prototype for an intelligent planning system that can get the agricultural machinery to operate in an optimal manner is in the pipeline, and according to researchers, it will be ready for implementation in the agricultural sector within a few years. When this happens, it will result in an immediate and significantly improved optimisation of the agricultural machinery's driving pattern.

The farmer of the future sits behind a desk

The next phase in the development of the intelligent systems is to connect them together so that the individual agricultural machines involved in the operation in the field function as a single device where each of the machines knows the roles and tasks of the other machines.

The work being done in the fields may therefore look quite different in the future. The technology makes it possible for a single operator to handle a whole fleet of combines, tractors and other vehicles from an office far away from the field.

Via a computer both driverless and manually operated agricultural machinery can be informed automatically of the task

AGRICULTURAL MACHINERY WITH COMPUTER BRAINS



- Researchers from Aarhus University develop intelligent and highly specialised solutions for optimising how agricultural machinery navigate in the field. The use of computer-controlled agricultural robots has been shown to reduce both the strain on the soil and fuel consumption in the sector. Large multinational manufacturers of agricultural machinery are on the verge of implementing the new technology in their product development.

ⓘ A more efficient utilisation of the agricultural sector's agricultural machinery can lead to major economic and environmental savings. In recent years, researchers have made significant progress in developing computerised brains for everything from tractors and combines to fertiliser distributors.

they are to perform and the route that is the most expedient for them to take. The computer also collects information on e.g. previous crops, nutrients and special circumstances for that field which may mean that the soil should be handled in a specific manner to optimise the yield.

Intelligent control protects the soil from machine loads

Intelligent control systems also optimise material handling operations like manure application. The heavily loaded manure spreaders will only be set to operate in areas where the field is best able to withstand the Load.

As the vehicle gradually empties, it will be directed to areas of the field that are more vulnerable because of previous damage as a result of pressure from the agricultural machines or as a result of the inherent texture characteristics of the soil.

The intelligent systems can also be used when harvesting the fields. The combines are sent out to work their way through the crop while other transport vehicles is kept ready for when the combine's tank needs emptying. Here, the system can calculate exactly where the harvesting equipment should be positioned and thereby avoid wasting time.

PROJECT FACTS

Title: GrassBots and GeoPal

Financial framework: 0.6 million EUR, ICT-AGRI and EU's 7th Framework Programme for Research and Central Denmark Region

Schedule: 2012 – 2015

Project partners: University of Southern Denmark (SDU), DK; Harper Adams University College, UK; Aalto University, Finland; Agro Business Park, DK; Kongskilde Industries A/S, DK; Conpleks Innovation ApS, DK; Lynex ApS, DK; MTT Agrifood Research Finland; Bertelsen Design, DK; CLAAS Agrosystems AG, Germany; LACOS Computerservice GmbH, Germany; Landwirtschaft, Energie an Umwelt Sàrl, Luxemburg.

Contact: Senior scientist Claus Aage Grøn Sørensen, claus.soerensen@eng.au.dk

COMPUTER MODEL BRINGS FIELD TO THE FARMER'S DESKTOP



▶ Tavs Nyord heads an industrial postdoc project, the purpose of which is to develop computer simulation methods that can describe soil movement and draught forces during soil tillage.

- With the help of computer modelling researchers try to describe how individual soil particles react when the field is cultivated by agricultural machinery. They hope that the technology can be used as an alternative to practical field experiments in the process of designing new agricultural machinery.

How do soil particles in a field react when agricultural machinery is used for soil tillage? The answer can be found with the help of a computer model that simulates how the particles move individually and in relation to one another. At the same time, information about the force transferred to the machine can be estimated and used in the design of new equipment.

So far the researchers have tested the method to analyse the soil cutting forces and how the soil is moving during injection of slurry in three selected types of Danish soils.

The computer model can be very important in the development of new agricultural machinery and tools for a more effective and sustainable food production. Knowing how the soil reacts to external forces provides a good prerequisite for optimising the preparation of the soil and thereby the crop yield.

THE WORLD IS WAITING FOR MORE EFFICIENT FARMING

The number of people in the world increases together with average prosperity, which in turn leads to increased pressure on the supply of food. At the same time, there is a growing demand for biomass for energy production and in order to meet the global demand for agricultural products, it is necessary to make plant production more efficient rather than appropriating an even larger area of land for cultivation.

A critical factor for the efficient production of foods and biomass is that the working of the soil is energy efficient and has a high quality. Researchers from Aarhus University are in front when it comes to procuring knowledge for the development of machinery and tools for working the soil.

Bringing the field to the desk.

As part of an industrial postdoc project, the researchers will develop a computer model that is able to predict the soil cutting force during different kinds of soil tillage in soils from different geographical locations.

The three types of soil are placed in a so-called semi field facility in which a slurry injector is driven in.

The data from the soil moving measurements and the soil cutting forces are entered in the computer model which then visualises what happens to the soil under the actual conditions.

How the computer model works

For example, the model can indicate how the soil particles “fall down” after the slurry injector tine has been driven through the soil. It is possible to see whether the soil covers the slurry depending on different working depths, water content, texture etc. and assess whether it is possible to place the slurry less deeply in the soil and thereby reduce ammonia and odour emission from the slurry effectively.

Computer-based visualisations can in many cases replace the existing physical trials and thereby reduce cost and time in improving the design of new machinery.

PROJECT FACTS

Title: Distinct element method modelling of soil-tool interaction and soil movement during tillage

Financial framework: 1.8 million DKK, Industrial Post-Doc with Kongskilde Industries and The Danish National Advanced Technology Foundation

Schedule: 2012 – 2014

Project partners: Kongskilde Industries A/S and National Advance Technology Foundation

Contact: Assistant Professor Tavs Nyord, tavs.nyord@eng.au.dk

REDUCED ODOUR FROM PIG FARMS

- An innovative new ventilation system will help Danish livestock production to cope with more of the environmental challenges that the industry is facing.

A better indoor environment for employees in the pigsties, a considerable reduction in emissions and the development of an effective biological air purification method with large national and international market potential.

These are the very promising ambitions for a new research project with participation of researchers from Aarhus University who are working on biological air purification for pigsties in combination with a new ventilation principle, so-called local exhaust ventilation, that draws odour from manure out through the floor under the pigsties.

Under-floor air evacuation

Local exhaust extraction from the floor in combination with biological purification make it possible to get rid of large amounts of ammonia and odours from the pigsties in an effective and inexpensive way while, at the same time, reducing the volume of waste water which is today associated with cleaning.

Instead of cleaning all the air in the pigsty, the researchers concentrate on ammonia and odours which are given off in the slurry channel and therefore can be captured in a ventilation flow that only consists of 10-20 percent of the total amount of ventilation.

At the same time, the combined purification and extraction technology can reduce the nuisance caused by odour for the surroundings by up to 80 percent.

No more stench of manure

The method is particularly effective in removing the gas hydrogen sulphide which is one of the most important causes of the nasty smell from pigsties. So far this has been a complicated process if costs are to be kept at a realistic level. But it looks as if the new method can promote oxidation of the hydrogen sulphide so that the total environmental impact from livestock production is reduced significantly.

SMART VENTILATION

The ventilation system combines mechanical floor ventilation with natural ventilation in a new hybrid system that provides a better indoor environment in the pigsties. This benefits both the animals and humans while at the same time reducing the nuisance caused by odour for the surroundings. The systems are being developed in a way that will consume less energy overall while ensuring that the animals receive fresh air.

Part of the system's ventilation air is delivered directly into the animals' inhalation zones and is then evacuated down through the slated floors. In this way, the majority of ammonia is collected, which reduces the air demand and thus also the energy consumption of the ventilation.

PROJECT FACTS

Title: BioPunkt and SmartVent

Financial framework: 6.9 Million DKK and 1.9 Million DKK, GUDP Grønt Udviklings- og DemonstrationsProgram and The Danish National Advanced Technology Foundation.

Schedule: 2013 – 2016 and 2012 – 2014

Project partners: The Danish Pig Research Centre, Danish Technological Institute, SKOV A/S and Agrifarm A/S

Contact: Associate Professor Anders Feilberg, af@eng.au.dk



Photo: Aarhus University

▲ Researchers at Aarhus University are leading a project on biological air purification for pigsties in combination with local exhaust ventilation. The hope is to reduce the nuisance caused by odour from pig farms significantly.



Photos: Aarhus University



THE ANIMAN SCARECROW

A small flock of rooks is airborne to scout for food for the hundreds of other rooks at home in the breeding colony. They spot a field of strawberries and get ready to land as rooks love strawberries. In fact, the large black birds are amongst the strawberry grower's worst enemies.

But just as the flock gets ready to land and taste the delicious food, a well-known sound echoes through the air and causes the rook patrol to panic and flee. The well-known sound is actually the sound of rooks as they panic and flee.

That the sound does not come from the flock itself but from a speaker connected to a computer in the field below is something they do not notice.

Even if the rooks decide to land anyway – and maybe to even ignore the scarecrows' warning in their own language to leave the area again, the computer still has an "arsenal" of other sounds that will surely frighten off the unwelcome guests. This includes sounds such as dogs barking, gunshots, birds of prey shrieking etc., and the clever thing is that the computer itself decides when it is time to change its bird scaring tactics. It does this by constantly listening to whether the birds react as intended to its stimuli.

SCARECROWS THAT SPEAK BIRD

- Researchers from Aarhus University are behind the development of an intelligent scarecrow which can prevent large flocks of birds from landing on fields and eating the crops. This solves a very large economic problem in the agricultural sector.

Every year giant flocks of birds land on the fields all over Denmark and devour large parts of the yield or destroy grazing areas. This leads to considerable financial losses for the farmers who cannot do very much to prevent it from happening.

But now it looks as if researchers have discovered an effective, intelligent system to scare the birds away. With the help of speech recognition technology, the system senses the presence of the birds based on their sounds and can then emit an alarm.

In particular flocks of geese, seagulls and rooks have created problems for farmers and in the case of geese, the population has grown markedly in recent years. They often arrive in flocks of several thousand birds that can eat a great deal very quickly.

Computer speaks and understands bird language

Today farmers use gas cannons and other systems, using different acoustic and visual stimuli to scare the birds. None of these methods are effective, however, because the birds quickly become accustomed to the systems and ignore them.

What is unique about the researchers' new version of an intelligent scarecrow is that it can measure its own effectiveness in scaring the birds away. By registering sound, it can identify whether the birds are landing, whether they have settled on the field or whether they are fleeing. In other words, the system is adaptive. It measures whether its stimuli have the desired effect and reacts to this information.

"The system emits the first alarm to scare off the birds as they are on the way to settle on the field. If this does not work and the flock still lands, it emits a new alarm to scare the birds away," says Kim Arild Steen, PhD student at Aarhus University.

The researchers have mapped the connection between the behaviour of the birds and their sounds based on many hours of video and audio recordings of geese. The method is based on signal processing, pattern recognition and image analysis, which, when combined, makes it possible to translate the birds' own language.

Ready for the market

At present, the intelligent scarecrows have been erected in Denmark and also in a single case in Germany. So far they have been very effective at scaring away barnacle geese, greylag geese and rooks.

The scarecrow has been christened AniMan and the three researchers behind the invention have formed the company Wildlife Communication Technologies ApS.

PROJECT FACTS

Title: The intelligent scarecrow is a spin-off product from the Ph.D. project entitled "Pattern Recognition Methods for Reduction of Human-wildlife Conflicts"

Financial framework: The Ph.D. project, is financed by Wildlife Communication Technologies

Schedule: 2011 – 2014

Project partners: Agro Business Innovation A/S and Wildlife Communication Technologies ApS

Contact: PhD student and CEO Kim Arild Steen,
kim.steen@eng.au.dk



Photo: Colorbox

Following the attack on the World Trade Center and the Pentagon in 2001 and a number of other terrorist actions in the past years, focus has been directed towards society's ability to protect itself from future terrorist attacks.

This is an area where the infrastructural nerve centres of society such as airports, bridges, power plants and facilities, and communication channels play an important role. Just one of these systems being suspended can have serious consequences across other sectors and paralyse security in large areas or entire countries.

To be more resistant to future attacks, it is important to protect these critical parts of a country's infrastructure. But the available surveillance systems are typically manually operated and cover only the perimeter of the areas, thereby making it almost impossible to get a fully detailed overview.

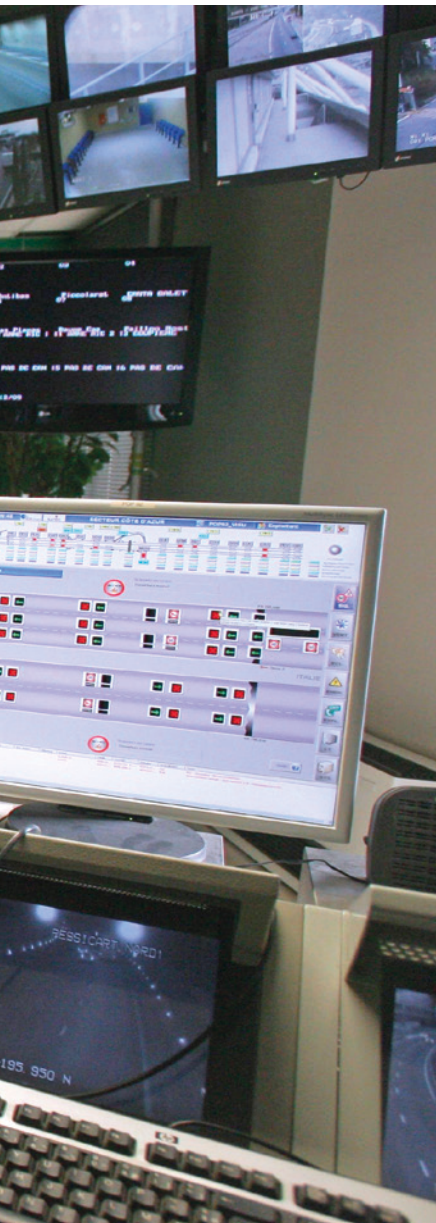
Automatic surveillance optimises security

Today control rooms typically have a number of people mo-

onitoring critical locations manually with the help of modern camera technology. This entails a risk of overlooking important incidents. Therefore, researchers are focusing on replacing manual control dependent on individuals with automated systems that draw on different forms of sensor technology and a new, advanced computer system. The advantages are a higher degree of security and a reduction of the costs connected with 24-hour staffing for surveillance.

The new surveillance system will utilise various sensor technologies such as radar and cameras. The sensors collect information about people's activities in a limited geographical area. This information can be gathered and used to identify any kind of suspicious behaviour and to send an alarm and activate a video camera in order to gain more detailed insight.

To provide a comprehensive overview of the security situation at any given location, the researchers will combine several different kinds of available data. A radar can show where an object is heading and in which direction, but not how heavy it



COMPUTER MODEL WILL REDUCE THE RISK OF TERRORIST ATTACK

- Are our current surveillance systems good enough to prevent attacks on the country's infrastructure? Researchers in an industrial postdoc project are working to develop a computer programme that is able to optimise security and reduce the threat of terrorism.

◀ Researchers are developing a computer system that can replace manual surveillance of critical security locations such as bridges, airports and power stations, with automatic detection of any form of suspicious behaviour.

is or whether it is airborne or moving on the ground. Here you need to monitor the object with other types of sensors that can provide a very detailed description of a critical situation when taken together.

Supplements existing surveillance systems

However, the complexity of the system makes it difficult to purchase, install and test. To make the system financially viable, the researchers will develop a computer programme that analyses the quality of the coverage and surveillance that can be obtained by using the sensors and video cameras that are already installed at the location. For example, in an airport there may already be cameras keeping an eye on the behaviour of the passengers.

The project is a collaboration between Aarhus University and the Danish company Terma A/S with the support of the Danish National Advanced Technology Foundation.

PROJECT FACTS

Title: Modelling of Sensor-fusion in a Surveillance System using System-of-Systems Techniques

Financial framework: 2.1 million DKK, Industrial Postdoc supported by The Danish National Advanced Technology Foundation and Terma A/S.

Schedule: 2013 – 2015

Project partner: Terma A/S

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INFRASTRUCTURE

WORLD CLASS FACILITIES

Aarhus University has a range of facilities relevant for research within the engineering disciplines. The facilities include advanced apparatus, instruments and laboratories. Below you will find a list of some of the most important facilities. For further information please visit our website: eng.au.dk/en/facilities

Test facilities

- Biofuel Laboratory
- Biogas Plant
- Cleanroom
- Engineering Centre Bygholm

Biological and Chemical Engineering

- Agro-Biotechnology Science Laboratory
- Air Physics Laboratory
- Protein Laboratory
- Livestock Housing Climate Laboratory

Civil and Architectural Engineering

- Soil Mechanics Laboratory

Mechanical Engineering

- Manufacturing Toolshop and Project Area
- Composite Laboratory
- Materials Testing Laboratory
- Biomaterials Laboratory
- Laboratory for Experimental Fluid Dynamics
- Dynamics Laboratory

Electrical and Computer Engineering

- Integrated Circuits and Electronics Laboratory (ICE-LAB)
- Femto Laboratory

CLASS 100 DUST FREE ENVIRONMENT

Aarhus University has Denmark's largest infrastructure for research in nanotechnology. One of the most important elements is the cleanroom.

It offers a wide range of state-of-the-art instruments for nano and micro-fabrication and characterisation. The cleanroom is

classified as Class 100. This refers to the very low number and small size of particles permitted per volume of air.

Air contains micro and nano-sized particles such as dust, diesel particles and pollen. Contamination from these particles can complicate the fabrication of micro and nanostructures, even

In the cleanroom, the concentration of particles is kept low through air-filtering and controlled air flow. This makes a unique environment for nano research.



FULL SCALE BIOGAS PLANT FOR RESEARCH

Aarhus University has a biogas plant for sustainable energy research at its disposal. It is used by both researchers and companies to experiment with technologies for all aspects of the treatment of biomass such as plants and fertiliser, as well as biogas production. The aim is to reduce the environmental impact of livestock production and improve the yield of biomass for both energy purposes and plant nutrition.

Biogas can be used instead of fossil fuels such as oil, coal and natural gas. Biogas is very important for the agricultural sector's "carbon footprint" as the emissions of greenhouse gases in particular can be greatly curtailed by treating livestock manure in a biogas plant. Here the nutrients remain in the degassed manure which can then be used in the fields with the added advantage that it is far less of an odour nuisance compared to untreated manure, and that it also lessens the risk of the leaching of nitrogen and phosphorus into lakes, rivers and watercourses.

The biogas plant has a 1,200 cubic metre reactor and handles gas production of approx. 4,800 cubic metres per day.

The plant also contains a number of laboratories, four smaller test reactors, instruments for the control and monitoring of the biogas process and technology for measuring the quality of the gas.

making it impossible. Thus for many fabrication purposes, working in a dust free environment is highly desirable. In a cleanroom, the concentration of nano and micron-sized particles is kept low through air-filtering and controlled air flow. The outside air is filtered before it enters the cleanroom.

Everyday life in the cleanroom

The air enters through the ceiling and it flows in a controlled downward, laminar flow from the ceiling to the floor. Particles in the room are trapped in the flow and pushed towards the floor which is equipped with holes to allow the air and trapped particles to exit the room, thus maintaining a low particle concentration inside the cleanroom. About 90 percent of the air is re-circulated after filtering.

The air in the cleanroom contains fewer than 100 particles of size 0.5 micron or larger per cubic foot. For air in an ordinary room, the corresponding number is approximately 1,000,000 particles. The main source of particles in the room comes from the people working there. To avoid unnecessary contamination special suits, boots and gloves are worn while materials that are known to generate a lot of dust, i.e. paper, pencils and make-up, are not allowed.

Highly specialised equipment

Nanostructuring and pattern generating techniques available in the cleanroom include electron beam lithography, nanoimprint lithography and photolithography. These techniques can generate patterns with feature sizes of between 10 and 100 nanometers. The patterns can subsequently be transferred to

Research and development themes

- How do you combine organic materials to achieve optimum biogas extraction?
- Which biomass additives and enzymes provide the optimum gas output?
- How do different forms of biomass impact on the environment?
- What are the advantages and disadvantages of different forms of pretreatment of biomass?
- Which methods of cultivation are of significance for the quality of the biomass and when should the crops be harvested?
- How can you utilise biogas optimally in fuel cells?
- How can you increase the technical productivity of the biogas plant?



The Biogas plant at Aarhus University

Photo: Aarhus University

metal and insulator thin films with thicknesses ranging from a few nanometers to microns.

Reactive ion etching and physical vapour deposition are also available in the cleanroom. Some of the most used materials are gold, aluminium, titanium, silicon and silicon dioxide. The cleanroom is equipped with characterisation instruments such as atomic force microscopy, scanning electron microscopy and ellipsometry.

TALENT DEVELOPMENT

THE ENGINEERING PHD CHALLENGE

PHD CHALLENGE is an annual research event at Aarhus University where all PhD students in the field of engineering get together to solve a technological challenge faced by society.

Each year, selected companies, government agencies and institutions are given the opportunity to make a presentation on a special current technological issue. Then the researchers work as hard as they can in groups for 24 hours and compete to come up with the most innovative solution.

The aim of PHD CHALLENGE is both to demonstrate the many different fields of application of the science of engineering and to train the department's researchers in a method of innovation that presupposes collaboration across different areas of specialisation.

At the same time, the event contributes to making the value creation of engineering research more evident for the outside world.

THE 2013 ASSIGNMENT

The global demand for clean water is increasing by the day and the world needs new solutions that can ease the pressure on scarce resources.

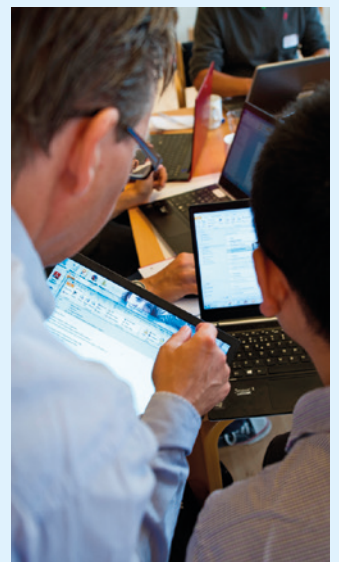
How do we ensure the optimum utilisation of our waste water in a sustainable way – both financially, socially and environmentally?

This was the 2013 challenge faced by the 60 researchers from the Department of Engineering. During a 24-hour innovation process, they had to come up with ideas for new technological solutions that can help to utilise of our waste water resources more effectively.

"We join forces once a year and come up with suggestions for solutions to a particular topical issue faced by society. In reality, this is a very simple attempt to get our research beyond the university's walls and, at the same time, a good exercise in interdisciplinary work for our researchers," says Thomas Toftegaard, Head of Department.



PHD CHALLENGE is an intensive innovation process. In just 24 hours, researchers must come up with an idea on how to handle waste water in the future. Associate Professor Rune Hylsberg Jacobsen (right) and PhD student Thomas Jensen and Associate Professor Anders Bentien.



RESEARCHERS STORE ENERGY IN WASTE WATER

- Electrify waste water and turn waste products into biogas that can be stored and then used when electricity is most expensive. For the group of engineers who won the Aarhus University PhD challenge 2013, this is a realistic future scenario.

Each time we do the dishes, take a bath or flush the toilet, we release waste water that must then be treated to eliminate waste products, chemicals and xenobiotics before being discharged into the watercourses again. This is a very energy-intensive process that consumes several million kilowatt-hours per year and thereby constitutes a significant part of Denmark's total CO₂ emissions.

Major item in the national CO₂ accounts

When waste water reaches the waste water treatment plant, it is led through a large sieve where the solid particles of organic material settle as sludge. This sludge can subsequently be used as the raw material for biogas production.

However, the residue water still contains a lot of organic material, primarily in the form of acids. In today's conventional treatment plants, the residue water is therefore pumped through a biological cleaning process via large turbines while bacteria transform the remaining waste products into nutrient salts. This process is called aeration and requires a very large supply of oxygen.

The disadvantage with this method is that a lot of energy is used to pump air into the basin. In addition, while breaking down acids, the bacteria produce CO₂ that is then emitted into the atmosphere, explains Thomas Jensen, PhD student at Aarhus University:

"Aeration is one of the primary CO₂ offenders when it comes to waste water treatment plants and therefore it would be a huge step in a more sustainable direction if it was possible to find an alternative method for treating waste water," he says.

Electrify the waste products

Along with his research team, he was declared the winner of the PHD CHALLENGE innovation competition with a new concept for handling waste water in which the energy consuming aeration of water is replaced by electrochemical cleansing based on electricity from excess energy.

"What we want to do is to use an electrochemical cell as an alternative to aeration. It adds a voltage to the waste water and thereby activates a chemical process that breaks down the polluting substances into gasses," explains Thomas Jensen.

The waste-water treatment plant as an energy buffer

The idea of electrifying the waste products in waste water is not new. It has already been tested with good results.

However, what is new is that the researchers connect the waste water treatment plants to the electrical grid and use them as large-scale storage facilities in the energy infrastructure of the future.

"If we connect the waste water treatment plant to the electrical grid, we can use the resources more efficiently. We can ensure that the electrochemical cleaning only takes place during the night for example, when we are asleep and when there typically is plenty of available surplus energy from wind turbines. The biogases that are created in this electrochemical reaction can be stored and used as an alternative to fossil fuels at a later time," explains Thomas Jensen.

Could become reality

The winning concept excited a unanimous judging panel comprising representatives from the Municipality of Aarhus, the pump concern Grundfos and the two water utility companies Herning Water and Aarhus Water.

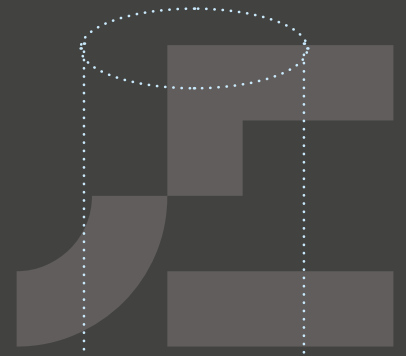
"The way we clean our waste water today is not future-proof. We need new and more sustainable methods and interdisciplinary research can help us on the way. The winning concept is innovative as well as realistic. It transforms an energy demanding process into an energy producing and energy storing process. This is both environmentally and commercially very interesting," says Per Overgaard, Manager, Aarhus Water.



Photo: Colorbox

Researchers will replace today's energy-intensive method of cleaning waste water with a process that produces and stores energy.

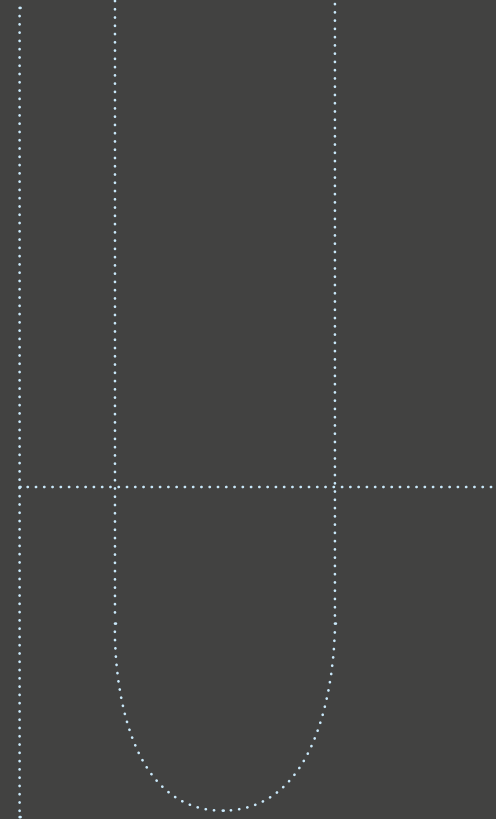




PHD PROJECTS



Next generation building environment, energy systems of the future, new materials, embedded ICT-based systems, production technologies, and novel products with improved functionalities. These are the core issues in the university's PhD programmes within engineering.





Department of Engineering offers PhD programmes with a strong focus on applied research and collaboration with the industry. Read more about 50 PhD projects.





SOFIE HALDRUP

PROJECT DESCRIPTION: The major goal of the project is to screen among ion-conductive membranes to select the most promising ones in terms of high conversion efficiency, stability, lifetime, etc. that are suitable for electrokinetic and thermoelectric conversion processes.

The basic ideas behind the project are 1) to study the physical transport properties, e.g. ion-conductivity, hydraulic permeability,

streaming potential, Seebeck effect and thermal conductivity, of commercially available ion-conductive membranes for which no specific data can be retrieved in the pertinent literature; and 2) to synthesise novel ion-conductive membranes with tuned transport properties. Indeed, current commercially available ion conducting membranes are optimised for fuel cell or electro-dialysis applications in which a large ion-conductivity is wanted. This does not necessarily hold for electrokinetic and thermoelectric membrane conversion processes.

The basic tasks of the PhD project:

- Syntheses of ion-conductive polymer membranes and, in this process, control the parameters: pore size from a few nm up to hundreds of nm, ion exchange capacity and water content in order to increase the water/ion coupling.
- Measurement of different transport properties with varying electrolytes and concentrations on specialised equipment.
- Estimate the electrokinetic and thermoelectric conversion efficiency of specific membranes, electrolytes and concentration, and assess the feasibility for larger scale use.

ABOUT THE PROJECT

Title: Synthesis and Characterisation of Nano Porous Ion-Conductive Membranes for Energy Conversion Purposes

Schedule: Jan. 2013 to Dec. 2015

Main supervisor: Assoc. Prof. Anders Bentien

Research section: Biological and Chemical Engineering

Contact: haldrup@eng.au.dk



CASPER CLAUSEN

PROJECT DESCRIPTION: The ability to accurately measure velocities, concentration and size of nano- and micro-particles in liquid and gas flows is a cornerstone in many environmental, medical and industrial technologies.

The scope of the project is related to research and development of a low-cost optical sensor technology that simultaneously can measure micro/nano particle size, concentration and

velocities. The overall goal is to investigate the feasibility of the optical technologies in relation to specific applications.

The tasks in the PhD-project include to

- develop integrated optical components in Aarhus University's cleanroom facilities,
- build lab-scale facilities for testing optical components,
- build functional models for test of specific applications,
- develop advanced signal processing techniques,

- use and integrate innovation models into the project in order to create specific goals with respect to applications and specification,
- increase knowledge on innovation and know-how within applications and techniques through cooperations with external partners (EU, USA).

ABOUT THE PROJECT

Title: Research and Development of Optical Components and Technologies for Simultaneous Measurement of Micro/Nano Particle Size, Concentration and Velocities

Schedule: May 2012 to July 2016

Main supervisor: Assoc. Prof. Anders Bentien

Research section: Biological and Chemical Engineering

Contact: casperc@eng.au.dk



METTE BIRCH KRISTENSEN

PROJECT DESCRIPTION: Ion conducting membranes are utilised in many industrial separation processes, e.g. electro-dialysis and Donnan dialysis, and in energy conversion processes, e.g. fuel cells, redox flow batteries etc.

In most of the current applications, desired membrane properties are high ion conductivity, high permselectivity, i.e. only cations or anions can penetrate the membrane, high mechanical

strength and chemical resistance. The commercial membranes are often very dense with small pore sizes in the order of a few nanometers. This results in low water content, relatively low ion conductivity and high permselectivity.

In certain membrane processes, the permselectivity is of less importance and higher water content and ion conductivity are wanted to increase the efficiency of the process.

This project examines existing and develops new synthesis pathways of perfluorinated membranes to achieve a higher water content and ion conductivity. In the same context, modifications to selected commercial membranes

will also be performed. Another part of the project aims at improving existing and building new set-ups for membrane characterisation.

ABOUT THE PROJECT

Title: Synthesis and Characterisation of Nano-Porous Perfluorinated Membranes

Schedule: Aug. 2013 to July 2017

Main supervisor: Assoc. Prof. Anders Bentien

Research section: Biological and Chemical Engineering

Contact: mettebk@eng.au.dk



DAVID NICOLAS ØSTEDGAARD-MUNCK

PROJECT DESCRIPTION: Energy conversion technology plays a vital role in many industrial applications today e.g. in the conversion of energy from electric into electrochemical as in batteries, or the conversion of kinetic/mechanical into electrical energy as in generators.

Converting energy from one form into another, e.g. from electric to kinetic energy, also holds

potential for creating alternatives to devices such as vapour compressors for cooling cycles.

The aim of this project is to investigate the potential use of nano-porous ion-conductive membranes in an industrial setting. The project is split into two parts. The first is the construction and use of specialised equipment for measuring the electrokinetic and thermoelectric conversion efficiency of nano-porous ion-conductive membranes with respect to electrolytes and concentration.

The second part of the project concerns the application of the membranes. The initial idea is to apply the energy converting ability of the membranes to convert electric energy into kinetic energy and thus use the resulting set-up as a vapour compressor. When this compressor has been characterised, it will be applied in a cooling cycle where the overall efficiency of the cycle will be investigated. Ultimately, the feasibility for larger scale use of this technology will be assessed.

ABOUT THE PROJECT

Title: Characterisation and Application of Nano-Porous Ion-Conductive Membranes for Energy Conversion Purposes

Schedule: Aug. 2013 to July 2017

Main supervisor: Assoc. Prof. Anders Bentien

Research section: Biological and Chemical Engineering

Contact: dnmunck@eng.au.dk



HONGQING YAO

PROJECT DESCRIPTION: Advanced Oxidation Processes (AOPs) as a set of chemical treatment procedures have originally been used extensively to remove organic and inorganic contaminants in wastewater treatment by oxidation.

AOPs are generally based on generation of high concentrations of highly reactive hydroxyl radicals. Recently, AOPs are considered to be new technologies for application in livestock buildings

and industrial facilities to reduce the emissions of volatile organic compounds and H₂S.

The introduction of cost-effective AOP technologies requires new research on the function and efficiency of the process involved. Examples of AOPs for air treatment are photocatalysis based on UV radiation with catalysts and O₃ treatment and catalytic scrubbers such as the Fenton's system.

The objectives of the project are to:

- explore the aqueous surface reactivity of hydroxyl radicals towards relevant volatile organic compounds and H₂S,
- investigate the efficiency of odorous compounds by using AOPs,
- assess the most promising technologies in field application.

ABOUT THE PROJECT

Title: Application of Advanced Oxidation Processes for Treatment of Air from Livestock Buildings and Industrial Facilities

Schedule: Feb. 2011 to Feb. 2015

Main supervisor: Assoc. Prof. Anders Feilberg

Co-supervisor: Senior Researcher Anders Peter Adamsen

Research section: Biological and Chemical Engineering

Contact: hongqing.yao@eng.au.dk



DANIEL GIRMA MULAT

PROJECT DESCRIPTION: The production of methane from agricultural and industrial wastes in anaerobic digestion (AD) has been used as pollution control and for energy recovery purposes.

However, the advantages of anaerobic digestion for treating organic wastes have not been brought into full play. This process is still far from optimised due to incomplete process understanding.

The overall aim of the PhD project is to generate an in-depth knowledge about the degradation mechanisms of key intermediates and most important methanogenic pathways for the formation of CH₄ in anaerobic digestion.

Analytical techniques based on stable isotope labelling combined with isotope ratio determination by optical spectroscopy and mass spectrometry will be developed and applied for understanding methanogenic pathways.

The aim of the project is to obtain new knowledge about the relative contribution of methanogenic pathways and the role of intermediate precursors such as hydrogen, formate and acetate to the total CH₄ production which

will be combined with a technology to optimise the production of biogas production from organic waste.

ABOUT THE PROJECT

Title: Methanogenic Pathways in Anaerobic Bioreactors by Stable Isotope Techniques

Schedule: Dec. 2011 to Nov. 2014

Main supervisor: Assoc. Prof. Anders Feilberg

Co-supervisor: Senior Researcher Anders Peter Adamsen and Postdoc Alastair James Ward

Research section: Biological and Chemical Engineering

Contact: danielg.mulat@eng.au.dk



RADZIAH WAHID

PROJECT DESCRIPTION: The aim of this study is to improve biogas potentials through pre-treatment and co-digestion processes.

Pre-treatment is important as it can increase the accessibility of microorganisms to cellulose during anaerobic fermentation, especially for highly lignified substrate, and thus increase the biogas potential. Different substrates such as agricultural crops, algae and animal manures

are used in this research. Briquetting and extrusion are two main pre-treatment techniques that will be analysed in depth. Different control parameters are manipulated to find the optimal settings and configuration of the machinery for the highest biogas yield and lowest costs in terms of energy.

The influence of co-digestion of plant materials with animal manures is another focus area as it may offer a range of process benefits. Animal manures provide buffering capacity and a wide range of nutrients while plant material with high carbon content balances the carbon to nitrogen (C/N) ratio, thus reducing the risk of ammonia inhibition.

Fundamental knowledge about anaerobic digestion of animal manures is investigated first before co-digestion with different substrates is initiated. This is important to fully understand the synergies of anaerobic digestion involved in biogas production from animal manures alone.

ABOUT THE PROJECT

Title: Co-Digestion of Mixed Substrates and its Pre-Treatment for Biogas Production

Schedule: Dec. 2012 to Nov. 2015

Main supervisor: Senior Researcher Henrik Bjarne Møller

Co-supervisor: Postdoc. Alastair James Ward

Research section: Biological and Chemical Engineering

Contact: radziah.wahid@eng.au.dk

THERESA MELDGAARD

PROJECT DESCRIPTION: The work of this PhD project is a sub-project within an innovation consortium called Center for Cellular Sygdomsanalyse (CCS). CCS is a cooperation between six smaller biotechnological companies with complementary skills and two academic partners.

The mutual goal is the development of new technology for characterising and, in the end, analysing tumour material with a view to design individualised and effective treatment strategies. The consortium puts emphasis on breast cancer.

The objective of this particular sub-project is to discover unique or better markers of different breast cancer cell subpopulations. By employing the phage display technology in which libraries of antibody fragments are displayed on the surface of bacteria specific virus particles called phages, antibody fragments are selected against different breast cancer cells. Through the identification of antibodies showing specific recognition of different cancer cell subpopulations, their cognate antigen can be identified and applied as markers.

The intention is to apply a panel of such antibodies in the development of analysis platforms. These platforms, such as a flow based cell-capture platform,

can hopefully aid in the characterisation of the composition of tumour cell subtypes within a given tumour. This will allow decisions on treatment choices to be made for a given patient.

ABOUT THE PROJECT

Title: Identification and Analysis of Functional and Cell Specific Biomarkers Supporting Individualised Treatment Strategies

Schedule: April 2010 to March 2014

Main supervisor: Assoc. Prof. Peter Kristensen

Research section: Biological and Chemical Engineering

Contact: tmm@eng.au.dk

MATHIAS JØRGENSEN

PROJECT DESCRIPTION: Cancer cells display vast amounts of genetic mutations leading them to divide, grow and invade neighbouring tissue. However, not all cancers are restrained within the adjacent tissue but can also change morphology and start to circulate via the blood. These cells are the so-called circulating tumour cells (CTCs) causing the cancer to spread to otherwise healthy tissue. CTCs are rare in a patient sample, accounting for about 5-50 cells per teaspoon of blood.

This project is concerned with isolating and characterising CTCs through a screening platform based on the phage display technique.

From the phage display technique platform, antibodies will be selected and used for coating microchips. The development of such microchips is a part of a collaboration with engineers from the fluid dynamics research group.

ABOUT THE PROJECT

Title: Screening and Selecting Antibodies against Rare Circulating Cancer Cells

Schedule: Aug. 2013 to July 2016

Main supervisor: Assoc. Prof. Peter Kristensen

Research section: Biological and Chemical Engineering

Contact: mlindh@eng.au.dk



MIA FALKEBORG

PROJECT DESCRIPTION: This project aims at developing a range of new food emulsifiers which, in addition to having surface-active properties, also possess antioxidative properties. Such emulsifiers find potential applications in the encapsulation of fish oil for use in food products.

A high intake of fish oil has been associated with several health benefits, and the addition of fish oil to regularly consumed food products is

believed to contribute to an increased health.

Encapsulation of the fish oil is necessary however as fish oil is very unstable and oxidizes easily. Fish oil can be encapsulated with emulsifiers, and antioxidants should be added for improved protection of the fish oil.

This project aims at developing innovative ingredients with combined emulsifier- and antioxidant properties.

The ingredients are developed from natural raw materials using environmentally friendly production processes. The ingredients are believed to be able to encapsulate fish oil in a stable emulsified form in which the fish oil is

protected from oxidation through the action of the antioxidants. Such a fish oil emulsion could potentially be added to various food products.

ABOUT THE PROJECT

Title: Development of Innovative Lipid-Based Materials for Encapsulation of Sensitive Bioactive Ingredients

Schedule: Sept. 2011 to Aug. 2014

Main supervisor: Assoc. Prof. Zheng Guo

Co-supervisors: Assoc. Prof. Marianne Glasius and Prof. Xuebing Xu

Research section: Biological and Chemical Engineering

Contact: miafalk@eng.au.dk

MOHAMAD FIRDAUS BIN MOHAMAD YUSOFF

PROJECT DESCRIPTION: This project is divided into two main parts. The main goal of both parts is to investigate and possibly develop a model that describes the mechanism and kinetics of interesterification.

The first part of the project focuses on how to utilise a specific kind of lipase to produce biodiesel. The reaction using enzymes is relatively complex and because of that, a unique strategy of disassembling the whole mechanism of the reaction is conducted.

The enzymatic reaction is divided into hydrolysis pathway and esterification pathway. Within these parts, an investigation of kinetics and reaction mechanism is carried out using the Michealis-Menten function.

When all the information is collected, a computer model that illustrates the whole reaction will be developed. The investigation also involves total fatty acid consumption, total water effect and enzyme concentration.

The second part of the project aims at developing a chemical catalyst including Brønsted acid functionalised ionic liquid and sulfonic functionalised MCM-41. Several solutions will be tested to investigate their function as a catalyst for biodiesel production and also as a solvent that facilitates the reaction.

The analysis of the reactivity of the catalyst will be conducted using several analytical instrumentations such as gas chromatography, mass spectrometry, high performance liquid chromatography and UV-spectrometry

ABOUT THE PROJECT

Title: Heterogenous Catalysis for the Production of Biodiesel

Schedule: July 2012 to May 2015

Main supervisor: Assoc. Prof. Zheng Guo

Co-supervisor: Senior Researcher Sergey Fedosov

Research section: Biological and Chemical Engineering

Contact: firdaus@eng.au.dk



STEINAR BIRGISSON

PROJECT DESCRIPTION: This project aims to develop new nanomaterials for application in Li-ion batteries.

The research is focused on synthesis methods that are industrially relevant and are based on the solvothermal reaction of the materials being studied. The main focus is on synthesis in supercritical fluids which has great potential as a new, environmentally friendly way to produce

chemicals industrially.

After the synthesis, the nanoparticles are structurally characterised with the help of X-ray diffraction, neutron diffraction, TEM/SEM, SAXS, XRF, ICP, BET and potentially X-ray absorption techniques (XANES/EXAFS).

Our group has developed and implemented a novel way for in-situ measurement of solvothermal reactions with great success. Therefore, the research will focus especially on in-situ synchrotron X-ray diffraction measurement to study reaction mechanism and nanoparticle growth.

The electrochemical characteristics of these materials will also be studied using the newly developed battery-lab in the Department of Chemistry at Aarhus University.

ABOUT THE PROJECT

Title: Li Ion Nanomaterials for Improvement of Large Scale Energy Storage

Schedule: Feb. 2013 to Jan. 2017

Main supervisor: Prof. Bo Brummerstedt Iversen

Co-supervisor: Søren Dahl, Haldor Topsøe A/S

Research section: Department of Chemistry, Aarhus University

Contact: steinar@eng.au.dk



JAKOB FISKER

PROJECT DESCRIPTION: The vast majority of concrete slabs are only supplied with longitudinal reinforcement while expensive shear-reinforcement is only placed in case of shear forces of extraordinary magnitude. Thus, in most situations, the capacity of the slabs with respect to shear-forces is provided by a combination of the concrete itself along with the longitudinal reinforcement. Unfortunately, the fundamentals

of this vital mechanism that allows for such structures to be designed are still not fully understood, and most models used for design are empirical and lacks a physical and rational basis.

In addition, such slabs are often designed as statically indeterminate structures. In order to achieve a certain level of robustness, the final structure must therefore possess a certain level of ability to withstand larger deformations without failing.

It is well known that the ability of reinforced concrete to deform is due to development of cracks. Hence, in this respect, the progressive development

of cracks is beneficial. However, when considering members without shear-reinforcement, the same cracks also introduce certain "weakened" regions which effectively reduce the capacity with respect to shear.

The aim of the project is, among others, to increase the understanding of this rather delicate relation between the inevitable development of cracks and the shear-capacity of slabs.

ABOUT THE PROJECT

Title: Continuous Members in Reinforced Concrete

Schedule: Aug. 2012 to July 2014

Main supervisor: Prof. (Docent) Lars German Hagsten

Research section: Civil and Architectural Engineering

Contact: jafi@iha.dk



MICHAEL DAHL KNUDSEN

PROJECT DESCRIPTION: Much can be achieved by making energy consumption of buildings more flexible so that the use of energy takes place at times when it is most convenient for the overall energy system.

This project examines the flexibility potential in relation to controlling the energy system of a building. This is done by using a model of a building that includes weather forecasts, energy

prices and occupant behaviour.

The approach is essential to finding the combination of future actuator set-points that result in the best outcome with respect to indoor climate and economy.

ABOUT THE PROJECT

Title: Smart Grid Flexibility Potential in Model-Based Building Control

Schedule: Aug. 2013 to July 2016

Main supervisor: Ass. Prof. Steffen Petersen

Research section: Civil and Architectural Engineering

Contact: mdk@eng.au.dk



MADS KNUDE HOVGAARD

PROJECT DESCRIPTION: For decades, the prevailing material for very tall chimneys for power plants has been concrete. Combined, Rambøll and MT Højgaard have been involved in all phases of the construction of the very highest in Denmark.

Most modern wind turbine towers are tubular steel towers and until now the high labour costs have tipped the scale in favour of steel towers.

But as technology advances rapidly towards larger turbines, it is only natural to assume that concrete will be the new first choice for multi MW designs, as it did for chimneys. For this scale of structures, the mechanical properties of concrete can be superior to those of steel if the experiences and know-how from concrete chimney construction are applied throughout the project.

Structural health monitoring (SHM) is the perpetual process of monitoring the structures' integrity. By equipping SHM to a civil structure, the owner is provided with decision support. So far, for the structures that have been equipped with SHM, the value in terms of total life-cycle benefits has rarely been estimated.

By associating a risk optimised decision policy, the SHM effort can be optimised and the initial target safety of the structure may be recalibrated upfront. In some cases, this translates into reductions on the Partial Safety Factors, leading to reductions on initial cost.

This project implements the risk based SHM system design, which is a research heavy topic, on the development of cast concrete wind turbine towers for multi MW turbines.

ABOUT THE PROJECT

Title: Incorporating Structural Health Monitoring in the Design of Slip Formed Concrete Wind Turbine Towers

Schedule: Feb. 2012 to Jan. 2015

Main supervisor: Prof. Rune Brincker

Co-supervisor: Jens Christian Kirk, Rambøll

Research section: Civil and Architectural Engineering

Contact: mkho@eng.au.dk



ANDERS SKAFTE

PROJECT DESCRIPTION: When measuring the dynamic properties of a civil structure, the information is always limited to the amount of sensors placed on the structure. This often results in sparse modal models and rough estimations.

The main focus of this project is to develop a model that provides information about the dynamics of a structure in points where no sensors have been placed.

This is done by making a transformation between a set of experimentally obtained mode shapes and a set of mode shapes from a Finite Element Model (FE). The overall principle is that a set of mode shapes can be described as a linear combination of another set of mode shapes as long as the changes between the two models are small. This is known as the Local Correspondence Principle.

The set of experimentally found mode shapes can be found by making an Operational Modal Analysis on the measured response and has the advantage of providing "true" information in a limited number of points.

On the other hand, the FE model provides a set of "fictive" mode shapes in a large number of points. As long as the FE model doesn't differ too much from the real structure, the estimated mode shapes can successfully be found making a linear transformation of the FE mode shapes.

The method will provide new ways of analysing structures. Displacements can be transformed to strains and stresses, which will be a helpful tool when analysing fatigue where the stress history is an important factor. Furthermore, the method will be suitable for monitoring of structures.

ABOUT THE PROJECT

Title : Fullblown ODS

Schedule: Oct. 2011 to Sept. 2017

Main Supervisor : Prof. Rune Brincker

Research section: Civil and Architectural Engineering

Contact: ask@iha.dk



JANNICK BALLEBY HANSEN

PROJECT DESCRIPTION: The main focus of this PhD project is on vibration-based damage detection on civil as well as mechanical structures.

This subject can, in a global context, be classified as a "Structural Health Monitoring" (SHM) discipline. The SHM term covers a broad range of different methods and techniques with the coincident goal or purpose to detect damage,

position and magnitude in a structure.

For researchers as well as commercial companies, SHM is an area of great interest due to the fact that SHM has the potential to replace traditional damage detecting techniques which, in most cases, are mere visual inspections supplemented by material samples extracted from the structure.

It is commonly known that damage, e.g. holes or cracks, in a structure will have an impact on the global dynamic properties, in other words the modal parameters.

These parameters can be extracted by means of "Operational Modal Analysis", sophisticated sensors and data acquisition equipment, even on large civil structures. Hence, damage in a structure can be detected if modal property shifts are observed. The aim of this project is to develop a method which is able to detect and pin-point damage on an arbitrary structure.

ABOUT THE PROJECT

Title: Vibration-Based Structural Health Monitoring

Schedule: Nov. 2011 to Dec. 2016

Main Supervisor: Prof. Rune Brincker

Research section: Civil and Architectural Engineering

Contact: jbha@iha.dk



PETER OLSEN

PROJECT DESCRIPTION: In the future, the application of Structural Health Monitoring (SHM) will be a key element when considering structures such as large span bridges, high-rise buildings or wind turbines.

SHM is a network of sensors placed wisely on the structure, monitoring the physical parameters of the structure. The sensors inform the control centre or the maintenance crew if any change in

the structure is detected, revealing crack growth or failure of secondary structural elements. This increases the safety of the structure and makes it possible to replace parts or fix the structure before failure.

The SHM system consists of sensors and an analysis part to process the measured signals. In this process, the identification of the structures' physical parameters is essential. As it will be an enormous amount of data which have to be analysed, this procedure will have to be automated.

The focus of this project is on Automated OMA. OMA is short for Operational Modal Analysis and is used in modal testing to find the modal parameters

such as eigenfrequency, modeshapes and damping ratio of a machine or a structure. The process of automating the estimation process when working with OMA demands development of an algorithm that is stable and need no interaction from the user.

The main object of the project is to investigate the use of well-known identification techniques in both time domain and frequency domain in combination with filtering techniques to automate the identification process. The identification of several criteria for choosing the physical parameters is another main focus of the project.

ABOUT THE PROJECT

Title: Automated Operational Modal Analysis

Schedule: Nov. 2012 to Oct. 2018

Main supervisor: Professor Rune Brincker

Research section: Civil and Architectural Engineering

Contact: pto@iha.dk



CHAO ZONG

PROJECT DESCRIPTION: The ventilation system of animal houses is important in livestock production due to its significant influence on local thermal conditions, indoor air quality and emission to the neighbouring atmosphere.

Precision zone ventilation consisting of direct air supply into the Animal Occupied Zone (AOZ) and precision exhaust ventilation from the source zone can provide more efficient climate control and improved air quality. The objective of this project is to develop the knowledge of precision zone ventilation in pig production buildings, aiming at achieving more effective ventilation and improving indoor air quality as well as reducing the required capacity of air cleaning devices.

Experimental investigations are carried out both in a pig production facility and in a 2-D chamber in the laboratory. The two-dimensional Laser Doppler Anemometry (LDA) is used for measuring velocity speed and characterizing flow type in the boundary layer. N_2O is applied as tracer gas. The artificial

pigs developed at APL are used to simulate the heat production of pigs at different locations. Computational Fluid Dynamics (CFD) is used for computer modelling.

ABOUT THE PROJECT

Title: Precision Zone Ventilation Design and Control in Pig Housing

Schedule: Oct. 2011 to Sept. 2014

Main supervisor: Senior Researcher Guoqiang Zhang

Research section: Civil and Architectural Engineering

Contact: chao.zong@eng.au.dk



HAO LI

PROJECT DESCRIPTION: The aim of this project is to improve animal welfare and reduce environmental impact. A new concept for monitoring the thermal and airflow conditions in animal zones will be introduced. Furthermore, we will set up a dynamic predictive model to create a precision environment control strategy at individual animal or defined zone level.

Micro-complex ventilation involves integrating precision local ventilations in animal zones and near manure fouled floors or manure surfaces within the building ventilation. In order to gain knowledge about air motion and distribution in animal occupied zones, and about system effects on emission reduction, the project will investigate an integrated micro ventilation concept in livestock housing.

Data will be gathered by using both Computational Fluid Dynamics (CFD) simulations and full scale experiments. After the establishment of the system, optimisations are also needed. Then, to validate the optimal system, varied techniques including local cross ventilation, heat exchange and passive

earth-air heat/cooling will be investigated. The proposed system combines the advantages of natural, mechanical and displacement ventilation, making it a technology with great efficiency and potential.

ABOUT THE PROJECT

Title: Complex Ventilation and Micro-Environmental Control in Livestock Housing

Schedule: Okt. 2013 to Sept. 2016

Main supervisor: Senior Researcher Guoqiang Zhang

Research section: Civil and Architectural Engineering

Contact: hao.li@eng.au.dk



KIM ARILD STEEN

PROJECT DESCRIPTION: The purpose of this project is to develop methods and algorithms for automation in agriculture.

The main focus is wildlife management systems where new technology could automate or improve existing methods.

The main contribution of the work is the development of pattern recognition algorithms which are capable of detecting and recognising wildlife in an agricultural setting. This includes audio and video based systems that are capable of measuring the presence and behaviour of wildlife.

The expected result of the PhD work is a proof of concept solution which can be used in further development and full-scale tests.

ABOUT THE PROJECT

Title: Pattern Recognition Methods for Reduction of Human-Wildlife Conflicts

Schedule: Feb. 2011 to April 2014

Main supervisor: Prof. (Docent) Henrik Karstoft

Co-supervisor: Ole Green, Kongskilde Industries A/S

Research section: Electrical and Computer Engineering

Contact: kim.steen@eng.au.dk



DANIEL SIBOSKA

PROJECT DESCRIPTION: For most of the population, our eyes have become the primary access to the world around us. However, much of the visual stimuli that enter our eyes is filtered out before it reaches our consciousness/visual awareness. Our visual system is extraordinarily good at this filtering process, though sometimes important information is filtered away which can be devastating, e.g. in traffic situations.

This project seeks to explore the mechanisms which control whether visual information reaches our visual awareness or is filtered out. We will do this by measuring magnetic signals (magnetoencephalography – MEG) generated from specific areas in the brain when this process occurs and see how these mechanisms modulate the activity in the brain.

The first such mechanism we explore is how spatial attention, i.e. where we are directing our eyes, modulates this filtering process. To do this, we need to be able to control how much spatial attention the test subjects are able to allocate to a given visual stimulus. This will be achieved through the use of a gaze con-

tingent display which can change the visual content on the screen depending on where the subject is looking.

The development of such a gaze contingent display with a faster response time than the human eye and which can be used while recording MEG signals is a prerequisite for the examination of the effect of spatial attention on our visual awareness.

ABOUT THE PROJECT

Title: Visual Awareness Negativity and Spatial Attention

Schedule: Jan. 2012 to Dec. 2014

Main supervisor: Prof. (Docent) Henrik Karstoft

Research section: Electrical and Computer Engineering

Contact: dasi@eng.au.dk



THOMAS JENSEN

Industrial PhD, Kongskilde Industries A/S

PROJECT DESCRIPTION: The aim of this project is to research and develop a system for sensor based online control of the degree of tillage for a seedbed cultivator moving in the field.

The system will include a vision system for characterising the seedbed quality. The vision system will consist of a series of laser range scanners positioned on the seedbed cultivator which

continuously generate a map of the raw and processed soil. The quality of the seedbed is correlated with aggregate size in the soil surface, i.e. the cloddiness of the soil. Large clods result in a too airy seedbed and thus the risk of drying out the seeds. On the other hand, a too processed seedbed has the risk of sealing the soil surface after heavy rain and thus resulting in bad germination. Additionally, it is a sign of too intensive seedbed cultivation and thus of unnecessarily high energy consumption while cultivating.

The online control of tillage intensity is based on image analysis, and the seedbed cultivator is adjusted continuously while running in the field. Since the

same field often consists of many types of soil, the system must be able to react to the changes in soil type and adjust the tillage intensity accordingly.

ABOUT THE PROJECT

Title: Intelligent Soil Tillage using Image Sensors

Schedule: Sept. 2012 to Oct. 2015

Main supervisor: Prof. (Docent) Henrik Karstoft

Co-supervisors: Senior Researcher Lars Munkholm and Ole Green, Kongskilde Industries A/S

Research section: Electrical and Computer Engineering

Contact: thje@eng.au.dk



LARS GLAVIND

PROJECT DESCRIPTION: This PhD project is in the field of fiber optical sensors for measuring the load on a wind turbine blade.

The advantages of using an optical sensor instead of typical electronic sensors in a wind turbine blade are the immunity to lightning and the longer lifetime of the sensor. A system that measures the load of the blades can provide information which can be used to optimise the

production and design of a wind turbine.

The focus is on applied research on a new type of sensor that can measure the load on a wind turbine blade and provide better information about the shape of a blade during operation of the wind turbine.

ABOUT THE PROJECT

Title: Fiber Optical Load Sensors for Wind Turbines

Schedule: Sept. 2009 to Feb. 2014

Main supervisor: Prof. Martin Kristensen

Co-supervisor: Assoc. Prof. Bjarne F. Skipper

Research section: Electrical and Computer Engineering

Contact: lagla@eng.au.dk



CLAUS BALLEGAARD NIELSEN

PROJECT DESCRIPTION: A System of Systems (SoS) is a system type that has risen from the increased complexity found in present-day system engineering. An SoS denotes a collaborative system which consists of many independent, heterogeneous constituent systems that combine information and functionality in order to reach a synergistic functionality that is greater than the sum of the constituent systems' abilities.

The SoS Engineering field faces the challenge of its constituent systems being individually owned and developed, which means that there is no centralised authority to take action or make decisions. As a result, decisions have to be agreed on, collaboratively, between the individual owners/developers of the constituent systems. Therefore the interfaces, data types, communication channels and interactions between the systems need to be agreed upon during development.

The purpose of the PhD project is to research how existing and new methods can be adapted, combined and innovated to improve the foundation of SoS

engineering. The PhD research is focused on aiding collaboration by utilising a combination between the field of software engineering and the field of systems engineering.

ABOUT THE PROJECT

Title: Well-Founded Engineering of System of Systems

Schedule: May 2011 to April 2014

Main supervisor: Prof. Peter Gorm Larsen

Research section: Electrical and Computer Engineering

Contact: clausbn@eng.au.dk



LUIS DIOGO MONTEIRO DUARTE COUTO

PROJECT DESCRIPTION: Systems of Systems (SoS) are very large scale systems whose constituent parts are themselves systems. This means that the constituents often have a very large amount of independence. They can have independent management, infrastructure, etc. They can also have independent and sometimes opposing goals, and they can sometimes collaborate

and at other times compete. However, they are all a part of the larger SoS.

Because of the massive size of an SoS, it is not practical, or even possible at times, to make analysis, modifications or experiments directly on the SoS. So, models of SoS become essential tools to help us reason about them.

This aim of this project is to improve modelling of SoS in two ways:

- 1) by trying to discover and catalogue design patterns (reusable solutions) for SoS modelling;
- 2) by improving the tools for analysis of models by extending them to an SoS specific language, i.e. the COMPASS Modelling Language (CML). The

specific tool dealt with is a generator of proof obligations for consistency and correctness of models.

ABOUT THE PROJECT

Title: Design and Analysis of Models for Systems of Systems

Schedule: Oct. 2012 to Sept 2015

Main supervisor: Prof. Peter Gorm Larsen

Co-supervisor: Joey Coleman, PhD

Research section: Electrical and Computer Engineering

Contact: ldc@eng.au.dk



JOSÉ ANTONIO ESPARZA ISASA

PROJECT DESCRIPTION: An embedded system is a special purpose computing device commonly operating with low computing power and sometimes under limited energy availability.

One of the techniques that can be used to develop these kinds of systems is model-driven engineering. Under this design approach, the engineer uses modelling technologies to represent the system at a high level of abstraction. Following

this initial representation, the model is progressively transformed into a final implementation.

The aim of this project is to adopt this approach to design and implement embedded systems that operate under tight energy budgets. The challenge is to incorporate the notion of energy consumption into different modelling paradigms. The reason behind applying several paradigms resides in the fact that embedded systems' energy consumption can be studied from different angles, i.e. physical, communication or computation.

By using different modeling approaches, one can select the most suitable for each angle and obtain energy estimations from different points of view.

The results of this project are being progressively applied in a case study in which an electronic compression stocking to treat leg venous insufficiency is developed. The aim is to evaluate how the energy consumption predictions determined by the models relate to the actual implementation and how the modeling process benefits system development.

ABOUT THE PROJECT

Title: System Level Power-Aware Design for Mission-Critical Embedded Systems

Schedule: May 2012 to April 2015

Main supervisor: Prof. Peter Gorm Larsen

Co-supervisor: Prof. (Docent) Finn Overgaard Hansen

Research section: Electrical and Computer Engineering

Contact: jaei@eng.au.dk



PETER WÜRTZ VINTHER JØRGENSEN

PROJECT DESCRIPTION: In this project, the development of software tools for efficient model-based development of Cyber-Physical Systems (CPSs) is explored. These are systems in which computational units are collaborating on controlling physical entities such as mechanical or electrical actuators in order to achieve a common goal.

I am interested in how the insight obtained during modelling can be transferred most efficiently to the implementation phase where the system is realised. I am working with automated transformation of VDM (Vienna Development Method) models into code that can be executed on the target platform of the CPS. In particular, I intend to address the general case where the target platform is distributed, i.e. the system is composed of several computers communicating across a network.

In addition, I have been considering ways to move gradually from a model to the realisation of the system. For this, I have been working with Hardware-In-the-Loop (HIL) simulation where VDM components of functionality are being

transformed into implementations and co-executed with the model. In this way, one can benefit from the abstraction mechanisms of modelling and the fidelity of using component implementations during development.

ABOUT THE PROJECT

Title: Enablers and Methodologies for Cyper-Physical Systems

Schedule: May 2013 to April 2016

Main supervisor: Prof. Peter Gorm Larsen

Research section: Electrical and Computer Engineering

Contact: pvj@eng.au.dk

FAISAL FAROOQ

PROJECT DESCRIPTION: Brain Computer Interfaces (BCIs) are an emerging technology that uses electrical activity in the brain, measured by non-invasive electroencephalography (EEG), to enable direct communication between the human brain and external devices such as computers. Over the past several years, BCIs have become an important research topic because of their ability to help patients suffering from severe loss of motor functions such as ALS, stroke, etc. Indeed, such interfaces can increase an individual's independence leading to an improved quality of life and reduced healthcare costs.

The recently introduced ear-EEG methodology is a promising enabling technology for wearable EEG systems. Ear-EEG records EEG signals within the ear canal by embedding electrodes on a customised ear piece similar to ear-plugs used in hearing-aid applications. Ear-EEG is, compared to alternative technologies, a discreet, unobtrusive, robust and user-friendly technology.

Whereas most BCIs are based on visual evoked potentials, the objective of this project is to develop auditory BCIs based on the Ear-EEG platform. This is feasible because it has been shown that auditory evoked potentials (AEP) can be recorded with good signal quality from ear-EEG.

The aim of the project is to develop new auditory paradigms where the AEPs can be easily controlled by the user's attention, and to develop advanced signal processing algorithms for detection of the AEP modulations.

ABOUT THE PROJECT

Title: Ear-EEG and Applications to Brain Computer Interface (BCI)

Schedule: Sept. 2012 to Aug. 2015

Main supervisor: Prof. (Docent) Preben Kidmose

Research section: Electrical and Computer Engineering

Contact: fafa@eng.au.dk



SIMON LIND KAPPEL

PROJECT DESCRIPTION: Ear-EEG is a novel EEG (electroencephalography) recording approach in which the EEG signal is recorded from electrodes embedded on an ear-piece placed in the ear canal. The ear-EEG has great potentials within continuous brain monitoring in everyday life and will have application within both medical and consumer electronics devices.

The integration of brain monitoring based on EEG into everyday life has been hindered by the limited portability and long set-up time of current wearable systems as well as by the invasiveness of implanted systems.

To address these issues, the ear-EEG has been introduced which is a discreet, unobtrusive and user-centred approach to brain monitoring. The ear-EEG recording concept has been tested by using several standard EEG paradigms and benchmarked against standard on-scalp EEG.

All ear-EEG recordings made so far have been based on wet-electrode technology. In order to improve the usability and user-friendliness, this project

will exploit so-called dry-contact electrode technology. This has impact on the design of the electrode itself, the supporting mechanics and the electronic instrumentation for acquiring the EEG signal.

ABOUT THE PROJECT

Title: Characterisation and Evaluation of Dry-Contact Electrodes for Ear-EEG

Schedule: Oct. 2013 to Sept. 2016

Main supervisor: Prof. (Docent) Preben Kidmose

Research section: Electrical and Computer Engineering

Contact: slk@eng.au.dk



CAMILLA ARNDAL ROTVEL

PROJECT DESCRIPTION: During the last decade, overweight and obesity have become an increasing global issue. According to WHO, in 2008, around 1.4 billion people over the age of 20 were overweight, at least 500 million were obese and at least 40 million children under the age of five were overweight.

The Food Industry's response to the obesity epidemic has been to produce a number of low fat and sugar food products that enable the consumer to eat the same food while consuming fewer calories. However, an investigation conducted by the Food Administration shows that people tend to consume extra-large servings of the light products, negating any benefits the light products might offer.

A solution to the above-mentioned obesity epidemic requires a more thorough understanding of the brain's response to varying salt, sugar and fat levels and subjective satiation. Traditionally, food ingredient selection is based on physical and sensory analysis methods. However, in connection with salt, sugar and fat substitution products, objective measurement methods lack the

ability to describe what we can register with our senses. In this regard, brain recordings are particularly interesting.

The idea behind the project is to utilise EEG methods to screen salt, sugar and fat substituents when selecting new food ingredients. The goal is to compare EEG results with physical or sensory data for new food ingredients with the hope of supplementing selection criteria for new food ingredients with objective physiological EEG responses.

ABOUT THE PROJECT

Title: Development of Methods for Objective EEG Analysis of Brain Activity induced by Sugar, Salt, Fat and their Substitutes

Schedule: Sept. 2013 to Aug. 2018

Main supervisor: Prof. (Docent) Preben Kidmose

Co-supervisors: Stine Møller, DuPont Nutrition BioSciences, Ole Larsen, Syddansk Universitet and Gert Christoffersen, Neural Scientific

Research section: Electrical and Computer Engineering

Contact: caro@eng.au.dk

MOHAMMAD SADEGH MOHAMMADI

Joint PhD programme with Macquarie University, Australia

PROJECT DESCRIPTION: A Body Area Network (BAN) consists of multiple, tiny, low-power, intelligent, wearable or implanted sensor nodes which are radio-enabled and can communicate wirelessly. The sensor nodes can collect various important physiological data for diagnosis or fast emergency response, and deliver various personalised therapeutic, treatment-related applications and services.

BAN is a new emerging technology that is used in areas such as healthcare, entertainment, games and sport science. It is expected to enhance the patient health care experience by providing independent living solutions for people that need constant health care. Furthermore, BAN can reduce the demand on the health care infrastructure and medical staff in the hospitals. Essentially, there is a unique combination of four major requirements in a realistic BAN:

- Energy efficiency
- Low complexity
- Robustness against harsh fading conditions
- Protection against interference and error

The aim of this project is firstly to investigate the characteristics of the typical BAN applications and the corresponding difficulties and limitations. The next step is to analyse these limitations to provide remedial solutions to achieve the performance requirements. The analysis is aimed to address both Physical (PHY) and Medium Access Control (MAC) layers.

ABOUT THE PROJECT

Title: Reliable Communication in Body Area Networks

Schedule: Sept. 2013 to Feb. 2017

Main Supervisors: Assoc. Prof. Qi Zhang, Aarhus University and Eryk Dutkiewicz, Macquarie University

Research section: Electrical and Computer Engineering

Contact: msmo@eng.au.dk



XIONG ZHOU

PROJECT DESCRIPTION: The need for health-care devices for everyday life is increasing. These devices can provide a long-term, unobtrusive monitoring to prevent chronic diseases which are the biggest killers according to the statistics of WHO, e.g. heart disease, stroke, hypertension, diabetes, etc. Past devices are bulky and high-power and have limitations to the use away from specific places, e.g. clinics

and hospitals. Ultra-low-power, wireless, small-size and user-friendly are the basic requirements of today's healthcare system.

For a long time, there has been a continued expectation that the biomedical system can be power autonomous which can be facilitated by energy harvesting from the ambient energy sources, e.g. thermal, kinetic (motion, vibration), radio frequency and solar power. However, current works have not reached this point yet. The topic of this project is the utilisation of low-voltage techniques to decrease the system's power as much as possible as the potential of low-voltage techniques to aggressively reduce power has

not been well addressed in the literature. To satisfy this task, the system's total power must decrease to $\sim 100\mu\text{W}$ including analogue front-end (AFE), μP (digital processing) as well as data transmitting and receiving via radio frequency. A potential application is the Ear-EEG.

ABOUT THE PROJECT

Title: An Ultra-Low Power Wireless Biosensing SoC Utilising Low-Voltage Techniques for Body-Worn Healthcare Applications

Schedule: June 2013 to May 2016

Main supervisor: Assoc. Prof. Qiang Li

Co-supervisor: Prof. (Docent) Jens Kargaard Madsen

Research section: Electrical and Computer Engineering

Contact: xizh@eng.au.dk

MARTIN PETER CHRISTIANSEN

PROJECT DESCRIPTION: This PhD project deals with the challenges faced when designing and deploying an autonomous vehicle guidance system in the agricultural domain. Automatic guidance systems for agricultural machines, i.e. auto-steering systems, employ sensory input from the Global Navigation Satellite System (GNSS) and/or other localisation systems. The auto-steering systems can increase efficiency in terms of reduced overlap, less operational time and fuel.

Before an auto-steering solution can be operational on a given vehicle, it is necessary to calibrate several (control) parameters of the auto steering system. These calibration parameters are dependent on the technical performance of the vehicle. We believe that better control parameters could be selected by utilising a simulated model of an agricultural machine. The simulated model will be able to execute and evaluate multiple candidate solutions using optimisation and search algorithms. The conjecture is that modelling and simulation would be less costly than selecting parameters and try to manually fine-tune an auto-steering system.

ABOUT THE PROJECT

Title: Modelling, Simulation and Evaluation of Autonomous Agricultural Vehicle Guidance

Schedule: Sept. 2011 to Sept. 2014

Main supervisor: Senior Researcher Rasmus Nyholm Jørgensen

Co-supervisors: Prof. Peter Gorm Larsen and Ole Green, Kongskilde Industries A/S

Research section: Electrical and Computer Engineering

Contact: mpc@eng.au.dk

MORTEN LARSEN

Industrial PhD, Conpleks Innovation

PROJECT DESCRIPTION: Software development for agricultural robotics is complicated and hence time-consuming and expensive.

Agricultural robots are particularly challenging with respect to the development of software due to the combination of an open, unpredictable environment and a complex, open-ended range of tasks.

Model-driven software development is a systematic approach to automatically generated software within a given domain based on a model.

The scientific goal of this project is to improve and develop model-driven software techniques, domain models, underlying software architecture and code generation techniques. This will enable us to create a software platform for automatic generation of control programmes that suit the specific requirements of agricultural robots.

The developmental goal of this project is to provide systematic and automated techniques for the development of a software platform that can be utilised for field robots in various scenarios. This software platform will be directly applicable to the development of control programmes for specific agricultural robots.

ABOUT THE PROJECT

Title: Model-Driven Software Development for Agricultural Robotics

Schedule: May 2013 to April 2016

Main supervisor: Senior Researcher Rasmus Nyholm Jørgensen

Co-supervisor: Prof. Peter Gorm Larsen

Research section: Electrical and Computer Engineering

Contact: mola@eng.au.dk

JAKOB PILEGAARD JUUL

Industrial PhD, Webstech

PROJECT DESCRIPTION: When storing grain and other farm produce, proper drying and storage are important. Using wireless sensors distributed in the storage enables a farmer to monitor how the drying/storage is progressing and to take action if something is not as it should be. This helps reduce losses and get a higher overall quality.

A number of challenges face a wireless sensor network deployed in such a scenario. Farm produce can contain relatively high amounts of water as well as high concentrations of salts leading to an unfavourable environment for wireless communication.

To help in the process of monitoring storages, the aim of this project is to develop a wireless sensor network capable of functioning reliably under the specific conditions. The system should also be able to localise the sensors of the network as this enables targeted intervention in trouble areas.

ABOUT THE PROJECT

Title: Localisation of Wireless Sensor Network Embedded in Biomass

Schedule: March 2010 to Oct. 2014

Main supervisor: Assoc. Prof. Rune Hylsberg Jacobsen

Co-supervisor: Ole Green, Kongskilde Industries A/S

Research section: Electrical and Computer Engineering

Contact: jakobj.larsen@eng.au.dk



SØREN AAGAARD MIKKELSEN

PROJECT DESCRIPTION: In the near future, many countries face big challenges in relation to distributing electrical energy because of the penetration of renewable energy sources that begin to take over traditional energy production. Furthermore, current state-of-the-art solutions are expensive compared to the modest cost savings that they are able to generate.

This project concerns the system architecture design and communication aspects of an intelligent home for the future smart grid services. Specifically, it focuses on getting ICT systems to communicate within a heterogeneous network infrastructure and address the problem of an optimal distribution of intelligence in an ICT framework, e.g. where the decision about actuation should take place.

To facilitate an economical viable solution for both the consumers and the grid operators, it uses the existing Internet connection in the residential houses as pathway for communicating and transferring data. The communication will be based on open protocols that must be modified for home appliances

with limited memory and processing power to enable them to operate within a reasonable time frame. However, to interconnect the constrained devices into the smart grid, we need a novel, light-weight and self-configurable communication solution that does not compromise robustness, service guarantees and cyber security.

ABOUT THE PROJECT

Title: Energy Demand Aware Open Services for Smart Grid Intelligent Automation

Schedule: Oct. 2012 to Sept. 2015

Main supervisor: Assoc. Prof. Rune Hylsberg Jacobsen

Research section: Electrical and Computer Engineering

Contact: smik@eng.au.dk

SERGI ROTGER GRIFUL

PROJECT DESCRIPTION: In the near future, there will be a higher penetration of renewable energy sources into the electrical grid. The entrance of these distributed energy resources into the system will require smarter solutions to balance the electricity production and consumption. This future grid is known as the Smart Grid.

The aim of this project is to make a large residential complex and its consumers "Smart Grid Ready" by the development and operation of a Virtual Power Plant (VPP). A VPP can be understood as a power plant which, instead of just producing electricity, is also able to modify the energy consumption of the end-user, thus providing demand response. The designed VPP will monitor and control the energy usage in the building. Furthermore, the VPP of the building will pool and offer the overall demand response to an external entity at a higher tier in the aggregation hierarchy.

The new student's residence at Aarhus harbour will be used as a test bed under the name of Grundfos Dormitory Lab. This is a 159 apartment building with a very low consumption profile, equipped with more than 3200 sensors.

The project deals with the Information and Communication Technology (ICT) for the construction of a VPP at building level. Specifically, this involves concept development, demand response engineering, sensing and actuation technology, data mining and forecasting as well as system integration for demonstrating part of the concepts developed. The PhD project aims at advancing the state-of-the-art in VPP technologies for the Smart Grid.

ABOUT THE PROJECT

Title: Virtual Power Plants for Distributed Energy Resources

Schedule: May 2013 to April 2016

Main supervisor: Assoc. Prof. Rune Hylsberg Jacobsen

Research section: Electrical and Computer Engineering

Contact: srqr@eng.au.dk



FEMINA HASSAN AYSHA BEEVI

PROJECT DESCRIPTION: The aim of the project is to develop a platform based on Data Distribution Service (DDS) for ambient assisted living in the home healthcare domain. In this project, we investigate how DDS based platforms can address the problem of interoperability of heterogeneous, distributed, ubiquitous healthcare systems and enable quality analysis of the medical data exchanged. It will also be investigated how quality of service parameters can be used to configure personal healthcare services.

The OMGs Data Distribution Service standard is an open data centric publish/subscribe middleware standard for a wide variety of computing environments, ranging from small networked embedded systems to large scale information backbones.

Ambient Assisted Living (AAL), a convergence of Assisted Living and Ambient Intelligence, is a new paradigm in social computing that allows the elderly to live at home even if they are sick. AAL systems for healthcare make use of

Personal Health Devices (PHD) that support continuous health monitoring. A DDS based platform will help achieve the seamless integration of the home healthcare platform with heterogeneous healthcare information systems.

ABOUT THE PROJECT

Title: Investigation of building a Data Distribution Service based Platform for supporting Ambient Assisted Living in a Home Healthcare Domain

Schedule: Feb. 2013 to Jan. 2016

Main supervisor: Assoc. Prof. Stefan Hallerstedte

Co-supervisors: Ass. Prof. Christian Fischer Pedersen and Ass. Prof. Stefan Wagner

Research section: Electrical and Computer Engineering

Contact: feay@eng.au.dk

KRISTIAN PETER ANDREASEN

PROJECT DESCRIPTION: The introduction of radically new technology into the market is a complex and often very costly and time consuming process.

In this PhD project, I will analyse the development process of the hydrogen and fuel cell innovation system in Denmark and the introduction of these technologies into the current energy system. The hydrogen and fuel cell innovation system is comprised of the network of actors involved in research, development, production and commercialisation activities for the hydrogen and fuel cell technology.

The outcome of this research will be a set of strategic recommendations for the actors involved in the innovation system in order to benefit the future socio-technical development.

The hydrogen and fuel cell technology is a very interesting technology to follow for the energy systems of the future since it has the potential to solve many of the challenges involved in the transition to a fully sustainable energy system. This could be as an energy storage solution for intermittently produced electricity from wind power in order to be able to supply the power when consumers demand it and hence, not necessarily when it is produced.

Another advantage is related to the transportation sector which is the largest

emitter of manmade greenhouse gasses today and hence, should be among the most important focus areas for technological transition. However the transportation sector, is also the most difficult area in which to intervene because it requires changes at all levels of society, namely at consumer, organisational, industry, society and governmental level. In time, hydrogen and fuel cell technology can potentially eliminate transportation emissions without sacrificing the benefits of the current technology.

ABOUT THE PROJECT

Title: The Future of Hydrogen and Fuel Cell Technology in the Sustainable Socio-Technical Transition Processes of the Danish Energy System

Schedule: Aug. 2011 to July 2014

Main supervisor: Prof. Michael Evan Goodsite

Co-supervisors: Torben René Jensen and Andreas Schotter

Research section: Business Development Engineering, AU Herning, Center for Energy Technologies

Contact: kristiana@hiv.au.dk



GARETH EDWARDS

PROJECT DESCRIPTION: Carrying out agricultural operations at an opportune time can have great benefits, both for the field/environment and for the farmer.

The aim of the project is to develop a system which is able to evaluate and predict the readiness of many fields, perhaps covering a large area, to determine the best time for given operations to be executed. Furthermore, based on this

evaluation, another aim is to produce a system capable of planning when and where machinery is needed so that operations can be executed in the most efficient manner.

The readiness of a field can be considered as a combination of the trafficability and workability. Trafficability is the ability of the soil to support vehicles without causing irreversible damage, whereas, for harvest, the workability is the maturity of the crop and the grains' moisture level.

Knowing the readiness of all the fields which need to be harvested allows a plan to be made for the order in which the field must be harvested to produce

the best results, rather than simply harvesting the nearest field first. The system can also be used at the beginning of the season to examine the benefits of changing production to different non-traditional crops, or to see the benefit of investing in new machinery.

ABOUT THE PROJECT

Title: Development of a Field Readiness Indicator and Decision Support System

Schedule: Sept. 2010 to Feb. 2015

Main supervisor: Senior Researcher Claus Grøn Sørensen

Co-supervisor: Senior Researcher Lars Munkholm

Research section: Mechanical Engineering

Contact: gareth.edwards@eng.au.dk



VICENT GASSO

PROJECT DESCRIPTION: The general objective of the project is to explore and advance the existing methods to assess sustainability of agricultural supply chains. Specifically, it aims to shed more light on the optimum assessment scope design in terms of physical boundaries and degree of specificity for efficiently informing about the sustainability performance of agricultural systems.

To develop a design approach sensitive to a wide range of challenges present in the global agricultural market, two case studies from very different contexts are analysed:

- 1) the supply chain of the maize energy-crop production in southern Denmark and
- 2) the supply chain of the Sustainable Winegrowing framework in New Zealand. The project results will provide an assessment framework that stimulates stakeholders' trust and learning which, in turn, will help to enhance change towards more sustainable agricultural production systems.

ABOUT THE PROJECT

Title: Assessing Sustainability of Agricultural Supply Chains: Scoping the Assessment in a Pluralistic World

Schedule: June 2011 to June 2014

Main supervisor: Senior Researcher Claus Grøn Sørensen

Co-supervisor: Ass. Prof. Frank W. Oudshoorn

Research section: Mechanical Engineering

Contact: vicent.gasso@eng.au.dk



HANS HENRIK PEDERSEN

PROJECT DESCRIPTION: Wide span is a new tractor concept that allows you to grow crops in wide beds. The tractor is wide when driving in the field. When transported, it is long and narrow. By use of wide span, tractors' compaction of the soils due to field traffic can be reduced to cover approximately 10% of the field area only.

The overall hypothesis of wide span technology on farms is that crops can be produced at lower costs and with reduced environmental impact compared to traditional growing systems. During my project I will:

- specify design requirements for growing systems and a wide span technology. These are based on structured interviews with potential farm users from Europe, Australia and New Zealand
- evaluate the impact of a compaction on the soil conditions. This was done through a field trial with onions
- assess the environmental impact of the wide span growing system compared to traditional growing systems



KUN ZHOU

PROJECT DESCRIPTION: Most agricultural field operations, e.g. sowing, fertilising and harvesting, require a vehicle, e.g. a tractor with an implement, to drive in the field along a route such that the field area is completely covered.

The farmer is interested in finding an optimal field coverage plan in order to minimise the time, distance or fuel spent, and at the same time minimise areas with missing or overlapping

treatments. In farming operations, multiple operations have to be performed during the annual production of a crop and any one of these operations may have its own operational feature, e.g. working width, working speed, etc. In order to achieve the maximum field efficiency in the system, there is need to develop an approach for predicting the overall operational performance of all machines in a crop production system and the operational costs.

The overall aim of this research is to develop algorithms and models for optimised coverage planning supported by web-based applications. This aim involves three specific challenges: The first is to find the optimal route for the

ABOUT THE PROJECT

Title: Wide Span Technology for Efficient and Environmentally Friendly Vegetable Production

Schedule: March 2011 to July 2014

Main supervisor: Senior Researcher Claus Grøn Sørensen

Co-supervisors: Ass. Prof. Frank W. Oudshoorn and Senior Researcher Lars Munkholm

Research section: Mechanical Engineering

Contact: hansh.pedersen@eng.au.dk

agricultural vehicles to cover a field with multiple obstacles, e.g. trees and wet areas. The second challenge is to develop a model for simulating the machines' activities, e.g. fertilising, spraying and transporting the grain. Farmers can then use the model as the decision-supporting tool. The third challenge is to develop a web-based coverage path planning system that can provide farmers with timely and helpful decisions ahead of the field operations.

ABOUT THE PROJECT

Title: In-Field Coverage Planning with Multi-Objective Optimisation in Field Operations

Schedule: Feb. 2012 to Jan. 2015

Main supervisor: Senior Researcher Allan Leck Jensen

Co-supervisor: Senior Researcher Dionysis Bochtis

Research section: Mechanical Engineering

Contact: kun.zhou@eng.au.dk

inferior convergence rates compared to high order discretisation methods such as spectral element methods. It is therefore desirable to further develop spectral methods to obtain detailed information about flow processing in complex geometries for complex fluids.

The aim of the project is to develop an in-house CFD code based on spectral discretisation techniques with an emphasis on a stable description of the in-stationary formulation. The application will be used to characterise and extract detailed information about the flow field of the high shear mixer from GEA with the objective of optimising their design with respect to energy consumption.



KENNET OLESEN

PROJECT DESCRIPTION: GEA-Liquid in Skanderborg, Denmark is developing liquid/liquid mixing equipment for the dairy, food and pharmaceutical industry.

To further develop and optimise their mixing processing equipment, it is mandatory to obtain a better understanding of the dynamics of mixing. A common mixing situation at GEA-Liquid involves two or more immiscible fluids such as

water and oil. To form a stable, homogeneous emulsion, large shear forces are required which a high-shear mixer can produce.

Solution of momentum equations for complex liquids in complex geometries requires use of advanced numerical methods. A system of partial differential equations is the basis for the mathematical model used to describe the motion of fluids. Different discretisation techniques such as finite difference, finite volume and finite element methods have been developed to reduce the differential equations to an algebraic system. Although the mentioned discretisation methods are being used to solve flow problems, they suffer from

ABOUT THE PROJECT

Title: Liquid/Liquid Mixing of High Viscous Fluids

Schedule: June 2013 to May 2016

Main supervisor: Assoc. Prof. Bo Gervang

Co-supervisors: Prof. Henrik Myhre Jensen and Marc Gerritsma

Research section: Mechanical Engineering

Contact: keol@eng.au.dk



MARTIN ANDREAS FALK JENSEN

Industrial PhD, CLAAS Agrosystems

PROJECT DESCRIPTION: The objective of this PhD project is to provide methodologies and the corresponding software systems for the optimisation of tasks performed by vehicles involved in field operations including both primary units, e.g. combine harvesters and organic fertiliser applicators in area coverage tasks, and supporting units, e.g. transport carts in in-field

and inter-field travelling tasks.

The selected optimisation criteria include the minimisation of

- 1) fuel consumption,
- 2) soil compaction and
- 3) operation completion time.

Advanced research methodologies originated from the engineering management discipline are being developed in order to match the complexity of the biological systems and provide robust solutions for operations

executed in a natural environment. In parallel, the practical realisation of the developing methods is of high concern.

ABOUT THE PROJECT

Title: Real-Time Optimised Path Planning for Machinery in Agricultural Field Operations

Schedule: Nov. 2010 to July 2014

Main supervisor: Senior Researcher Dionysis Bochtis

Co-supervisor: Senior Researcher Claus Grøn Sørensen

Research section: Mechanical Engineering

Contact: martinf.jensen@eng.au.dk



MADS KRABBE

PROJECT DESCRIPTION: Hard coatings can be applied on materials to enhance their mechanical properties. The coatings can be applied on e.g. cutting tools which can be coated to enhance wear resistance, or on gears and bearings to reduce friction and enhance life.

In this interdisciplinary project between Department of Physics and Astronomy and Department of Engineering, the aim is to develop

methods to link microstructural characterisation with measurements and calculations of the coating system including the mechanical and especially the fracture mechanical properties.

The mechanical data will be obtained by nano-indentation which yields hardness, Young's modulus and possibly creep. By comparing nano-indentation data with theoretical fracture mechanical models, quantitative values of fracture toughness are obtained. Better understanding of the fracture mechanisms in hard coating and the influence of coating/substrate interaction on the fracture mechanisms is also needed.

To understand the wear properties of a coating, it is of paramount importance to know both the hardness and the fracture toughness. It is of key interest in the project to establish a link between the mechanical and fracture mechanical properties and the wear resistance of the coating.

ABOUT THE PROJECT

Title: Optimal Mechanical Properties of Nano-Composite Hard Coatings

Schedule: April 2010 to March 2014

Main supervisor: Prof. Henrik Myhre Jensen

Research section: Mechanical Engineering

Contact: makr@eng.au.dk



JENS LYCKE WIND

PROJECT DESCRIPTION: The project concerns stability analysis of composite material subjected to compressive loading.

In 1996 Christoffersen and Jensen developed a smeared out constitutive model that could describe the deformations of a unidirectional fiber composite. To verify this model, a discretised model of the fiber composite is being developed.

With this verification, the weak spots of the smeared out model can be classified and a guideline of usage can be developed.

The reason for examining this is that composite materials are much weaker in compressive load than in tensile load. For that reason, the industry would like to gain a greater insight into the failure mechanisms associated with compressive loading failure of composite materials. By mapping mechanisms of deformation, we can better exploit the good properties of composite materials and thereby produce lighter and stronger structures.

The results of the research can be applied in all contexts where composite materials are used, e.g. the wind turbine-, aerospace- and automotive industries, and can contribute to developing the green energy sector.

ABOUT THE PROJECT

Title: Compression Analysis of Unidirectional Fiber Composites

Schedule: Aug. 2011 to Nov. 2014

Main supervisor: Prof. Henrik Myhre Jensen

Research section: Mechanical Engineering

Contact: jlw@eng.au.dk



ALEX MØBERG

PROJECT DESCRIPTION: The focus of this project is on the non-linear material model which can be used in calculations of fiber composite. The model has been derived analytically in 2D and has been implemented in the Abaqus finite element software package.

The further work in this project will involve testing and implementing the model in the commercial finite element software Nastran/Marc to

be able to efficiently analyse real structural components to final failure. Afterwards, the model will be generalised into a 3D model.

Once the model has been built in, it can be applied to study effects such as buckling including buckling-driven delamination, elastic spring back due to residual stresses etc.

ABOUT THE PROJECT

Title: Simulation of Composite Structures based on Micro Mechanical Modelling

Schedule: Sept. 2013 to Aug. 2016

Main supervisor: Prof. Henrik Myhre Jensen

Co-supervisor: Prof. (Docent) Flemming Mortensen

Research section: Mechanical Engineering

Contact: alexm@eng.au.dk



PER CHRISTIAN HYLDAHL

PROJECT DESCRIPTION: When designing complex mechanical systems, design engineers often turn to computer-aided engineering tools to help them in the design process.

If the mechanical system is dominated by large rigid-body motion rather than deformations, multibody dynamics can be used. In recent years, the multibody approach has been expanded to incorporate deformations to enhance

simulation results and gain detailed insight into the performance of systems that include components that cannot be assumed rigid.

Current methods for modelling flexible components in the multibody framework are limited by assumptions of small and elastic deformations. Tendencies in later years' product development have challenged the capabilities of these methods to the utmost. Especially the design of large, slender and lightweight component, such as wind turbine blades is in need of new and specialised modelling techniques. Such techniques must be able to capture complex deformations due to large and time varying loading scenarios.

This PhD project aims to investigate current state-of-the-art research within methods for modelling components that undergo large deformations. The focus of the project is on formulation and modelling techniques but with the applicability and computational performance kept in mind.

ABOUT THE PROJECT

Title: Nonlinear Flexible Bodies for Multibody Simulation

Schedule: Aug. 2011 to July 2015

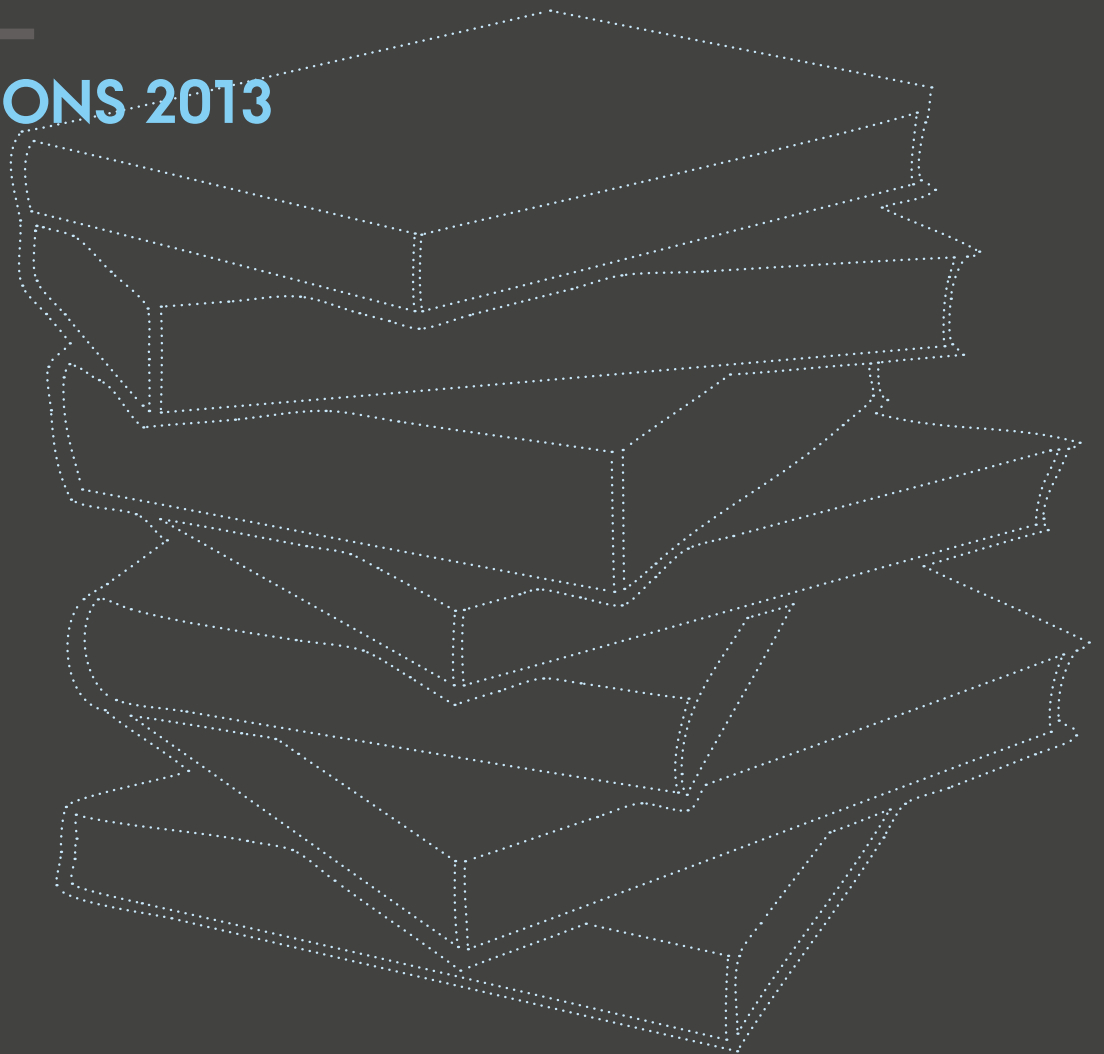
Main supervisor: Prof. (Docent) Ole Balling

Research section: Mechanical Engineering

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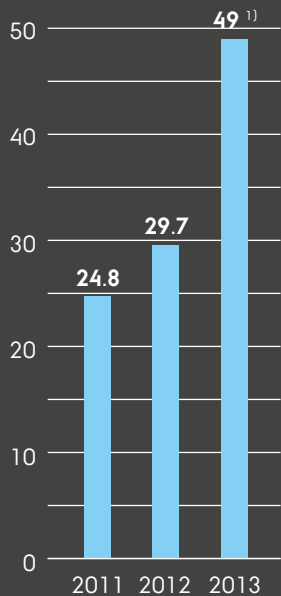
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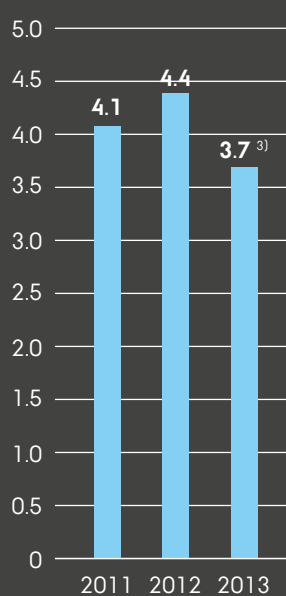
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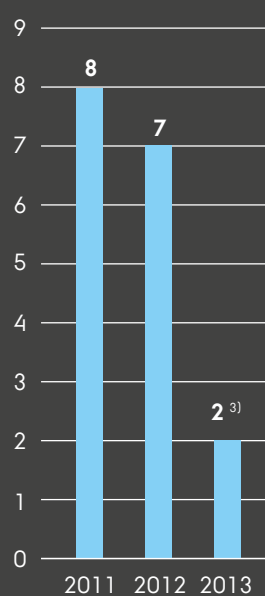
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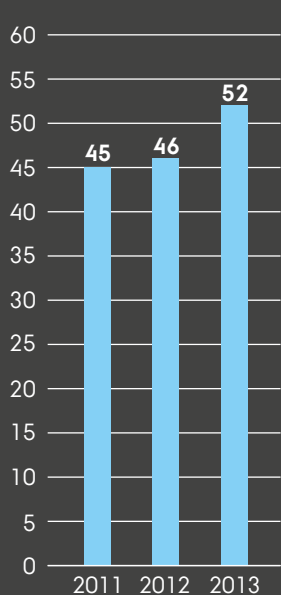
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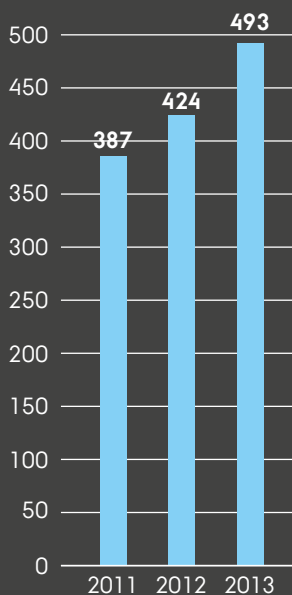
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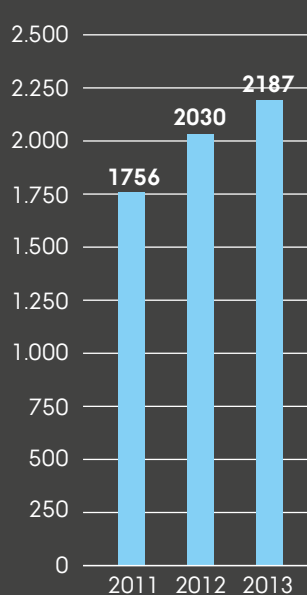
NUMBER OF
ENROLLED
PHD STUDENTS⁴⁾



MASTER'S DEGREE
STUDENTS
IN ENGINEERING



BACHELOR'S DEGREE
STUDENTS
IN ENGINEERING



1. Partly based on budget estimations

2. Senior VIP: Professors, Professors (Docent), Senior Researchers and Associate Professors

3. Calculated based on data from 1 November 2013

4. Number of PhD students enrolled on 31 December

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