

MATERIALS

AT THE DANISH TECHNOLOGICAL INSTITUTE



**DANISH
TECHNOLOGICAL
INSTITUTE**

Materials – a prerequisite for welfare

The development of materials has always been a cornerstone in the development of our society and welfare. Not least these years, where Denmark, while recovering from an exhausting financial crisis, is looking into a changed global competitive market where differentiation and the development of niche products are prerequisites for marketing products.

The choice of materials and intelligent use of the new opportunities offered by materials research are important parameters for continued production in Denmark.

This is not solely a Danish challenge, but to a large extent an international challenge. Therefore, the European Commission, among others, has

designated Advanced Materials as one of five Key Enabling Technologies (KET) for the European industrial production industry. Under the programme Future and Emerging Technologies (FET), the EU has identified new materials as a core area of research, eg. the graphene initiative – a so-called FET Flagship.

New materials and forms of production emerge at an increasing pace, and concepts such as Manufacturing Materials, nanomaterials, graphene and other carbon nanomaterials flourish. One of the main challenges is how new materials, and the opportunities they create, can be incorporated into an industry where traditional materials such as iron, steel and plastics are dominant, readily availa-

ble and proven. It requires foresight and courage of the individual industry to embrace these new opportunities. DTI focuses on lowering companies' barriers for introducing new materials and production technologies into their value chains by offering know-how, hands-on experience and pilot-scale production at an early stage in the decision process.

DTI was founded with the aim of addressing the industry's need for help, support, training and inspiration during the first industrial revolution at the beginning of the 20th century. Today, on the verge of the next industrial revolution – "Industry 4.0" – we continue to carry this responsibility.



Welcome to Materials at the Danish Technological Institute

The Materials division is based on many years of experience within development and application of materials in industrial contexts. We participate in research and development together with top universities and research institutes and we offer consultancy to the industry on materials-related opportunities and challenges.

In our division, we cover the interaction between new and advanced materials, process technology and efficient forms of production. It is our clear focus to contribute to the development of next-generation high-value products and manufacturing processes. The use of new technology makes radical innovation possible throughout the value chain from concept development to pilot scale production and

it is our goal to create new business opportunities in Denmark.

We also offer consultancy services within traditional materials applications, and our specialised laboratories cover misidentification, durability tests, strength assessment, materials analyses, lifetime and residual lifetime assessment and as certification and inspection tasks on all traditionally used materials. You are therefore in safe hands when discussing new opportunities versus traditional solutions with us – we simply have knowledge and experience from both camps.

The division represents more than 120 highly qualified specialists and experts, ensuring incorporation into

the challenges of the industry. We have participated in more than 100 research and development projects over the past five years, and we serve more than 3,000 unique customers each year.

In this booklet, you can find out more about the analyses, services, project partnerships and research and development that we offer. You can also see examples of cases and projects that we have carried out for customers and in collaboration with companies and other knowledge institutions. If you have any questions, please do not hesitate to contact us.

Mikkel Agerbæk, Vice President, Materials

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A photograph of Mikkel Agerbæk, a man with glasses wearing a white shirt and a dark blazer, standing in a laboratory or industrial setting. He is positioned to the right of the frame, looking towards the camera. In the foreground and background, there is complex industrial machinery, including a large cylindrical component and various pipes and cables. The background shows a wall with horizontal slats.

– DTI helps companies implement the latest production methods and materials in the high-tech products of the future with a view to turning Denmark into a world-class production country.

Mikkel Agerbæk, Vice President, Materials

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The Materials division at DTI holds a strong concentration of knowledge within advanced materials and the processes and value chains associated with materials.

The division takes part in ensuring that Danish production companies are at the forefront of the development of materials in Denmark and abroad. This way, companies are provided with unique opportunities for tailor-made properties in a market of fierce competition.

Our employees are among the leading experts within the fields of materials design, process techniques, surface technologies, bulk properties, 3D print and nanocomposites, among others.

In our laboratories we also have advanced equipment allowing us to develop, analyse and document highly specialised systems, eg. within packaging and materials for new energy applications.

Facilities and areas of expertise

The Materials division has one of the largest and most comprehensive materials laboratories in Denmark. On this basis, we offer a wide range of services to Danish industry; including accredited laboratory testing, advanced material analysis, accident and failure analysis, type testing, process and product consultancy, research and development activities and dissemination of knowledge. We hold a leading position within the following areas:

- Consultancy, development and production of ceramic coatings
- Testing and simulation of packaging concepts as well as transport testing and simulation of packaged products
- Scanning electron microscopy (SEM), X-ray surface analysis and micro CT scanning
- Analyses of polymers, metals and medical devices
- Weathering, salt spray, QUV and corrosion testing
- Additive Manufacturing, prototyping and metrology analyses
- Manufacturing of catalytic gas cleaning components and membrane-/barrier systems
- Supercritical and polymer-based synthesis processes
- Auto ID test centre
- Pilot production of surface coatings, including nanofilm, thin films, nano structures and Sol-Gel coatings
- Advanced ion implantation, CVD and PVD coatings
- Certification in accordance with the Machinery Directive, ATEX, PED etc.

In addition, we cooperate with other specialised divisions at DTI when specific professional competencies are required. In total, DTI has more than 1,000 academically qualified experts who can be mobilised in solving your particular challenge.



We can help you with

Testing and analysis

- Accident investigation and error analysis
- Technical documentation and quality control
- Function testing and modelling
- Accredited mechanical testing of metals, plastics and composites (DANAK)
- Materials selection and substitution
- Modelling of the physical properties of products and packaging
- Life-cycle analysis and assessment
- Consultancy services within scale-up and production optimisation
- Prototype testing
- CFD analyses and advanced FEM modelling

Certification and inspection

- Approval of statutory requirements for packaging
- CE-marking of building materials
- Quality system for welding workshops
- Certification of production companies
- Statutory inspection of rides (amusement parks etc.)
- Certification of transportable constructions
- Machinery Directive, ATEX and pressure equipment: CE marking, consultancy, type testing, training and certification

Pilot production

- Functional surfaces based on thin films, glass ceramic coatings or polymer systems
- Additive Manufacturing (AM), 3D printing in metal and plastic
- Shift in production to AM-based technology
- Extrusion and compounding in nano-composites and polymeric materials
- Advanced functional packaging systems

Research and development

- Development of specific functionality optimised surface coatings
- Prototype development, analysis and testing in the development process
- Development of packaging, packaging materials and packaging functionalities
- Modelling of long-term properties of polymers and composites
- Modelling of the properties of advanced 3D-printed designs
- Development, testing and field testing of test reactors for catalytic processes and gas cleaning

and much more



Skræddersyede digitale løsninger

Case: Bæredygtig og sikker transport

Case: Bæredygtig og sikker transport

Vindtjenester til farmaceutisk industri

Klimatiltagene i udførelse

Case: Bæredygtig og sikker transport

Katalysematerialer

Vindtjenester til farmaceutisk industri

Case: Bæredygtig og sikker transport

Katalysematerialer
Hvordan performer de og hvorfor?

The Factory

Reduce the risk of investment with high-tech pilot production

Investing in new technology and new production facilities can be a rather expensive and risky affair. As a result, the process leading up to the production of new products often takes much longer than necessary. Projects may even come to a complete halt due to "bugs", malfunctioning and general uncertainties. However, it does not have to be like this. DTI offers profound technological know-how and an opportunity to lower the implementation barriers for new technologies through pilot production. This allows you to generate revenue and test your products on the market without large initial investments.

For years, DTI has made facilities available to Danish companies, but we are also looking into using the facilities in an innovative way in order to develop new services, which provide Danish companies with an easier path to testing and implementing high-tech components in their products. The target group is in part small start-up companies with a need to be able to document their ideas/products and in part well-established SME's and very large companies.

– Small companies, in particular, experience barriers in terms of improving existing products or

introducing new products on the market, even though they may have a viable and sustainable idea. These companies have considerable and unfulfilled potential, and in collaboration with DTI they can create both growth and new jobs, says Mikkel Agerbæk, Vice President, DTI.

DTI invites companies to enter into a collaboration with the goal of developing, testing and establishing high-tech product development and production in Denmark.



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– Other European countries have come far in terms of supporting businesses through pilot production of advanced components and high-tech products – we must strive to do the same.

SYNERGY: Intelligent business with the *Industrial Internet of Things*

In the coming years, data-driven innovation and development will have a decisive influence on speed of innovation and opportunities of growth. This is concluded by analyses and foresights in Denmark and abroad.

In many ways, companies covered by a requirement of traceability today are one step ahead of the trend. These companies are used to securing large volumes of data, and with intelligent linking of traceability data with other Big Data, they have a unique opportunity to predict market development with a link to the company's competences.

Industrial Internet of Things (IIoT) is the combination of Big Data and Internet of Things (IoT), where the use of sensor technology makes it possible to measure, connect, control and estimate processes and products in ways that were not possible before and thereby create a basis for traceability, automation and identification of new sources of innovation.

The food sector is one area covered by a requirement of traceability of all materials in direct contact with food due to consumer safety. The requirement applies to the entire supply chain and covers producers

of raw materials and packaging materials in direct contact with food.

Today, a number of technologies can be used to ensure traceability while at the same time making it possible to collect and analyse Big Data, such as identification, temperature, humidity, pressure and location; technologies that can be adapted to specific needs and at prices that make the application both interesting and profitable for companies.

With a valid data basis, companies can go from being just proactive to being able to predict developments and adjust strategies accordingly.



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NETWORK: BigScience.dk lights the path to big business

The Danish Big Science Secretariat (BigScience.dk) is a successful link between Danish companies and the major European research infrastructures, colloquially referred to as Big Science facilities – eg. CERN, ESS, ESRF, ITER, ESO and MAX IV.

BigScience.dk aims at providing Danish companies with the optimum prerequisites for winning commercial Big Science contracts – leading to competency- and innovation boosts in the companies. At BigScience.dk, we collect knowledge about the Big Science organisations and their technologies. In addition, we develop new knowledge, gene-

rate networks and offer commercial and technological services making it possible for companies to achieve their goals.

– There are plenty of highly qualified companies in Denmark with relevant competencies that are capable of entering into complex and high-tech contracts with Big Science facilities. We make sure that potential suppliers receive the necessary information and develop a strong network in relation to the Big Science facilities. BigScience.dk ensures not only increased earnings in Denmark; it also generates the boost needed to put Danish companies on the Big

Science map of the world.

As a result, the competitiveness of the companies involved increases, says Juliette Forneris, Manager of the Danish Big Science Secretariat.

BigScience.dk is a collaboration between the Danish Technological Institute and the Technical University of Denmark. It is funded by the Danish Agency for Science, Technology and Innovation with additional support from the Capital Region of Denmark and the European Regional Development Fund. Today, BigScience.dk has a large and extensive network of qualified companies, which actively pursue Big Science contracts.



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Become a Big Science supplier

Read about the demand in the Big Science market, how your company can join the network and be inspired by other companies' success stories at www.bigscience.dk and www.english.bigscience.dk

Illustration: European Spallation Source



Tribology Centre

– The surface is right where the interaction with the surroundings takes place, and with customised surface properties the impossible becomes possible.

Research, development and production of optimised surfaces generate new products, less maintenance and increased productivity through new and innovative solutions. In essence, we can apply entirely new surface properties to materials.

The only limit is your imagination.

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CASE: Optimised properties with the right surface coating

Using vacuum-based evaporation processes it is possible to customise coatings with specific properties and thus translate creative ideas into design-optimised products.

This has been demonstrated by DTI in close collaboration with the Danish company Raidho Acoustics – a renowned producer of high-end loudspeakers. The company's loudspeakers have repeatedly been announced best in the world.

Raidho Acoustics wanted to develop a loudspeaker membrane

with a very high level of stiffness, in order for the membrane's natural frequencies to be extended beyond the audible range, but at the same time with a low mass to ensure fast response time. A development process with DTI resulted in a sandwich structure with, on the one hand, great stiffness, and, on the other hand, muted amplitude on the membrane's natural frequency.

The solution was a customised diamond-like carbon (DLC) coating with a thickness of only a few micrometres with underlying layers

supplying the substantial stiffness required for this application.

– We found DTI's willingness to take a risk during the development phase to be very important to us, says Michael Børresen, Executive R&D Manager, Raidho Acoustics.

– Also, DTI has the facilities to take on a volume of production that suits our needs as an SME. This has been an important match in terms of guaranteeing the continued growth of our company, Michael Børresen adds.



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Diamond-like carbon (DLC) coatings are widely used as a hard, durable low-friction coating. The coating is often used on components to reduce friction and can, in some cases, eliminate lubrication with oil. Moreover, in many cases, galling can be eliminated with a DLC coating due to the self-lubricating properties of the coating.

CASE: Danish high-tech in European super-telescope in Chile

DTI and the Danish company Polyteknik A/S have joined forces in mapping a coating system for the European astronomy flagship, VLT (Very Large Telescope), located on a Chilean mountaintop in the Atacama Desert at an altitude of 2,300 metres. VLT is run by the European Southern Observatory, ESO.

– This is an outstanding result of a close collaboration between DTI and Polyteknik A/S, facilitated by the Big Science Secretariat. Owing to the unique network and our combined competences, we succeeded in winning the ESO contract, says Lars Pleth Nielsen, Director, DTI.

The VLT observatory consists of several telescopes, including four large telescopes, each with a primary mirror with a diameter of eight metres. Over the years, the four telescopes have explored space and made several epoch-making discoveries. Also, the telescopes are able to work together so that their vision in space corresponds to that of an observatory with a 200+ metre diameter mirror.

The surfaces of the mirrors must be re-coated at suitable intervals in order to catch the light from stars and galaxies far away. The coating equipment is designed to coat the

large mirrors, which are the core components of the telescopes.

– We must admit that it is not without a certain sense of pride that we send our people to the other side of the Earth to help validate the condition of the most critical components in the equipment used to coat the world's biggest mirrors for the largest telescopes on earth, says Jens William Larsen, Owner of Polyteknik A/S.

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Photo: European Southern Observatory, ESO



Packaging and Logistics

– Packaging and Logistics has considerable nationally and internationally recognised competencies within advanced packaging technologies.

We assist Danish food companies with innovative solutions to strengthen their competitiveness, so that Denmark can gain a share in the great potential of high-tech development.

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CASE: Bottles made from recycled paper and sand

The paper company EcoXpac A/S and DTI have developed a prototype of bottles made of fibres from recycled paper. The biodegradable bottles can replace plastic bottles and be recycled as paper waste. When discarded in nature, the bottles will naturally dissolve and become part of nature's cycle – with no pollution whatsoever.

– The new bottle is made from paper and beach sand. Production is cheap, it can be used directly in all filling plants, and later it can be reused, recycled and incinerated or composted, says Søren Rahbek Østergaard, Team Manager, DTI. EcoXpac A/S has developed a pilot production unit for production of the

fibre bottle. The raw material is new and recycled paper, which is mixed with water in a large pulp blender. The mixture is then moulded into the shape of a bottle by use of a vacuum. The production unit is able to produce the fibre bottles in immediate connection with the filling plant at the producer's facility.

– Empty packaging is expensive to transport, so the most effective solution is to produce the fibre bottles as close as possible to the filling plants. This way, the compact paper fibres can be sent directly to the food producer, and recycled paper from the local area can become bottles, says Martin

Petersen, CEO, EcoXpac A/S.

DTI and EcoXpac A/S are in the process of developing a waterproof coating based on beach sand or other sustainable materials to replace the conventional plastic coating on the bottle's interior. The project is supported by the Danish Market Development Fund and is part of the innovation initiative 'Production in Denmark', which aims to strengthen the competitiveness of Danish companies.



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CASE: High-tech packaging for use in the microwave oven

Foods compete on obvious parameters such as quality and price but also on convenience, ie. products aimed at the busy and conscious consumer who buys ready-made foods in order to save time.

The microwave oven is ideal for this particular product segment as it allows the consumer to heat a meal in a matter of minutes using very little energy.

In a busy everyday life, foods that can be heated in a microwave oven such as bread, pizzas and hamburgers are very convenient, and in general, demand for microwave foods has increased –

not only for bread products but also complex ready-made dishes. Consumers want less cooking time without compromising on taste, high nutritional value and quality experience – they want the traditional experience of a home-cooked meal. Microwave products rarely live up to this and the problem is quite simple: Low-tech packaging that is not optimised for use in microwave ovens will destroy any good quality and taste experience. For instance, frozen bread products are challenging to cook in a microwave oven because of the textural changes that occur when heating bread straight from the freezer.

DTI is currently working on controlling the microwaves inside the packaging in order to cook the food similar to conventional ovens, ie. warm all the way through and with a crispy crust on bread and pizzas.

With the correct technology – almost invisibly embedded in the packaging – the microwave oven can easily compete with the conventional oven in terms of quality. Imagine if it was possible to bake a ready-made frozen rye bread in 12 minutes or a pizza with a crispy crust in just five minutes.

It is not easy but DTI has the advanced resources to find the best solution.



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Plastics Technology

– As the industry's demands for product quality, durability and documentation increase, the companies' need for development, testing and consultancy on materials increases with it. Plastics Technology offers a range of services to help companies achieve their goals, when the boundaries for properties and application areas of plastic materials are challenged.

To many companies, reductions in energy consumption and resources are also important factors. Therefore, we also focus on new energy technologies and recycling – always with materials and processes as our primary focus.

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CASE: Polymer materials for 3D printing

With 3D printing technology it has become possible to quickly convert concept ideas into prototypes or direct production of small batch sizes.

As the market of 3D printing grows, many SMEs procure their own 3D printers melting or sintering together polymer powders layer-by-layer to form components and final products. Polymer powder as well as 3D printers are relatively cheap; however, the young technology needs to be improved and tested and the polymer material must be adjusted and tailored to the company's needs.

Plastics Technology has expert knowledge and advanced laboratory facilities to accomplish this task. We offer to assist companies during the entire process from needs analysis and consultancy to development and qualification of material properties.

3D printer manufacturer, Blueprinter, teamed up with DTI to optimise its printing processes and materials use through a development process.

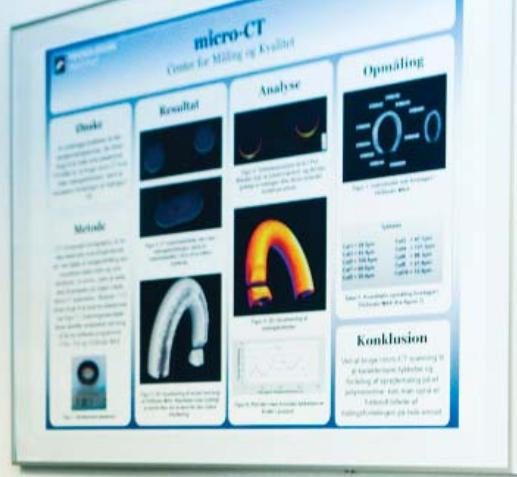
Blueprinter obtained, among other things, greater theoretical and measurable knowledge of the polymer material they use for 3D printing, including powder

composition, particle size and distribution and melting point. The sophisticated thermal and chemical analyses and micro CT scanning carried out in the analysis laboratory at DTI provided the company with a solid data base for developing the reproducibility and optimising the printing process.





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PROJECT: New Danish technology for gasification plants

Denmark is a global leader in the transformation from fossil fuel to renewable energy sources. One of the promising technologies that will become important in the future energy system is gasification of biomass eg. wood and straw. It opens for multiple utilisations, eg. direct fueling of a gas turbine driven CHP plant or further catalytic conversion into methane or liquid fuels.

The gasification gas is a so-called synthesis gas, consisting primarily of hydrogen, H₂, and carbon monoxide, CO. Biomass gasification, however, develops a significant

amount of tar, which contaminates the catalyst converting the synthesis gas into eg. liquid fuel.

In order to render biomass gasification more attractive, it is therefore necessary to develop the next generation of tar reforming technologies. In collaboration with Haldor Topsøe, DTI has developed a mobile pilot reactor for chemical processes. The mobile pilot reactor is an important step of the journey towards increasingly flexible and financially sustainable use of biofuels.

DTI is now testing catalytic

cleaning of gasification gas from gasification of straw. When gas cleaning reactors are integrated into large straw gasification plants, it will allow the gasses to be used directly in eg. gas engines for efficient production of heat and electricity. In the long term, gasification gas from gasification of straw may be converted into liquid fuels or synthetic natural gas.





With gas cleaning of synthesis gas from gasification of biomass, you can take the important step towards sustainable production of cleaned bio fuels in collaboration with DTI.



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Functional Coating



– There is an optimum surface treatment for any material, any product and any process. Our finest task is to ensure that only the optimum surface treatments are applied to our customers' materials and products and in our customers' processes. Whether they are small components for the medical industry or large processing plants for offshore oil production.

On the basis of a unique coating technology, we develop, test, produce and apply coatings with properties tailored to the materials they must be applied to and the circumstances under which the materials are to be used under.

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CASE: Coating technology for oil production

Process equipment surfaces that are in contact with crude oil extracted from the underground are exposed to various types of fouling. Often, this results in the formation of considerable deposits in the process equipment. Deposits may be organic and inorganic, eg. waxes, asphaltenes, limestone, barium carbonate etc. In the production line, such deposits cause the unit processes to foul out, increasing the need for maintenance and ultimately leading to costly production shut-downs.

Problems with fouling in offshore process equipment are increasing

due to the fact that retrieved oil now contains significantly larger amounts of unwanted material than previously. The increase in fouling is caused by increasing volumes of crude oil being extracted from known oil reservoirs primarily due to improved oil recovery technologies, which make it possible to optimise the utilisation rate of the individual wells.

DTI has developed an entirely new type of coating. The coating is a so-called Sol-Gel-derived glass ceramic hybrid coating named CORE Coat (Crude Oil Repellent Coating) O10 – or in short CC010 – which prevents

oil deposits, dirt and fouling from accumulating in the production equipment. With the CC010 coating, plate heat exchangers can be operated up to four times longer before service procedures are needed. In the period from the preliminary tests in the North Sea in 2009 and till today, DTI has coated more than 10,000 plate heat exchanger plates for oil and gas customers. Today, the coating service is available to the entire industry.



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PROJECT: Ice-repellent surfaces for industrial processes

In industrial processes, unwanted formation of ice on surfaces can have many and serious consequences. Falling ice from wind turbine blades poses a danger, and ice may reduce the electricity production and increase wear and tear of the turbine. Ice on aircraft wings poses a security risk and increases fuel consumption, and in freezers and heat exchangers ice reduces efficiency and increases energy requirements.

In an ongoing R&D project, DTI is developing surface treatments that minimise the accumulation of ice on surfaces. The innovative coatings apply various strategies that affect the accumulation of ice, eg. by

reducing the adhesion of ice, by lowering the freezing point of condensed water and by preventing ice from spreading over larger areas.

In a newly developed advanced test chamber, temperature, humidity and airflow is controlled while a timelapse video is recorded of the accumulation of ice. In doing so, it has been possible to get detailed insight into how different structures and surface treatments affect the icing process. This insight has been used in part to develop three innovative coatings; anti-icing coatings, coatings with reduced adhesion of ice and coatings which effectively reduce accumulating ice, and in part to achieve a

better understanding and control of the processes causing condensation.

Through industrial- and product-oriented projects, Functional Coating is adding to a unique knowledge base, which forms the basis for commercial products and services. In addition to our solid basis in coating chemistry, DTI has unique insight into ice adhesion problems as well as many other, surface-related issues. DTI therefore offers a unique combination of knowledge to Danish producers of eg. HVAC control systems, heat pumps, air-to-air heat exchangers and other components that are exposed to unwanted icing.

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Metal and Surface Technology



– Optimum utilisation of materials provides Danish production companies with a platform upon which to develop new components and products in global supplier chains. We help companies realise the full potential of the materials. On the basis of a strong metallurgical and test technical knowledge base, DTI seeks new solutions globally and test them in accordance with standards, perform state-of-the-art analyses and adjust experimental setups to customer's specific needs – always under strict confidentiality and integrity.

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PROJECT:

Industrial applications of magnets

In cooperation with Danish industrial companies within the framework of the innovation consortium REEgain, DTI is developing new knowledge in the field of corrosion of permanent magnets and functional testing of components and systems with permanent magnets.

Over the past five years, permanent neodymium magnets have seen an industrial breakthrough, and today, they are used in, among other things, electric motors for e.g. the automotive industry, hard disk drives and magnetic bearings/couplings.

The application of permanent magnets provides manufacturers with exciting new opportunities; however, often the need to protect the magnets against environmental influences or carry out functional tests that reveal possible reasons for failure during the lifetime of the products is underestimated.

Neodymium magnets are very sensitive to corrosion attacks due to their chemical composition and microstructure. If used under wrong conditions even surface protected magnets may lose 75 % of their magnetism in only a few weeks due to corrosion.

DTI helps companies find the correct corrosion protection coatings to avoid component breakdowns as well as establish quality requirements for raw materials and coatings supplied by subcontractors.

Magnetic systems and components should be tested in realistic situations through mechanical functional testing and corrosion testing. For this purpose, DTI is an ideal partner in helping to define and carry out tailored test campaigns.



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CASE: Stress testing of welded offshore structures

Currently, significant value creation is taking place in the Danish offshore industry; both related to Danish oil and wind turbine companies, but also from the long line of subcontracting companies.

The harsh offshore environment imposes strict requirements on materials and welded joints. Also, service visits are often very difficult and cost-intensive. DTI tests and validates materials and welding procedures for the leading Danish offshore suppliers and subcontractors. In the field of standardised tests, we are specialised in providing a quick and flexible

service in close collaboration with the customer. Customised tests are planned and carried out in-house or on-site in cooperation with the customer.

The occurrence of cracking, when taking place in highly corrosive environments, is particularly serious for offshore materials and weldings. Advanced tests of the materials' fracture toughness reveal which material solutions and procedures may be applied with advantage. The CTOD test (Crack Tip Opening Displacement) is a fracture mechanics test, which is used in the design, optimisa-

tion and maintenance planning of structures, in particular for offshore purposes. Defects and weaknesses in materials are difficult to prevent from occurring during manufacturing, processing and operation. The CTOD test describes the material's resistance towards preventing a crack from causing a fracture.



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Product Development

– Yesterday, 3D printing was a phenomenon reserved for prototypes. Today, the technology is ready to become part of the production process. The technology shows great potential and it's time for Danish companies to welcome the new possibilities.

Jump into it together with DTI. We optimise CAD designs and produce 3D printed objects for industrial applications, complete with post-processing, quality control and documentation.

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PROJECT: 3D printers to make aircraft and space industry repairs

Every minute an aircraft is grounded is a waste of time and money. The aircraft industry is keenly interested in reducing the time spent on ordinary regular inspections, and not least, actual repairs. DTI is partner in a project under the EU's Seventh Framework Programme, which develops methods for quick and efficient on-site production of aircraft components by means of 3D printers, also known as Additive Manufacturing. 'RepAIR' is the name of the project.

The aim of the RepAIR project is to make future repairs and main-

tenance of aircraft components more efficient by use of Additive Manufacturing. With the help of 3D data files, the technology allows for production and repair of components by adding material on a layer-by-layer basis.

With Additive Manufacturing it is possible to produce spare parts directly on-site. This eliminates much of the waiting time and makes it possible to operate with almost no costly capital locked up in stock. In some cases, the entire supply chain of spare parts can be reduced, which results in consid-

erable cost reductions, in part due to the component price and in part because the plane spends less time on the ground. In addition, the new business models will be sustainable, because, among other things, the new form of production will result in significant material – and thus also weight – reductions (up to 70 %), due to virtually no restrictions in terms of the geometry of the design. The weight savings will result in reduced fuel consumption and thereby more sustainable aviation.



Partners

The RepAIR project partners are leading European and American companies and research institutions, including Boeing, Lufthansa Technik, University of Paderborn, Cranfield University, AIMME, SLM Solutions, Avantys Engineering, Danish Aerotech and APR S.r.l. and ATOS and O'Gayar Consulting.

Find more information about RepAIR at www.rep-air.eu



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CASE:

Production of phono cartridges

Since 2008, the world's largest producer of phono cartridges, the Danish company Ortofon A/S, has been using Additive Manufacturing (AM) for pilot production of its new cartridges. This has resulted in no fewer than four new generations of cartridges (MC A90, SPU 90th, Xpression and MC Anna). The state-of-the-art AM technology, where the product is made in a 3D printer, is used in a central part of the production process.

A creative designing space

Accepting DTI's offer of pilot production with AM has resulted

in much faster product development and time-to-market for Ortofon A/S:

– Additive Manufacturing has given us a bigger creative designing space, because we are no longer limited by a particular geometric shape. We don't produce tools, which means that we've managed to reduce the production process from four to six months to a few weeks. The time factor means that we can now test new ideas, and it gives us an enormous level of freedom, says Leif Johannsen, Chief of Acoustics and Technology, Ortofon A/S.

The perfect sound

Ortofon was one of the first Danish companies to use AM commercially. Today, the company uses AM as a strategic tool in product development, pilot production and batch production of the company's new cartridges, including MC Anna, which was launched in 2012. During this process, Ortofon A/S worked with DTI to optimise the process parameters to ensure that the cartridge obtained the right acoustic properties.



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3D printing technology allows Danish industrial companies to quickly design and print three-dimensional products with complex structures and have them put into production at DTI.

Ceramic Speed is one of the Danish companies cooperating with DTI to apply the latest techniques and use the large degree of freedom in design offered by the 3D printing technology. The company has received input for design and manufacturing of the small light gear wheels located on the back external gear on racing bicycles.



Find more information about the Materials division at www.dti.dk/services



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