PROGRAMME, LIST OF PARTICIPANTS and ABSTRACTS

DCAMM

13th Internal Symposium

Monday, March 14 to
Wednesday, March 16, 2011

MUNKEBJERG HOTEL
VEJLE

TECHNICAL UNIVERSITY OF DENMARK
and AALBORG UNIVERSITY

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Organizing committee:
Erik Lund, Christian Niordson, Ole Sigmund and Mathias Stolpe

Technical Assistance:
Gerda Helene Fogt

Organization:
DCAMM and the DCAMM Research School

General information:

The language of presentation is English.

First year Ph.D. students present in the poster session. The posters should be in A0 format. Please include a picture of yourself in the poster. Second and third year Ph.D. students are given 10 minutes for their presentation and 5 minutes for discussion. All others are given 15 minutes for their presentation and 5 minutes for discussions.

All presenters are requested to send the electronic presentations to Mathias Stolpe (M.Stolpe@mat.dtu.dk) no later than 12.00 on Wednesday 9 March 2011. This is to avoid delays and technical problems between the presentations. All presentations will be available on a provided computer in the conference room. Acceptable formats are Microsoft PowerPoint files (.ppt), Adobe Portable Document files (.pdf) and multimedia files which can be viewed by Windows Media or QuickTime player.

Programme for Monday afternoon, March 14th, 2011

11:30	Arrival
12:00 - 13:00	Lunch
13:00 - 13:05	Welcome and practical information, CHRISTIAN NIORDSON (DTU Mechanical Engineering, 5 minutes)
	1 – SIMULTATIONS (Chairman: NIELS L. PEDERSEN, DTU Mechanical Engineering)
13:05 – 15:10	JENS NØRKÆR SØRENSEN (DTU Mechanical Engineering, 20 minutes) Multiple Vortex Breakdown in Swirl Flows
	JOHANNES T. RASMUSSEN (DTU Mechanical Engineering, 15 minutes) Multi-resolution vortex particle flow simulation
	ALF SØE-KNUDSEN (M-TECH, AAU, 15 minutes) On accuracy of wave number prediction and energy flux calculation by use of wave finite elements analysis
	MICHAEL ELMEGÅRD (DTU Mathematics, 15 minutes) Attracting low-dimensional submanifold of a finite element model
	MUSTAFA ASLAN (RISØ DTU, 15 minutes) Modelling of Stress Singularity in Bimaterial Wedge by Finite Element Modelling
	CHRIS VALENTIN NIELSEN (DTU Mechanical Engineering, 15 minutes) 3D finite element simulations of resistance welding
	HARA NAGA KRISHNA T. PALLETTI (M-TECH, AAU, 15 minutes) Nonlinear thermo-mechanical finite element analysis of polymer foam cored sandwich structures
	VICTOR ZERMANO (DTU Mathematics, 15 minutes) Computation of Superconducting Wind Turbine Generators
15:10 - 15:30	Coffee break
	INVITED PRESENTATION (Chairman: CHRISTIAN F. NIORDSON, DTU Mechanical Engineering)
15:30 – 16:15	THOMAS BUHL (RISØ DTU, 45 minutes) The Challenges of Wind Energy
	2 - OPTIMAZATION I (Chairman: OLE SIGMUND, DTU Mechanical Engineering)
16:15 – 17:00	JOSÉ PEDRO BLASQUES (DTU Mechanical Engineering, 15 minutes) Optimal design of laminated composite beams with applications to wind turbine blades

NGUYEN DANG MANH (DTU Mathematics, 15 minutes)
Isogeometric Shape Optimization of Magenetic Resonators

PETER NØRTOFT NIELSEN (DTU Mathematics, 15 minutes)
Isogeometric Shape Optimization for Fluids

17:00 – 19:00 POSTER SESSION

(1) SØREN J. ANDERSEN (DTU Mechanical Engineering)
Simulation and Prediction of Wakes and Wake Interaction in Wind Farms

(2) HAMID SARLAK CHIVAEE (DTU Mechanical Engineering)
Simulation of Wakes in Offshore Wind Farms

(3) PETER CHRISTIANSEN (DTU Mechanical Engineering)
Modelling defects evolution and residual stresses for the forged components

(4) TORBEN CHRISTIANSEN (DTU Mechanical Engineering)
High-order finite difference solution of the Euler equations for nonlinear waves

(5) RAPHAËL COMMINAL (DTU Mechanical Engineering)
Numerical modelling of extrusion of functionally graded ceramics materials

(6) RASMUS CORDTZ (DTU Mechanical Engineering)
The Influence of Sulfur on Large 2-Stroke Diesel Engines

(7) MASOUD JABBARI (DTU Mechanical Engineering)
Numerical modeling of tape casting of functionally graded ceramics materials

(8) MARTIN FELIX JØRGENSEN (DTU Mechanical Engineering)
Aerodynamic and Mechanical System Modelling

(9) DMITRY KOLMOGOROV (DTU Mechanical Engineering)
Enhancement of hyperbolic grid generation technique for wind turbines

(10) ULRIK LARSEN (DTU Mechanical Engineering)
Design and modeling of innovative machinery systems for large ships

(11) ELHAM MOUMENI (DTU Mechanical Engineering)
Analysis of nucleation modeling in ductile cast iron.

(12) CLAUS SULDRUP NIELSEN (DTU Mechanical Engineering)
Bio-DME as engine fuel

(13) MARTIN BJERRE NIELSEN (DTU Mechanical Engineering)
Modeling of Rotating Structures

(14) KONSTANTINOS POULIOS (DTU Mechanical Engineering)
Tribological Aspects of the Wind Turbine Yaw System

(15) SIGNE SCHLØER (DTU Mechanical Engineering)
Irregular wave forces on monopole foundations. Effect of full nonlinearity and bed slope

(16) KNUD A. KRAGH (Risø DTU)
Yaw Error Estimation Using Spinner Based LIDAR

(17) MORTEN ANDERSEN (DTU Mathematics)
Streamline Topology of Helical Fluid Flow

(18) TIMOTHY FEYEREISEN (DTU Mathematics)
Spatiotemporal Pattern analysis of turbulent drag reduction

(19) FRANK VINTHER (DTU Mathematics)
Mathematical modelling of membrane separation

(20) ALEMSEGED WELDEYESUS (DTU Mathematics)
Free Material Optimization for Wind Turbine Blades

(21) BRIAN BAK (M-TECH, AAU)
Progressive Damage Simulation of Laminates in Wind Turbine Blades under Quasistatic and Cyclic Loading

(22) RADOSLAV DARULA (M-TECH, AAU)
Solving Electro-Magneto-Mechanical Coupled System by means of Method of Multiple Scales

(23) SAEED D. FARAHANI (M-TECH, AAU)
Human posture and movement prediction based on musculoskeletal modeling

(24) STEFFEN LAUSTSEN (M-TECH, AAU)
Design of Sandwich Structures with Grid Scored Core Materials for Wind Turbine Blades.

(25) SØREN NØRGAARD SØRENSEN (M-TECH, AAU)
Parameterizations for Multi-material Topology Optimization of Composite Structures

(26) PENG WANG (M-TECH, AAU)
Experimental Characterization and Modelling of Advanced Polymer Composite Materials for Use in Window Frames

(27) GUANGLEI WU (M-TECH, AAU)
Error Analyses of a 3-PPR Planar Parallel Robot

(28) MEHDI BAYAT (CIVIL, AAU)
Stochastic Stability Analysis of a Wind Turbine with Flexible Blades

(29) KRISTOFFER A. DICKOW (CIVIL, AAU)
Prediction of Noise Transmission in Lightweight Building Structures

(30) PARTHKUMAR D. GANDALAL (CIVIL, AAU)
Mitigation of Structure Borne Noise in Wooden Panels by Periodic Stiffening

(31) SØREN MADSEN (CIVIL, AAU)
Buckling Analysis of Bucket Foundations for Wind Turbines on Deep Water

19:15 - Dinner

Programme for Tuesday morning, March 15th, 2011

08:00 - 09:00	Breakfast
	3 – MATERIALS AND FAILURE I (Chairman: JAKOB S. JENSEN, DTU Mechanical Engineering)
09:00 - 10:05	KIM LAU NIELSEN (DTU Mechanical Engineering, 20 minutes) Cohesive Traction-Separation Laws for Tearing of Ductile Metal Plates
	REZA AZIZI (DTU Mechanical Engineering, 15 minutes) Elastic plastic evaluation of metal matrix composite with strain gradient plasticity
	MARTIN LEONG (M-TECH, AAU, 15 minutes) Failure of sandwich structures with wrinkle defects
	AMIN KIMIAEIFAR (M-TECH, AAU, 15 minutes) A probabilistic approach to assess the reliability and probability of failure of adhesive scarfed lap joints in composite materials
10:05 – 10:30	Coffee break
	4 – Wind Turbines (Chariman: KIM BRANNER, RISØ DTU)
10:30 – 12:00	ZUZANA ANDRLOVÁ (RISØ DTU, 15 minutes) Structural Design of Large Future Wind Turbine Blades under Combined Loading
	ANASTASIA NEZHETSEVA (CIVIL, AAU, 15 minutes) Compact reinforced composite (CRC) transition structures for offshore wind turbine foundations
	MAHDI T. SICHANI (CIVIL, AAU, 15 minutes) Estimation of Extreme Responses of Wind Turbines under Normal Operation by Means of Controlled Monte Carlo Simulation
	GIREESH K.RAMACHANDRAN (DTU Mechanical Engineering, 15 minutes) Response of a TLP floating wind turbine subjected to combined wind and wave loading.
	IVAN B. SØNDERBY (RISØ DTU, 15 minutes) Design of low order linear models for wind turbine control design
	NÉSTOR RAMOS GARCIA (DTU Mechanical Engineering, 15 minutes) Unsteady viscous-inviscid interactive airfoil code for wind turbines.
12:00 - 13:00	Lunch

Programme for Tuesday afternoon, March 15th, 2011

5 – MATERIALS AND FAILURE II
(Chairman: P. TERNDRUP PEDERSEN, DTU Mechanical Engineering)

13:00 - 14:15	NIELS HØJEN ØSTERGAARD (M-TECH, AAU, 15 minutes) Lateral buckling of the tensile armor layers of flexible pipes
	ALI SARHADI (DTU Mechanical Engineering, 15 minutes) Thermal modeling of the precision glass moulding process
	JON SPANGENBERG (DTU Mechanical Engineering, 15 minutes) Prediction of the impact of flow induced inhomogeneities in Self Compacting Concrete (SCC).
	MICHAEL WENANI NIELSEN (DTU Mechanical Engineering, 15 minutes) Thermomechanical model of curing and residual stress development during wind turbine blade moulding
	SIAVASH T. TAHER (M-TECH, AAU, 15 minutes) Thermal Degradation of Polymer Foam Cored Sandwich Structures
14:30 - 18:00	Social Event
18:30 -	Conference dinner

Programme for Wednesday morning, March 16th, 2011

08:00 - 09:00 Breakfast

6 – MODELLING AND ANALYSIS I
(Chairman: POUL HJORTH, DTU Mathematics)

09:00 - 10:20 FRANK SCHILDER (DTU Mathematics, 20 minutes)
Continuation guided experiments

MORTEN ENEMARK LUND (M-TECH, AAU, 15 minutes)
Validation of patient specific gait models

EMIL BUREAU (DTU Mechanical Engineering, 15 minutes)
Experimental bifurcation analysis by using control based continuation

NIELS FUGLEDE (DTU Mechanical Engineering, 15 minutes)
Roller chain drive analysis: simplified modeling and dynamic effects of meshing

ALEJANDRO CERDA VARELA (DTU Mechanical Engineering, 15 minutes)
Mechatronics Applied to Fluid Film Bearings: Towards More Efficient Machinery

10:20 - 10:45 Coffee break

7 – MODELLING AND ANALYSIS II
(Chairman: SØREN R.K. NIELSEN, CIVIL, AAU)

10:45 - 11:45 SUBRATA BHOWMIK (DTU Mechanical Engineering, 15 minutes)
Real-Time Implementation of Semi Active Control Strategies for Structural Vibration Mitigation with Magneto-Theological Damper

LAI ZHANG (DTU Mathematics, 15 minutes)
Bifurcation analysis of a size structured population model

MOHAMED A. ABDELRAHEEM (DTU Mathematics, 15 minutes)
Lightweight Cryptography

MAZIYAR NESARI ZADEH (M-TECH, AAU, 15 minutes)
Analysis of Wave Propagation in Curved Elastic Layers

11:45 - 12:45 Lunch

Programme for Wednesday afternoon, March 16th, 2011

8 – OPTIMIZATION II
(Chairman: NIELS OLHOFF, M-TECH, AAU)

12:45 – 14:25 YURIY ELESIN (DTU Mechanical Engineering, 20 minutes)
Time-domain topology optimization of nanophotonic waveguides

FENGWEN WANG (DTU Mechanical Engineering, 15 minutes
Robust design of photonic crystal waveguides for slow light

JACOB ANDKJÆR (DTU Mechanical Engineering, 15 minutes
Topology optimized acoustic and low-contrast all-dielectric optical cloaks

CASPER S. ANDREASEN (DTU Mechanical Engineering, 15 minutes)
Topology Optimization of Poroelastic Structures

BIN NIU (M-TECH, AAU, 20 minutes)
Design Optimization of Foundation for Rotating Machinery Against Standing-wave Vibration in a Building

JONAS DAHL (M-TECH, AAU, 15 minutes)
Topology optimization of compliant mechanisms made from non-linear elastic materials.

14:25 Coffee

15:45 Departure from the hotel

List of Participants

DTU Mechanical Engineering-FAM:
Andkjær, Jacob*
Andreasen, Casper S.*
Azizi, Reza*
Bureau, Emil*
Elesin, Yuriy
Fogt, Gerda Helene
Friis, Kasper Storgaard
Fuglede, Niels*
Jensen, Jakob Søndergaard
Jørgensen, Martin Felix*
Lazarov, Boyan S.
Nielsen, Kim Lau
Niordson, Christian
Oztop, Muin*
Pedersen, Niels L.
Pedersen, Pauli
Poulios, Konstantinos*
Sigmund, Ole
Thomsen, Jon Juel
Varela, Aléjandro*
Wang, Fengwen*

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Bredmose, Henrik
Chivaee, Hamid Sarlak*
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García, Néstor Ramos*
Kolmogorov, Dmitry*
Larsen, Poul Scheel
Nielsen, Claus*
Ramachandran, Gireesh K.*
Rasmussen, Johannes T.*
Schløer, Signe*
Schramm, Jesper
Sørensen, Jens Nørkær

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Bingham, Harry
Blasques, José A.*
Christiansen, Torben*
Nielsen, Martin Bjerre*
Pedersen, Preben Terndrup

DTU Mechanical Engineering-TES:
Larsen, Ulrik*.

DTU Mechanical Engineering-MPP:
Christiansen, Peter*
Comminal, Raphaël*
Hattel, Jesper
Jabbari, Mir Masoud*
Moumeni, Elham*
Nielsen, Chris Valentin*
Nielsen, Michael Wenani*
Sarhadi, Ali*
Sonne, Mads Rostgaard
Spangenberg, Jon*
Tutum, Cem C.*

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Feyereisen, Timothy*
Gravesen, Jens
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Nielsen, Peter Nørtoft*
Schilder, Frank
Starke, Jens
Stolpe, Mathias
Vinther, Frank*
Weldeyesus, Alemseged*
Zermeno , Victor*
Zhang, Lai*

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Aslan, Mustafa*
Buhl, Thomas
Branner, Kim
Hansen, Jens Zangenberg*
Hansen, John M.
Kragh, Knud A.*
Sønderby, Ivan Bergquist*
Sørensen, Bent

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Aalborg University
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Bai, Shaoping
Bak, Brian*
Dahl, Jonas*
Darula, Radoslav*
Farahani, Saeed*
Jensen, Lars
Jørgensen, Martin Heide
Kimiaeifar, Amin*
Laustsen, Steffen*
Leong, Martin*
Lund, Erik
Lund, Morten Enemark*
Niu, Bin
Olhoff, Niels
Palletti, Hari Nari Krishna
Rauhe, Jens Chr.
Schjødt-Thomsen, Jan
Sorokin, Sergey
Søe-Knudsen, Alf*
Sørensen, Søren Nørgaard*
Taher, Siavash T.*
Wang, Peng*
Wu, Guanlei*
Zadeh, Maziyar N.*
Østergaard, Niels Højen*

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Dickow, Kristoffer A.*
Gandalal, Parthkumar G.*
Kirkegaard, Poul Henning
Madsen, Søren*
Nezhentseva, Anastasia*
Nielsen, Søren R.K.
Sichani, Mahdi Teimouri*

§8-medlemmer:
Redanz, Pia

	Ph.d.	andre
FAM	10	11
FM	9	4
SKK	4	2
TES	1	0
MPP	8	3
MAT	10	6
Risø, DTU	5	4
M-Tech, AAU	16	10
CIVIL, AAU	6	3
§8	0	1
	69	44
alt		113

* Ph.D.-student

Programme for Monday afternoon, March 14th, 2011

1 – SIMULTATIONS
(Chairman: NIELS L. PEDERSEN, DTU Mechanical Engineering)

13:05 – 15:10 JENS NØRKÆR SØRENSEN (DTU Mechanical Engineering, 20 minutes)
Multiple Vortex Breakdown in Swirl Flows
Vortex breakdown is a phenomenon that appears in many practical problems in aerodynamics, geophysics and engineering sciences. For example, it is observed in tip vortices behind wings and propellers, in atmospheric tornadoes and cyclones, and in flame-holders in combustion devices. Vortex breakdown is characterized by a structural change of the vortex core, associated with an abrupt deceleration of the axial velocity on the vortex axis, which sometimes develops to a recirculation zone.
In the present study two new experimental set-ups have been designed, which allowed us, in a systematic manner, to detect multiple helix modes, or multiplets, in vortex breakdown. We base this search on the results from a stability analysis (Okulov & Sørensen, 2007) showing that an assigned vortex flow can significantly enhance the stability of vortex multiplets. First, a full theoretical analysis of the effect of an intensively swirling assigned flow is performed to determine the stability properties of multiplets. Next, the results of this analysis have been used experimentally to study the various flow regimes appearing in a closed cylindrical cavity with a rotating lid. As a result, we have detected flow regimes with pronounced stable multiple helical modes of vortex breakdown.

JOHANNES T. RASMUSSEN (DTU Mechanical Engineering, 15 minutes)
Multi-resolution vortex particle flow simulation
The hybrid vortex particle-mesh VIC algorithm interpolates particle vorticity to a mesh, solves a Poisson equation for the stream function using FFTs and calculates velocities as the curl of the stream function. The substantive derivative of particle strengths is calculated on the mesh. By interpolating mesh values back to the particles, particle strengths and positions can be updated without expensive direct particle-particle interaction. The no-slip condition of complex solid bodies is imposed with Brinkman penalization.
To circumvent the uniform mesh requirements of the FFTs the vorticity field can be divided into two regions. An arbitrarily shaped patch of vorticity and the remaining exterior vorticity field. Due to the linearity of the Poisson equation the velocity field corresponding to the total vorticity field is the sum of the free-space solutions to the Poisson equation to each region.
Hereby the flow on the patch can be simulated at a higher resolution, while including the influence from the coarser exterior region

ALF SØE-KNUDSEN (M-TECH, AAU, 15 minutes)
On accuracy of wave number prediction and energy flux calculation by use of wave finite elements analysis
This presentation is concerned with justification of the ‘rule of thumb’ (10 to 12 linear elements per wave length), which is well known to the community of users of the finite element (FE) method in dynamics, for the accuracy assessment of the wave finite element (WFE) method. WFE is often used in situations, when the wave propagation in a slender structure should be analysed, but wave numbers cannot be found analytically. Unlike analytical

methods, WFE method generates wave numbers dependent on a type and a size of the finite elements employed. As is recognized, a few lowest branches in the dispersion diagram obtained with WFE are genuine and accurately found, with other branches being spurious or inaccurate.
An explicit formula linking the size of a window in the dispersion diagram, where the WFE method is trustworthy, with the coarseness of a FE mesh employed is derived. It is obtained by the comparison of the exact Pochhammer- Chree solution for an elastic rod having the circular cross-section with its WFE approximations. It is shown that the WFE power flow predictions are also valid within this window.

MICHAEL ELMEGÅRD (DTU Mathematics, 15 minutes)
Attracting low-dimensional submanifold of a finte element model
Often FE models quickly end up being so high-dimensional that numerical bifurcation methods for obtaining the essential dynamical system behaviour are unlikely to be successful due to computational limitations.
This curse of high-dimensionality can be alleviated by dimension reduction methods. When macroscopic behaviour can be observed, it indicates the existence of an attracting low-dimensional submanifold of the phase space such as periodic orbits or tori.
In this presentation the dimension reduction will be applied to a nonlinear mechanical system, specifically, the forced transverse vibrations of a rod including nonlinearities via springs and/or dampers.

MUSTAFA ASLAN (RISØ DTU, 15 minutes)
Modelling of Stress Singularity in Bimaterial Wedge by Finite element Modelling
Determination of the tensile strength of unidirectional composites is an experimental challenge. Typically, unidirectional composites break close to the grips and split along the tensile direction. Traditionally, the problem has been approached by the use of local reinforcement of the specimen in the gripping areas, the so-called tabs, but the problem has not efficiently solved in practice. A key problem is that the stress state at the end of the tab can be singular, leading to premature failure. In this study, dependence of the order of the stress singularity at the vertex of a dissimilar isotropic homogeneous wedge has investigated in terms of the elastic mismatches and tab angle. Finite element modelling is performed to analyse a stress singularity. The results will be used for creating a better specimen/tap design which will be tested experimentally.
It is expected that strength of the singularity in the wedge of the material will decrease with decreasing tab angle and decreasing stiffness of the tab material.

CHRIS VALENTIN NIELSEN (DTU Mechanical Engineering, 15 minutes)
3D finite element simulations of resistance welding
The resistance welding process is simulated by a 3D finite element code including mechanical, electrical and thermal modelling. Contact modelling is a main issue as it is crucial for correct modelling of the process. Therefore focus has been put on the modelling and testing of the contact problems. Through experiments and comparisons with simulations, the mechanical contact has been studied. Different geometries of a mild steel, a stainless steel and an aluminium have been tested in the different material combinations. Good agreement is observed between experiments and simulations both as regards geometry and force-displacement curves. Simulations of resistance

welds will be shown, where also the electrical and thermal contacts are modelled. These have not yet been verified by experiments, but critical issues will be pointed out and a brief overview of possible future work will be given.

HARA NAGA KRISHNA T. PALLETTI (M-TECH, AAU, 15 minutes)
Nonlinear thermo-mechanical finite element analysis of polymer foam cored sandwich structures
The performance of polymer foam cored sandwich structure depends on the properties of face sheets and core, temperature field imposed, geometrical dimensions. They have been extensively used for a wide variety of applications including boat hulls and ship structures, wind turbine blades as well as for structural applications in the fields of transportation and aerospace. During the service period, they are often subjected to elevated temperatures. This temperature loading which is within the operating range of temperatures cannot be ignored because polymer foams have temperature dependent material properties. Polymer foams exhibit significant degradation of the material properties with increase in temperature. For example, PVC foams loses all their stiffness and strength at about 80–100^{o}C, while PMI foams completely lose their heat distortion resistance at about 200^{o}C. Simultaneous application of the mechanical loads on the structures leads to the early disintegration or failure of the structure due to the interaction between thermal and mechanical loads. Either the increase of the temperature at constant mechanical loads or the increase of the mechanical loads at constant elevated temperature subsequently results in the early failure or disintegration of the sandwich structure

VICTOR ZERMANO (DTU Mathematics, 15 minutes)
Computation of Superconducting Wind Turbine Generators
Over the last years, the concept of Superconducting rotating machinery has gained momentum. This is mainly due to the lower cost and bigger production rate of high critical current superconducting wires. Several examples of a full scale machine include a 36 MW generator developed by American Superconductor. In general, estimates can be used to calculate the losses due to the Joule heating present in the superconducting materials. However, the nonlinear resistivity of the superconducting materials makes the equivalent Eddy problem difficult to calculate when ripple fields are considered. This is of particular interest for the development of a superconducting generator for wind turbine applications. This is due to the fact that wind turbines are inherently subject to dynamic power loads. Therefore AC losses are expected in the superconducting coils of the rotor. This work presents the latest developments towards the simulation of a superconducting rotating machinery. This is the main goal of the PhD thesis project: “Computation of Superconducting Wind Turbine Generators”. The analysis correponds to a synchronous generator with a superconducting rotor and normal stator.

15:10 – 15:30 Coffee break

INVITED PRESENTATION
(Chairman: CHRISTIAN F. NIORDSON, DTU Mechanical Engineering)

15:30 – 16:15 THOMAS BUHL (RISØ DTU, 45 minutes)

The Challenges of Wind Energy

Even though wind energy is starting to be perceived as a developed and modern business there are still numerous challenges to be dealt with. Apart from the economical fact that wind energy is not competitive with energy from fossil fuels, there are several challenges within numerical modeling that need to be addressed. The uncertainties in the models cost several millions of Euros for a large offshore wind farm due to obvious conservatism.

This presentation is about a few of these challenges mostly related to offshore wind energy.

Wind resources are essential for power production; however, there are still large uncertainties in estimating the wind resources. Wake effects is a huge research area covering both wakes in a wind farm but also neighboring wind farms' effect on each other. These highly complex flow problems influence the power production as well as the loading of the turbines in the wakes of other turbines. To include detailed flow modeling, aeroelastic and hydro-elastic simulation in an optimization procedure to minimize the cost of future development of offshore wind farms is computationally unrealistic. Many of the mentioned issues have recently been investigated in an EU project called TopFarm and will be presented here.

A rule of thumb for the cost distribution of offshore wind farms is about 75% of capital expenses (CAPEX) and 25% on operational expenses (OPEX). For water depths of up to approximately 12-15 meters the foundation cost is about 25% of the CAPEX. As the sites with shallow waters become developed, future sites will be developed on deeper water resulting in a higher cost of the foundations. Hence, the trend for offshore wind energy is to upscale the turbine. There are numerous upscaling challenges e.g. the mass scales with the power 3. A 61.5 meter blade today weighs about 18 tons and could fit a 5 MW turbine. Upscaling with the power 3 could result in a blade weighing over 150 tons for a 20 MW turbine. The upscaling issues will also be addressed in this presentation.

16:15 – 17:00 2 – OPTIMIZATION I
(Chairman: OLE SIGMUND, DTU Mechanical Engineering)

JOSÉ PEDRO BLASQUES (DTU Mechanical Engineering, 15 minutes)

Optimal design of laminated composite beams with applications to wind turbine blades

An approach is presented for the identification of optimal fiber orientations, stacking sequence and material distribution in the design of laminated composite beam structures.

The global response of the beam is analyzed using a three dimensional beam finite element model. A cross section analysis tool has been developed which is able to correctly estimate the stiffness properties of beams sections of arbitrary geometry while accounting for the effects of material anisotropy and inhomogeneity. These properties are subsequently integrated along the beam length to construct an accurate beam finite element model. The main advantage of this methodology concerns the significant reduction of the size of the structural matrices compared to other equivalent modeling approaches like shell and solid finite element models. This modeling technique is applicable to long slender composite structures which present a certain degree of material and geometrical continuity along its length, like wind turbine blades.

The optimal design problem is solved using optimal design techniques stemming from multi-material topology optimization. A constitutive parameterization for multi-material problems is presented where the stiffness of the material at each point of the design domain is evaluated as a weighted sum of candidate materials. A penalization technique is combined with a continuation approach and a sequence of problems is solved. Consequently, the continuous design variables are progressively forced into a discrete solution. Analytical expressions have been derived for the gradients of the cross section stiffness properties with respect to the material properties. The optimization problem is solved using robust and efficient gradient based techniques.

Numerical results are presented which illustrate the potential of the approach in the design of laminated composite beams.

NGUYEN DANG MANH (DTU Mathematics, 15 minutes)

Isogeometric Shape Optimization of Magenetic Resonators

In 2007, Marin Solja_ci_c and his co-workers proposed a new method of transferring power wirelessly via strongly coupled magnetic resonances [1]. The proposal provides possibilities for wirelessly recharging electrical devices such as laptops, cell phones. Among many other recent attempts to improve efficiency of the wireless power transfer, this framework utilizes advantages of isogeometric shape optimization [2, 3, 4, 5] to design a 2D model with a couple of magnetic resonators. Main impediments have been encountered in the problem are how to parametrize the physical domain and hinder the shapes of the antennas from being unphysical. Remedies for the latter and main shape optimization results will be presented.

PETER NØRTOFT NIELSEN (DTU Mathematics, 15 minutes)

Isogeometric Shape Optimization for Fluids

The aim of this work is to use the unification of finite element methods (FEM) and computer aided design (CAD) embedded in isogeometric analysis to solve shape optimization problems within fluid mechanics.

The flow problem considered is governed by the 2-dimensional steady-state, incompressible Navier-Stokes equations. These partial differential equations are solved for fluid velocity and pressure using B-spline based isogeometric analysis. The accurate geometry representation and high degree of continuity of the flowfields are some of the method’s advantages.

In shape optimization for fluids we search for an optimal design of the flow domain that minimizes a prescribed objective, while satisfying suitable constraints. With the ability to represent complex shapes in few design variables, and the unification of the analysis and geometry models, isogeometric analysis is highly suited for shape optimization purposes.

The methodology is presented through a concrete example in which a simplified airfoil is designed to minimize the drag with a constraint on the lift as well as several constraints on the geometry.

17:00 – 19:00 POSTER SESSION

SØREN J. ANDERSEN (DTU Mechanical Engineering)

Simulation and Prediction of Wakes and Wake Interaction in Wind Farms

The aim of the present work is to investigate the wake behind wind turbines and wake interaction within wind farms. The wind turbines are simulated using CFD and utilizing the actuator line method. The work builds on previous work using the actuator disc method. The starting point is a idealized case with one turbine and cyclic boundaries, essentially yielding an infinite row of turbines, in order to investigate the turbulence generated inherently by wind turbines. Eventually a parametric study will be conducted, examining the influence of parameters such as sheared inflow, incoming turbulence, stability of the atmospheric boundary layer and spacing of the wind turbines.

HAMID SARLAK CHIVAEE (DTU Mechanical Engineering)

Simulation of Wakes in Offshore Wind Farms

As the number of installed wind turbine power plants raises, wind turbine failure investigations become more and more important. Blade failure, which can result either in the whole or partial blade breakdown and throw, is the most common type of wind turbine failure and may cause severe damage to humans and environments. The current research is an extension of an earlier study for prediction of blade trajectories of wind turbines subjected to wind and gravitational loads (J. N. Sørensen, 1984). The trajectories are obtained based on three dimensional rigid body motion of the blade. The varying lift and drag coefficients with respect to angles of attack are used and the effect of dynamic stall is taken into account. The results of a numerical analysis are discussed together with some available experimental data and a simple trajectory calculation based on a constant drag coefficient. Finally, the effects of release angle and tip speed ratio on the throw distance are computed and discussed.

PETER CHRISTIANSEN (DTU Mechanical Engineering)

Modelling defect evolution and residual stresses for the forged components

Windmill turbine components have a relative short lifetime before failure. Since windmill
downtime and replacement of failed components is expensive, it is therefore of importance to increase the lifetime of windmill turbine components.

The project focuses on windmill components which have been formed by for instance forging or extrusion. Traditionally the manufacture has mostly focused on subjects such as die lifetime and part forming feasibility. In this project the focus is on modeling defect evolution in the formed part due to the metal forming process. Defects could be void formation or could also originate from porosities in the initial casted billet, which are then moved by the forging process to undesired places in the component. This internal flow of defects during metal forming is normally not considered in traditional metal forming analysis.

Also during metal forming, residual stresses are being introduced in the material. These residual stresses should be taken into account by the designer of the formed part, because they influence the subsequent stress-strain analysis, which normally assumes a uniform stress distribution in the part. It is a part of the project to examine these formed residual stresses and their influence on the subsequent use of the component.

TORBEN CHRISTIANSEN (DTU Mechanical Engineering)

High-order finite difference solution of the Euler equations for nonlinear waves

This abstract describes the application of a high-order finite difference strategy to soving the Euler equations with a free-surface. The immediate goal is to determine the compuational penalty (if any) of moving from a potential flow to the Euler equations with this solution strategy. The long-term goal is to apply the strategy to nonlinear wave-structure interaction, in particular for the analysis of wave power generation devices.

The numerical solution strategy adopted here is based on that described in [1, 2] which extends the work of [3] to high-order finite difference schemes and non-uniform grid spacing. This work can, to some extent, also be seen as an extension of [4] to high-order and non-uniform grids.

We begin with an analysis of the linearized equations where, not surprisingly, the Euler equations become essentially identical to a potential flow formulation. The linear accuracy and stability properties of the Euler solver are thus also nearly identical to the potential flow solver. For non-linear problems, ensuring an adequate level of mass conservation is critical, and we discuss several strategies for doing so in the context of explicit time-stepping schemes and the finite difference method. Finally, some preliminary results are given comparing the accuracy of the solution to a potential flow solver for highly nonlinear periodic wave solutions based on stream function theory.

RAPHAËL COMMINAL (DTU Mechanical Engineering)

Numerical modelling of extrusion of functionally graded ceramics materials

Advanced ceramics with functionally graded properties have potentials to improve several technologies within the energy sector. One of the promising technology for reduction CO_2 emissions is ceramics oxygen membranes which have the ability to separate oxygen ions. Multi-layered tubular designs of thin oxygen membrane are of great interest because they can be operated at high pressure. The thin membrane can be manufacture with its ceramics support by co-extrusion. Then the ceramics blend needs to be mixed with a polymer in order to be shaped. Once extruded, the parts are to be sintered. During this operation at high temperature, polymer gets evaporated and ceramic has its micro-structure stabilised. Density and porosity are fundamental characteristics of the final product and are both controlled by the kinetics of sintering and the homogeneity after extrusion. Numerical modelling of the co-extrusion process will help to achieve a better understanding of the cohesion of interfaces of bi/tri-layered materials. Simulations will show the effect of several parameters. Particular attention will be focused on the influence of materials rheology, external heat transfers through conduction with the barrel, and frictional behaviour at the walls of the extruder. The model is a fully coupled thermo-mechanical problem, where the apparent viscosity depends on the temperature, which is generated by internal friction of the fluid. Results of the numerical simulations will be validated with experiments.

RASMUS CORDTZ (DTU Mechanical Engineering)

The Influence of Sulfur on Large 2-Stroke Diesel Engines

In most cases vessels equipped with large 2-stroke diesel engines operate on Heavy Fuel Oils (HFO) with a typical sulphur concentration between 2-5 % (m/m). During fuel combustion the sulphur is oxidized into SO_x components with around 95 % SO_2 and 5 % SO_3. SO_3 gas can react with H_2O on the liner wall surface and produce the highly corrosive sulfuric acid (H_2SO_4). Several investigations have shown that the acid corrodes the liner surface which leads to increased liner/piston wear. Therefore in practice corrosion is reduced by alkaline (base) additives in the cylinder lube oil. Corrosion is not neutralized completely since it is believed that a weakly corroded liner surface assists the lubrication performance of the oil film between the liner and piston due to a *rough* surface topography. Rough surfaces improves the ability of oil film pressure build up that is needed to separate the sliding surfaces from each other in order to avoid excessive wear and scuffing where the friction is dramatically increased.

To reduce SO_x emissions the sulphur concentration in Emission Controlled Areas (ECA) must not exceed 1 %. From January 2015 the limit is lowered even further to 0.1 %. This means that much less sulfuric acid will be present to provide a *controlled corrosion*. In practice this has induced examples of liner polishing caused by very fine abrasive lube oil contaminants like carbon particles giving a mirror like surface with a bad surface topography.

The aim of this project is to investigate the fate and influence of fuel sulphur in large 2 stroke diesel engines. This involves the trace of sulphur compounds from engine test bed experiments and identification of the effect of sulphur on the piston-liner tribology. Fourier Transform Infrared Spectroscopy (FTIR) is expected to provide information of the SO_2/SO_3 distribution in the exhaust gas. Possible drawbacks from reduced HFO sulphur concentrations will be examined. It is expected that a flexible tribometer will be used to simulate wear conditions with the use of realistic contaminated test lube oils. A challenge with this method is to examine actual lube oil contaminations in order to design a realistic test oil regarding abrasive particles and H_2SO_4 concentrations.

MASOUD JABBARI (DTU Mechanical Engineering)

Numerical modeling of tape casting of functionally graded ceramics materials

Functionally graded materials (FGMs) are used to produce components featuring engineered transition in microstructure and/or composition, where the property differences (mechanical, thermal or electrical) can be utilized. Tape casting is a standard shaping technique to form thin ceramic layers whose height is mainly controlled. One of the main scientific challenges of tape casting graded materials is to control the interface flow between the different materials. The aim of this project is to develop models to simulate the shaping of multilayer and graded materials by tape casting. The emphasis will be on analyzing the entry flow of multiple slurries from the reservoir into the doctor-blade region as well as the exit region where a free surface (meniscus) forms. This will encompass a detailed thermo-fluid model capable of tracking the material flow/deformation taking the formation of the free surface into account. The non-Newtonian behaviour of the slurry will also be taken into account and coupled with a heat transfer model such that the thermal effect on e.g. viscosity as well the viscoelastic dissipation’s effect on temperatures can be described. The modeling work will be targeted at achieving fundamental understanding about the detailed mechanisms of the interface between the layers at different situations such as wet-on-wet and wet-on-dry as well as the stability of the contact area between the materials and this will be used to guide the processing development.

MARTIN FELIX JØRGENSEN (DTU Mechanical Engineering)

Aerodynamic and Mechanical System Modelling

A number of modern wind turbines are known to have serious problems with the gear-box. The plan for the Ph.D. project is to model the drive train both on an overall level and in specific details. The overall modelling of the drive train will be performed using a multibody program made in a standard programming language. This model receives input from the other project contributors with respect to the load from the wind side (input) and the output side (generator). It is the plan that the model also receives input from own specific models of flexible parts of the drive train including the gear-box and the bearings. The modelling of the gear-box and bearings will be made using the FE method either with a commercial program (ANSYS) or/and with own programs wherever this is best suited.

DMITRY KOLMOGOROV (DTU Mechanical Engineering)

Enhancement of hyperbolic grid generation technique for wind turbines

Hyperbolic grid generation method based on upwind approximation has been developed for generation of mesh around wind turbine blades. The method uses a system of hyperbolic equations for grid generation. Due to hyperbolic property of the system, there exist characteristic directions and upwind scheme can be applied to the directions. The method incorporates subiteration procedure to solve nonlinear equations at each marching step in order to obtain both sufficient robustness and satisfactory grid orthogonality. Enhancement of the method includes the use of appropriate smoothing techniques, appropriate specification of cell volumes and metric correction procedure. Too small dissipation in numerical solution will not help prevent grid oscillations, but excess dissipation may cause crossing or overlapping of the grid lines. Therefore additional dissipation terms in discrete form of hyperbolic equations must be used properly with smoothing technique for construction orthogonal and smoothing grids. Determination of cell volumes is another issue for the method. If the proper cell volume is not specified the hyperbolic grid generation often results in grid-lines crossing. Therefore certain method of volume specification has been developed. The robustness of the method has been demonstrated for several blade geometries. The generated grid around blade of complex geometry with sharp edges, concave and high convex shows good orthogonality and smoothness and demonstrates good quality of the technique.

ULRIK LARSEN (DTU Mechanical Engineering)

Design and modeling of innovative machinery systems for large ships

The temperature of the exhaust gasses from large marine diesel engines are typically less than 400 °C and waste heat recovery (WHR) systems are used to recover the heat energy conventionally by using the Rankine cycle process. Alternative cycles such as the organic Rankine cycle (ORC) and the Kalina cycle have been shown to produce higher energy efficiency than the Rankine cycle at low temperatures in for example geo- and solar-thermal plants. These cycles utilize new types of working media, i.e. organic compounds and mixtures of ammonia and water respectively.

The PhD project will be aimed at designing and optimizing the combined ship power plant consisting of the main diesel engine and WHR system and find out which cycle design and which working fluid would be the most suitable for marine applications, considering thermal efficiency, emissions and practical aspects. For this purpose, Matlab will be used to model the main engine and the numerical system analysis software DNA (Dynamic Network Analysis), which is an in-house tool of the TES section at DTU, will be used and further developed for the WHR system. New components will be developed and incorporated and new working fluids will be incorporated in the program

ELHAM MOUMENI (DTU Mechanical Engineering)
Analysis of nucleation modeling in ductile cast iron
Heterogeneous nucleation of nodular graphite at inclusions in ductile cast iron during solidification has been investigated in this work. A 1D numerical model based on a finite volume discretization of the heat conduction equation for the solidification of SG cast irons which quantitatively accounts for the formation of non-eutectic austenite during cooling has been developed. This model includes the description of the nucleation and growth of the proeutectic graphite in hypereutectic alloys. As far as the model is concerned, emphasis has been put on the analysis of the carbon redistribution, thus on a careful expression of the carbon mass balance within some elementary volume.

CLAUS SULDRUP NIELSEN (DTU Mechanical Engineering)
Bio-DME as engine fuel
BioEng is a newly founded Nordic research network funded by the Nordic Top-level Research Initiative. The project intends to systematically investigate the performance of second-generation bio-fuels. An experimental and numerical test facility will be developed for parallel studies of different bio-fuels in various state-of-the-art engines provided by the industrial partners.
Differences between properties of conventional petroleum fuels and bio-fuels significantly affect three critical areas associated with usage in practical applications: engine combustion, performance and emissions.
Laboratory measurements of engine performance and emissions using bio-fuels
Sub-modules:
1 Engine performance and optimization testing
2 Emission testing
3 Reduction strategy campaign
4 Testing of gasoline/methanol blends in SI test vehicles
The engines and test vehicles for application in this project will be provided by the industrial partners according to state-of-the-art technology.

MARTIN BJERRE NIELSEN (DTU Mechanical Engineering)
Modeling of Rotating Structures
Many mechanical devices contain rotating parts, thus it is of particular interest to develop accurate and efficient computational techniques for the dynamic analysis. A particularly important aspect is the need for a stable and reliable time-integration procedure for the dynamic equations of motion, which are often formulated in a rotating frame of reference. Recently a conservative time integration algorithm has been developed for rotating systems at MEK-DTU. The equations are formulated in a hybrid state-space format in terms of the local components of the *absolute* velocities and the *local* displacements, which allows for application of the same spatial-interpolations for both state-space variables. This leads to a simple generalization of the equations of

motion in a stationary frame where all inertia effects are represented solely via two gyroscopic terms using the classic constant mass matrix, which remains valid even for non-isoparametric elements. As a consequence the centrifugal forces do not appear explicitly and it demonstrated that the energy conserving properties follow by representing the gyroscopic terms by the mid-point rule over the time increment. Furthermore the algorithmic representation of the non-linear internal forces takes a particularly simple form when a quadratic strain formulation is applied. This may be represented in either the 'product of mean values' format or the attractive global available form in terms of end-point forces supplemented by a geometric stiffness term. A suitable representation of algorithmic damping in the hybrid state space is also developed to dissipate energy from the poor represented high-frequency vibrations introduced by the time discretization. The properties and accuracy of the algorithm are illustrated by a few representative examples for translation-based solid elements as well as a finite-displacement beam element with geometric stiffness including rotational degrees of freedom.

KONSTANTINOS POULIOS (DTU Mechanical Engineering)
Tribological Aspects of the Wind Turbine Yaw System
Subject of this project is to investigate the fundamental tribological problems with respect to a wind turbine yaw system, integrating bearing and brake functionality. In contrast to typical sliding bearing applications where friction reduction is the main objective, in this particular case a high coefficient of friction is desirable in order to provide the wanted brake functionality. However, minimization of wear is still an objective. In order to derive all theoretical tools which are necessary to deal with the above presented problem, both theoretical and experimental work has to be carried out. Regarding the theoretical part, following subtasks should be considered:

– **Description of surface geometry**. In order to proceed with contact analysis between rough surfaces, the surface geometry has either to be obtained from measurements or to be generated numerically for prescribed roughness parameters. Algorithms for numerical roughness generation typically involve the solution of a large nonlinear equations system.
– **Contact analysis**. The pressure between two perfectly flat and smooth surfaces can be determined very simply, given the applied load and surface area. For rough surfaces though, a numerical analysis is necessary in order to determine the pressure distribution in the contact and take it into account in the friction coefficient calculation.
– **Mixed lubrication simulation**. In the case of presence of lubricant in the considered contact, part of the normal load will be carried by the fluid. In brake applications the effect of lubricant on the coefficient of friction has to be estimated and minimized. Numerical simulation is necessary in order to estimate the portion of the load carried by the lubricant.
– **Wear rate**. Wear rates are typically determined experimentally. However, in order to confirm experimental results and apply them to a range of similar operating conditions, physical modeling is necessary. Data fitting is used in order to establish a connection between the unknown model parameters and the experimental results.

SIGNE SCHLØER (DTU Mechanical Engineering)

Irregular wave forces on monopole foundations. Effect of full nonlinearity and bed slope.

Forces on a monopile from a nonlinear irregular unidirectional wave model are investigated. Two seabed profiles of different slopes are considered in the model. Morison's equation is used to investigate the forcing from fully nonlinear irregular waves and to compare the results with linear model theory and with stream function theory. The latter of these theories is only valid on a flat bed. The three predictions of wave forces are compared and influence of the slope of the bed is investigated. Force-profiles of two selected waves from the irregular wave train are furthermore compared with the corresponding force-profiles from stream function theory.

The results suggests that the nonlinear irregular waves give rise to larger extreme wave forces compared with the linear waves and that stream function theory in some cases underestimate the wave forces acting on the monopile.

The next step will be to combine the irregular fully nonlinear hydrodynamic model with an aeroelactic code. This will enable investigation of the balance between wave and wind contributions to the fatigue life time of offshore wind turbines.

KNUD A. KRAGH (RISØ DTU)

Yaw Error Estimation Using Spinner Based LIDAR

When extracting energy from the wind using horizontal axis wind turbines, the ability to align the rotor axis with the mean wind direction is crucial. The focus of this study is on exploiting recent advances in LIDAR wind speed measurement technology for accurate yaw alignment of horizontal axis wind turbines operating in turbulent flow. A method for yaw error estimation based on measurements from a spinner based LIDAR is developed. The method is applied to simulated measurements obtained using three different scan patterns. A two factor factorial simulation study is carried out for identification of parameters which are significant for the accuracy of the yaw error estimates. The significant parameters are studied further through simulations and results show that with the applied method the yaw error can be estimated with a precision of a few degrees, even in highly turbulent flows. The developed method is tested on data from an operating turbine, and an average yaw error of teen degrees during a period of two hours is observed. The estimated yaw error is compared to met-mast observations and the average yaw error suggested by the LIDAR method is confirmed.

MORTEN ANDERSEN (DTU Mathematics)

Streamline Topology of Helical Fluid Flow

An incompressible velocity field with helical symmetry is investigated. Helical symmetry means the velocity field 'looks' the same as one moves on a given helix. This means a stream function can be constructed.

The focus is on a proper description of helical symmetry and a bifurcation analysis of a flow with helical symmetry.

TIMOTHY FEYEREISEN (DTU Mathematics)

Spatiotemporal pattern analysis of turbulent drag reduction

It has long been observed, although not well understood, that the addition of a low concentration of high molecular weight polymers can reduce the drag associated with turbulent channel or pipe flow. The polymers affect the evolving structure of the fluid, causing greater definition of high and low speed velocity streaks and reduced strength of quasi streamwise vortices in the near wall region. Periods of reduced area-averaged wall shear rate and increased mean bulk flow rate seem to indicate phases of transitional or marginal turbulence as the fluid stretches the polymers [1]. The present work considers relatively large box viscoelastic DNS results in the near wall region over a range of polymer relaxation times. Investigating the fundamental interactions of these large scale structures with small scale polymer forces is accomplished by pattern analysis of wall normal planes in the buffer layer. Preliminary results show strong streamwise correlations in most cases while others show both spanwise and streamwise dependence with localized structures at the origin.

FRANK VINTHER (DTU Mathematics)

Mathematical modelling of membrane separation

Membrane separation is commonly used in chemistry and chemical engineering, where the separation of one or several species of molecules is of interest. This presentation will presents mathematical modelling of the dynamic interplay between the transport equations through the membrane and the transport equations within the bulk solution. Thus, resulting in a system of coupled ODE's and PDE's with time varying boundary conditions. The model is used for predicting optimal parameters for separation processes.

ALEMSEGED WELDEYESUS (DTU Mathematics)

Free Material Optimization for Wind Turbine Blades

The goal of this project is to develop new models and highly specialized algorithms of Free Material Optimization (FMO) of structures which are suitable for optimal design of wind turbine blades. The models will be based on the recently developed models for FMO of plates and shells for aerospace structures and will include design criteria based on stiffness, weight, and local stress properties. The available models will be generalized to layered plates and shells. The optimization methods developed to solve the FMO problems will be based on modern methods for large-scale optimization coupled with parallel linear algebra packages.

BRIAN BAK (M-TECH, AAU)

Progressive Damage Simulation of Laminates in Wind Turbine Blades under Quasistatic and Cyclic Loading

The governing damage mode compromising the structural integrity of structures made of laminated fibrous composite materials is generally known to be delamination during static and cyclic loading. This is due to the inherent properties of the laminate where the out-of-plane strength properties are governed by the weak matrix material interface, e.g. epoxy resin. Delamination damage is initiated under cyclic loading near structural details like ply-drops, free edges, joints and sharp bends as well as at manufacturing imperfections and defects like fiber misalignments, dry fibers, voids etc. This study is focused on the modeling of delamination damage initiation at and propagation away from out-of-plane fiber misalignments under static and cyclic loading within the framework of cohesive zone modeling and finite elements. Special attention is given to implementation of onset criterion based on the ongoing work of Ph.D. student Martin Leong, damage accumulation models suitable for use with cohesive elements and solution strategy for the degradation of material properties based on the damage accumulation model.

RADOSLAV DARULA (M-TECH, AAU)

Solving Electro-Magneto-Mechanical Coupled System by means of Method of Multiple Scales

An electro-magneto-mechanical system, analyzed in the contribution, is composed of an electromagnet, electric RL circuit and SDOF mass-spring-damper system. The system is described mathematically using a coupled system of differential equations of the second order (for mechanical system) and the first order (for electrical system). The coupling term, an electromagnetic force, is inversely proportional to the square of displacement (F_E=f(1/d^2)). Under the assumption of small amplitudes of vibration, the electromagnetic force term can be considered to be weakly non-linear. This weakly non-linear system of differential equations is analyzed using a method of multiple scales and the steady-state response of the coupled system is investigated. Using the method, operation conditions and stability of the system are analyzed as well.

The electro-magneto-mechanical system, presented in the contribution, can be practically implemented as a semi-active vibration controller, which uses an electromagnetic element to convert the mechanical energy (due to e.g. vibration of machine) to electrical one and dissipated at a shunt resistance.

SAEED D. FARAHANI (M-TECH, AAU)

Human posture and movement prediction based on musculoskeletal modeling

This study is concerned with the investigation and development of reliable methods for prediction of natural postures and movements using musculoskeletal modeling. The hypothesis of this research is that a wide range of movement strategies in humans is guided by a desire to optimize performance according to some criteria. Therefore, the main goal of this research is to identify these criteria, cast them into a mathematical form and implement them in musculoskeletal models using the AnyBody Modeling System (AMS). This leads to constrained optimization problems and its solution entails choosing a suitable criterion function, defining the constraints, and selecting the design variables. Different formulations of the optimization problem are investigated using examples and simulation via human musculoskeletal models.

Motion prediction is important because it drastically enhances the usability of digital manikins for many occupational purposes. From clinical and orthopedics point-of-views, human movement simulation entails the possibility for experts to predict the effect of prosthetic and orthotic devices. A virtual human model provides an efficient tool for upstream manufacturing and industrial design. Reliable simulation methods can reduce the number of design iterations and costly experiments to establish the human motion pattern for each design change and consequently increase the design quality of products. Improvement of the safety of manual working processes is always at the core of the work of ergonomists. Reliable motion prediction leads to significant improvement of the results in this field.

STEFFEN LAUSTSEN (M-TECH, AAU)

Design of Sandwich Structures with Grid Scored Core Materials for Wind Turbine Blades

The project concerns the development of validated predictive modeling tools, that enable the prediction of both load-response and failure behaviour of curved composite sandwich structures with grid scored polymer foam core material under quasi-static and cyclic loading in wind turbine blades.

The requirements for composite sandwich structures often dictate that they should have a single or double curved geometry, which implies that the sandwich structure needs to be draped in order to follow the geometry. This is usually not a problem for the face sheets, since these are made of thin layers of fabrics of different constitution. The foam core materials, which are used for a large variety of modern sandwich structures, are however much thicker and for such materials thermoforming is often not feasible. Thus, the core materials, which are usually delivered as plates, are cut in small blocks (typically perpendicular) and attached to a thin carrier fabric, which then can be draped. This type of core is known as “grid scored”.

When the manufacturing process is based on vacuum infusion, resin material passes through these cuts (or scores), thus creating a resin grid within the lightweight foam core. Since the resin material is much stiffer (with a factor of 10-100) than the foam material, the presence of the grid will affect the local stiffness and load transfer of the core material significantly. This in turn will change the stress distribution locally, and induce local stress concentrations in the interfaces between the core and face sheets in the vicinity of the intersections (or junctions) between the grid score and the polymer foam core. These local stress redistributions, which are also known as local effects, may seriously jeopardize the structural integrity of a composite sandwich structure.

Thus, the outcome of the project is a set of guidelines, which ensure a safe and at the same time not overly conservative (i.e. weight ineffective) design of sandwich structures with the grid scored foam configuration.

SØREN NØRGAARD SØRENSEN (M-TECH, AAU)

Parameterizations for Multi-material Topology Optimization of Composite Structures

Composite materials such as glass and carbon fiber reinforced polymers are used in a large variety of high performance structures ranging from badminton rackets to wind turbine blades due to their

low weight combined with significant stiffness and strength properties. They are typically used in thin-walled structures in the form of laminated composites, i.e. stacks of thin layers, or plies, of fibrous

material embedded in a polymer matrix. Optimal strength and stiffness of a composite structure is achieved through mathematical optimization methods by varying certain parameters.

Current parameterizations result in discontinuous lay-ups over the structural domain, but the parameterizations should allow for continuous plies over large domains for complex structures in order to obtain manufacturable designs. The objective of this Ph.D. project is to develop new parameterizations for multi-material topology optimization of composite structures that e.g. includes thickness optimization with discrete ply thicknesses.

The determination of an optimum laminate lay-up may be considered as an extended topology optimization problem, i.e. a combinatorial problem concerning the optimum material selection from a fixed number of candidate materials. This Ph.D. project applies (and ultimately extends) the so-called Discrete Material Optimization (DMO) approach developed by Stegmann and Lund (2005) that relaxes the discrete material selection problem to a continuous problem by expressing the material properties as a weighted sum of the candidate materials.

Focus on geometrical manufacturing constraints for laminates such as for instance allowable rate of thickness change and increased continuity between adjacent fiber angles may ultimately reduce the need for manual post-processing of the topology optimized design, and successful models and methods from this Ph.D. project can thus immediately be used for industrial design.

PENG WANG (M-TECH, AAU)

Experimental Characterisation and Modelling of Advanced Polymer Composite Materials for Use in Window Frames

Large amounts of energy are consumed for the heating of buildings. Roughly 30-60% of the energy loss of a building is due to windows, hereof a significant part through window frames. The political target is to reduce CO_2 emission by 75% in new buildings by 2020 in several European countries. Therefore the market for high-performance window frames is very promising. Fiberline Composites A/S, a leading manufacturer of composite window profiles, is developing a new concept for window frames which can provide super-insulation and high-strength with minimum cost of materials. For the development of this kind of window frames innovative material systems and optimal structural design are key issues. Fiberline Composites is exploring new material systems; functionally graded polymer foam core material (FGPC) to provide superior thermal insulation, and advanced thin-walled composite laminates made by pultrusion to provide for the structural requirements. The overall goals of this project are: 1) to develop a methodology to experimentally characterize the mechanical properties of a new class of FGPC materials developed by Fiberline by using a special testing technique based on Digital Image Correlations (DIC) combined with the Virtual Field Method to extract the elastic material parameters; 2) to develop a finite element analysis (FEA) based for the analysis and design optimization of window frames with embedded laminated FGPC layers.

GUANGLEI WU (M-TECH, AAU)

Error Analyses of a 3-PPR Planar Parallel Robot

In this paper, a 3-PPR planar parallel robot is presented and the error model is established and validated by experiments with respect to the joint clearances. The kinematics and workspace are analyzed. The error model is established by means of the differentiation method with due considerations of factors, including the assembly errors and joint clearance, which influence the mobile platform's positioning accuracy. Then the error estimation problem is transformed into a problem of optimization. Error measurements were conducted by virtue of the DVT smart camera from COGNEX company. Through implementing the experiments and processing the data by free software R 2.12, the error distribution is obtained. The results are compared with the simulated errors predicted by the developed model. According to the combination of the two results, the error model is instructive in eliminating and minimizing the errors.

MEHDI BAYAT (M-TECH, AAU)

Stochastic Stability Analysis of a Wind Turbine with Flexible Blades

The present research concerns some preliminary results within an industrial PhD. Project dealing with nonlinear, chaotic and stochastic behavior including stability analysis of wind turbine due to turbulence. This initial step presents a stability analysis with global rotor whirl in order to present the coupling effect of in-plane translation, tilt and yaw of tower and in-plane bending of blades. The time-dependent equations of motion of a six degree of freedom model of a horizontal-axis wind turbine with three blades are represented and it is calibrated to GL Garrad Hassan (GLGH) software. The model accounts for the in-plane bending motion of each blade, in-plane translation of the tower with tilting and yawing motions of the tower. It is intended to use the Floquet theory for analyzing the chaotic behavior of the developed model. A parametric study is carried out to demonstrate the whirling of the tower and coupling which are presented in the model. The effect of turbulence is also demonstrated. Results reveal the effect of coupling between tower stiffness and flexible blades. The final goal of the project will be the development of a reduced order super-element for a given blade, modeling the indicated issues, which will be included into GLGH software.

KRISTOFFER A. DICKOW (CIVIL, AAU)

Prediction of Noise Transmission in Lightweight Building Structures

Noise annoyance in dwellings and office buildings is an important problem. The noise transmission between adjacent rooms in a building occurs directly through separating constructions as well as over different paths that include flanking building elements. The standard EN 12354 describing a simplified statistical energy analysis (SEA) subsystem approach provides a valuable tool to predict the flanking transmission of air-borne and structure-borne sound already in the stage of design. The losses that occur at the junctions, where different building elements are interconnected, play a key role in the EN 12354 standard, since they dominate the sound insulation of flanking paths. However lightweight building constructions typically do not meet the requirements for ideal SEA subsystems and therefore applying the EN12354 standard to lightweight building constructions may result into imprecise predictions. The objective of the present research project is to obtain a better knowledge of noise transmission for junctions of lightweight building elements and derive more precise prediction models, either as an extension of the SEA approach or based on finite element (FEM) solutions.

PARTHKUMAR D. GANDALAL (CIVIL, AAU)

Mitigation of Structures Borne Noise in Wooden Panels by Periodic Stiffening

Noise transmission is a potential problem in buildings. The vibrations may pass from one room to another as flanking noise via joints or as direct transmission between neighboring rooms. For heavy structures, e.g. concrete buildings, statistical energy analysis (SEA) has been found to provide a reliable framework for prediction on noise transmission. Walls and floors in light-weight timber structures are usually constructed as wooden panels. Depending on the geometry, material properties and boundary conditions, such panels may resonate at different frequencies within the audible range, leading to emission of noise. Furthermore, the panels may serve as waveguides, transmitting noise from one room to another or between floors. The objective of this research project is to minimize the transmission and emission by embedment of periodic stiffeners within the panels. Periodic structures have been studied in relation to pipes and similar one-dimensional structures. Here it has been found that periodicity, introduced in the right manner, may diminish wave propagation significantly within prescribed frequency ranges. A similar result is expected for wooden panels, where vibrations caused by line sources as well as point sources (e.g. at joints or corners) should be analysed. The aim is to develop analytical solutions that can be utilized for design, employing a generalization of classical Floquet theory to functions with radial periodicity. A comparison with the results obtained by finite-element analyses should also be made.

The present research is part of the Interreg project “Silent Spaces”, funded by the European Union. The authors highly appreciate the financial support.

SØREN MADSEN (CIVIL, AAU)

Buckling Analysis of Bucket Foundations for Wind Turbines on Deep Water

In the present years, there is an increased focus on offshore wind farms. The expenses related to foundations constitute about one third of the total cost of an offshore wind farm. When wind turbines are located on deeper water, the cost of the foundations will increase even further. Thus a new technology is needed to reduce the total cost of offshore wind turbines. This could be the bucket foundation, also named “suction caisson”.

The installation of the bucket foundation is initially caused by self-weight penetration. Subsequent suction is applied inside the bucket. The suction creates a pressure differential across the bucket lid, which increases the downward force on the bucket while reducing the skirt tip resistance.

The geometry of the bucket foundation is a thin shell structure. As the water depth increases, the diameter of the suction caisson also increases and the aspect ratio between the caisson diameter and the wall thickness becomes very large. Thus instability, in form of buckling, becomes a crucial issue during installation.

Several analytical expressions for the structural buckling pressure of circular cylindrical shells exist, but none takes the lateral restraints offered by the soil into account by means of advanced finite element solutions. It may be beneficial to perform more refined analyses, taking into account the real boundary conditions.

In this study, the risk of structural buckling is addressed using numerical methods to determine the hydrostatic buckling pressures of large-diameter bucket foundations during installation in three different soils, i.e. a soft homogeneous soil, a hard homogeneous soil and a layered soil profile with varying strength and stiffness. The effect of the lateral restraint offered by the surrounding soil on the hydrostatic buckling pressures is analysed in this study.

For the initial installation phase the free height of the skirt is large and a low suction pressure is needed. For subsequent installation phases, a larger pressure is needed. Thus a critical embedded depth is found in this study. Further the critical skirt thickness will be found.

Furthermore this study will hopefully result in an alternative shape/design of the suction caisson, which has a smaller risk of buckling under high pressure.

Programme for Tuesday morning, March 15th, 2011

3 – MATERIALS AND FAILURE I
(Chairman: JAKOB S. JENSEN, DTU Mechanical Engineering)

09:00 - 10:05 KIM LAU NIELSEN (DTU Mechanical Engineering, 20 minutes)
Cohesive Traction-Separation Laws for Tearing of Ductile Metal Plates
The failure process ahead of a mode I crack advancing in a ductile thin metal plate or sheet produces plastic dissipation through a sequence of deformation steps that include necking well ahead of the crack tip and shear localization followed by a slant fracture in the necked region somewhat closer to the tip. The objective of this work is to analyze this sequential process to characterize the traction-separation behavior and the associated effective cohesive fracture energy of the entire failure process. Traction-separation laws are an essential component of finite element methods currently under development for analyzing fracture of large scale plate or shell structures. The present study resolves the sequence of failure details using the Gurson constitutive law based on the micromechanics of the ductile fracture process, including a recent extension that accounts for damage growth in shear. The fracture process in front of an advancing crack, subject to overall mode I loading, is approximated by a 2D plane strain finite element model, which allows for an intensive study of the parameters influencing local necking, shear localization and the final slant failure. The deformation history relevant to a cohesive zone for a large scale model is identified and the traction-separation relation is determined, including the dissipated energy. For ductile structural materials, the dissipation generated during necking prior to the onset of shear localization is the dominant contribution; it scales with the plate thickness and is mesh-independent in the present numerical model. The energy associated with the shear localization and fracture is secondary; it scales with the width of the shear band, and inherits the finite element mesh dependency of the Gurson model. The cohesive traction-separation laws have been characterized for various material conditions.

REZA AZIZI (DTU Mechanical Engineering, 15 minutes)
Elastic plastic evaluation of metal matrix composite with strain gradient plasticity
Plasticity of Metal Matrix Composites (MMC) with respect to the rate independent strain gradient theory [2] is studied. The nature of the theory demands a new type of boundary conditions including higher order stresses. These non-conventional boundary conditions give enhanced modeling capabilities, which are important to micron-scale applications such as micron reinforced materials. Having plastic strain field as an independent parameter in addition to the displacement field in numerical computation (Finite Element Method) allows one to control the suppression of the plastic flow which is crucial close to the fiber-matrix interface. An extracted unit cell with circular fiber is analyzed under in-plane shear, Fig. 1, transverse and longitudinal tension while generalized plane strain is considered. Fibers are treated as to be completely elastic while the matrix is elastic plastic with linear hardening. The results highlight the intrinsic sizeeffects on the overall response curve and plastic strain distribution. The amount of Bauschinger effect is also investigated and compared with both conventional and strain gradient plasticity.

MARTIN LEONG (M-TECH, AAU, 15 minutes)
Failure of sandwich structures with wrinkle defects
Wrinkle defects can be formed during the production of wind turbine blades and earlier studies have shown that the in-plane compressive strength of a sandwich panel with wrinkle defect will decrease dramatically. This study focuses on the failure modes of sandwich specimens consisting of thick GFRP face sheets and balsa wood core with a wrinkle defect under in-plane compression. Three distinct modes of failure were found, and the strain distributions leading up to these failures were established by use of digital image correlation (DIC). Finite element analyses were subsequently conducted to model the response of the test specimens prior to failure, and generally a very good agreement was found, although local strain values around the wrinkle defect showed some discrepancies. The Northwestern University failure criterion was applied to predict failure initiation.

AMIN KIMIAEIFAR (M-TECH, AAU, 15 minutes)
A probabilistic approach to assess the reliability and probability of failure of adhesive scarfed lap joints in composite materials
A probabilistic model for the reliability analysis of adhesive scarfed lap joints subjected to static loading representative for a main laminate in a wind turbine blade subjected to flapwise bending is developed using three-dimensional finite-element calculations. The von Mises, a modified von Mises and the maximum stress failure criteria are chosen to assess the reliability level of the scarfed lap joint, and this is compared with the implicitly required target reliability level defined in the wind turbine standard IEC 61400-1. The probability of failure for the different failure criteria is calculated and compared for different number of numerical simulations. A convergence study is performed to validate the FE model, and a sensitivity analysis on the influence of various geometrical parameters and material properties on the maximum stress is conducted. A design equation is used where partial safety factors are introduced together with characteristic values. Because the yield behavior of many polymeric structural adhesives is dependent on both deviatoric and hydrostatic stress components, different ratios of the compressive to tensile adhesive yield stresses in the failure criterion are considered. It is shown that the failure criterion and the number of simulations are the two main effective factors on the probability of failure.

10:05 – 10:30 Coffee break

4 – WIND TURBINES
(Chairman: KIM BRANNER, RISØ DTU)

10:30 – 12:00 ZUZANA ANDRLOVÁ (RISØ DTU, 15 minutes)
Structural Design of Large Future Wind Turbine Blades under Combined Loading
The purpose of the project is to investigate, which structural and aeroelastic design challenges that can be expected for future 120m long blades (20MW wind turbine). Design of studied 120m long blade was initially based on 34m long blade designed by SSP Technology A/S. As part of the investigation, the 34m long blade was exposed to combined load and finite element analysis results were compared with full-scale experiment.
The loading of blades is a combination of aerodynamic and gravity loads, so different load cases may be critical depending on the rotor size. During experimental validation, the blades are usually loaded in two directions

separately, flapwise and edgewise, by a number of single forces along the blade. These forces are extracted as critical loads based on aeroelastic simulations of all design load cases according to international standards. It remains an open question if the current design requirements based on separated flapwise and edgewise loads capture all important failure mechanisms that the blade may experience during operation. Based on these reasons a wind turbine blade was loaded in a non-standard direction and its behavior under this combined loading was investigated. Results of nonlinear finite element analysis and full-scale experiment were compared and the failure mechanisms of the blade were studied.

One of the main problems seems to be the weight of the blade due to varying direction of the gravitational load. The mass of the blade could be significantly decreased by implementation of carbon material to the structural components of the blade, for example to the load carrying part. This method could also be combined with the use of sandwich material in this part, which is nowadays mainly designed as single skin component. The feasibility of such solutions has to be considered also from the cost point of view, but if the savings in material and weight of the whole wind turbine due to the lighter blade are radical, the overall costs could even decrease

ANASTASIA NEZHETSEVA (CIVIL, AAU, 15 minutes)

Compact reinforced composite (CRC) transition structures for offshore wind turbine foundations

Offshore wind plays a very important role in renewable energy policy of Denmark making a considerable contribution to national CO_2 reduction goals. Denmark represents an area with a high offshore potential owing to the extensive coastline of both the Baltic and the North Seas. Production and installation of an offshore wind turbine is about 50 per cent more expensive than that of an onshore. Moreover, foundation can cost up to 1/3 of the total cost of an offshore wind turbine. Moving wind farms into deeper water depths requires installation of larger foundations. Traditionally used monopile and gravitational foundations have larger weight and require heavy equipment for their installation. Suction caissons, also known as upturned suction installed skirted or bucket foundations, were introduced as an alternative to pile foundations for use in residual soil conditions for the depths up to approximately 40 m.

As an alternative to steel, Contec-ApS has developed a composite structure made of comparatively thin steel sheets and high-tension concrete—compact reinforced composite (CRC)—invented by Aalborg Portland, Denmark, in 1986. Integrating a large content of short, strong and stiff steel fibres (usually 3–6 vol.%) into the high performance concrete ensures its ductility. Moreover, CRC has an excellent durability and higher compressive strength (150–400 MPa) compared to traditional concrete. The focus of this research is optimization of a transition piece (TP) connecting the offshore wind turbine column with a suction bucket (caisson) foundation. Detailed standards and norms are established for offshore constructions made of steel.It comprises optimization of the CRC transition piece structure to lower manufacturing costs without compromising its strength and stiffness. Several models will be compared to find the one providing the better force distribution, preventing buckling and stress concentration and reducing the amount of material used. Minimization of the material consumption will be based on assumed current cost of construction materials. Another focus of this research is scour formation around suction buckets with various TPs. Whitehouse et al compared scour development around TPs with cylinder, conical and a girder top with radial fins shapes. As a result, the scour development for the model with conical top was almost two times faster than that for the girder. Moreover, scour progressed to a significant depth compared with a skirt depth of the structure. Following their work, physical models of the conical and doubly curved TP geometries with additional cutaways will be experimentally tested in a wave flume at Aalborg University. The models will be scaled to simulate the process of scour formation around the suction caissons comparable to conditions in full scale offshore.

MAHDI T. SICHANI (CIVIL, AAU, 15 minutes)

Estimation of Extreme Responses of Wind Turbines under Normal Operation by Means of Controlled Monte Carlo Simulation

Assessment of reliability and design of wind turbines require a means for estimation of very low failure probabilities of the system. This task can be tackled from three different points of view. The first class of methods is the extreme value distribution fittings to the extracted data of a wind turbine. Alternatively the so-called Variance Reduction Monte Carlo simulations (VRMC) enable efficient estimation of the first excursion of the wind turbines within reasonable computation charge. Capability of these methods in reducing variance of the failure estimations is a key parameter which allows efficient risk analysis, reliability assessment and rare event simulation of structural systems. However, VRMC methods do not provide any means of understanding the evolution of the PDF of the process within time. A

well-known tool for realizing the evolution of the Probability Density Function (PDF) of a dynamic process is available as the solution to the Fokker-Planck-Kolmogorov (FPK) equation. Unfortunately solution of the FPK, even by means of numerical tools, is practically limited to the low order structural dynamic problems.

The aim of the study is to determine the most appropriate method for application on a wind turbine model. The focus of this study is on the VRMC methods. Among the various available methods Importance Sampling (IS), Distance Controlled Monte Carlo (DCMC), Asymptotic Sampling (AS) and Subset Simulation (SS) are considered in this study.

Failure probability of a Single Degree of Freedom (SDOF) oscillator is primarily estimated using the introduced methods. The results of all of the methods are compared with the Standard Monte Carlo simulation which allows comparison of the accuracy and efficiency of the methods. The method with highest merit is chosen and used to estimate the 50 year return period of a simplified model of a real 5MW wind turbine subjected to turbulent wind field

GIREESH K.RAMACHANDRAN (DTU Mechanical Engineering, 15 min.)

Response of a TLP floating wind turbine subjected to combined wind and wave loading

A tension leg platform (TLP) solution for a floating offshore wind turbine is investigated. A representative location has been chosen to define the environmental loading conditions. The initial study has been done for a two dimensional configuration subjected to wind and two-dimensional linear regular and irregular waves giving rise to the coupled response. The effect of wind loading is modelled by means of a varying aerodynamic thrust from unsteady Blade Element Momentum theory. The total system is formulated using fourteen degrees of freedom. Wind and wave loads are coupled through the tower top displacement and velocity. The model implementation has been verified through a number of test cases. The coupled responses reveal that the present design is stable in the prescribed environmental conditions except for a resonance effect for the pitch response. Further incorporation of appropriate pitch damping from the spokes or arms of the floater might influence the computed response. The two dimensional responses provide insight into the platform motion and wind turbine behaviour. Extension of the model to 3D and further coupling with an advanced aero-elastic code is being carried out and preliminary results may also be presented.

IVAN B. SØNDERBY (RISØ DTU, 15 minutes)

Design of low order linear models for wind turbine control design

The purpose of this work is to determine the necessary complexity of a control design model for a wind turbine.

A modern wind turbine can operate at variable rotor speed and at different blade pitch-angles. A wind turbine controller in normal operation may be used to optimize the extracted energy from the wind at low wind speeds and limit the aerodynamic loading on the wind turbine at high wind speeds.

A wind turbine controller must be designed on a model that correctly predicts the dynamical aero-servo-elastic response of a wind turbine to meet the objectives of the controller. The design models must be of low order for a controller to be designed and used in on-line control operation.

It is analyzed how to approximate the dynamical aeroelastic response of a wind turbine using few state variables by order reduction of a high order linear model. Order reduction is performed with the aim to approximate the aeroelastic dynamical response of inputs from generator torque and pitch-angle actuators and wind speed variations to the measured and controlled outputs, e.g. rotor speed and power. The aeroelastic response of the wind turbine is approximated by:

- Modal truncation using structural modes of a high order FE model. High frequency modes are ignored.
- Modal truncation using aeroelastic modes of a FE model coupled with a quasi-steady or instationary BEM model of the aerodynamic loading.
- Modal residualization using structural and aeroelastic modes with low frequencies and including a quasi-steady correction of modes with high frequencies.
- Balanced truncation where the few states are used, which efficiently describes the observed response at measured and controlled outputs due to inputs from control actuators and wind disturbances.

NÉSTOR RAMOS GARCIA (DTU Mechanical Engineering, 15 minutes)

Unsteady viscous-inviscid interactive airfoil code for wind turbines

The 2D and quasi-3D, steady and unsteady versions of a viscous-inviscid aerodynamic code will be presented. The code is developed to analyze the local aerodynamic behavior of an airfoil section of a wind turbine with a moving trailing edge flap. The code uses a viscous-inviscid interaction technique with strong coupling between the viscous and the inviscid parts via the transpiration velocity concept. The inviscid part is modeled using a panel method and the viscous part is represented by the boundary layer equations put into integral form and with extensions for 3-D rotational effects.

12:00 – 13:00 Lunch

Programme for Tuesday afternoon, March 15th, 2011

5 – MATERIALS AND FAILURE II
(Chairman P. TERNDRUP PEDERSEN, DTU Mechanical Engineering)

13:00 – 14:15 NIELS HØJEN ØSTERGAARD (M-TECH, AAU, 15 minutes)

Lateral buckling of the tensile armor layers of flexible pipes

The project concerns a specific failure mode in flexible pipes used in the off-shore industry for transport of fluid from a subsea reservoir containing oil or gas. A flexible pipe is in general a complex composite structure comprised by several unbonded layers with different properties. The project deals with the tensile armor layers, which are constituted by two layers of helically wound steel wires ensuring the structural integrity against axial loads.

During pipe laying in ultra-deep waters, a failure mode has been observed by which lateral buckling occurs in the tensile armour layers. The failure mode is governed by large wire deflections and is known to occur when a flexible pipe is exposed to compressive loads due to hydrostatic pressure on the end cap of an empty pipe and repeated bending cycles. Buckling of the armour layers causes compression and twist to couple, so failure can be detected as large pipe twist.

The project aims to investigate the physics of the lateral buckling failure mode by reproducing it in the laboratory in a test rig constructed specifically for this purpose. Furthermore, theoretical studies in wire mechanics based on curved beam equilibrium and concepts from differential geometry are conducted in order to establish a method for prediction of lateral buckling failure.

Experimental results will be compared with the prediction of mode shapes and limit load obtained by theoretical means.

ALI SARHADI (DTU Mechanical engineering, 15 minutes)

Thermal modeling of the precision glass moulding process

Efficient manufacturing process of the lenses for camera module in cellular phones has been leaded to use of glass materials instead of polymers. Furthermore, recent improvement in manufacturing process of the camera lenses has introduced a new technology which is called wafer based precision glass moulding technology. Utilization of wafer based precision glass-moulding technology has some important advantages such as cost reduction, tolerant manufacturing, supply chain simplification, higher image quality and so on. Precision glass molding is a one step high volume near net-shape precision fabrication method. Moreover, high required accuracy and complexity of this technology needs a good understanding of the process. Numerical simulation can help to understand the manufacturing process. In the precision glass moulding process, modelling of heat transfer to obtain the temperature distribution of the molten glass has a great importance because it significantly affects the productivity and thermal residual stresses in the final product. The current research deals with investigation of the heat transfer in precision glass moulding process. First, the finite difference based FVM is used to model one dimensional transient heat transfer in the glass moulding problem with considering time dependant thermal conductivity and heat capacity. Then the results are compared with FEM software. The obtained results make the basis for the generalization of the simplified model to the actual transient heat transfer model in the precision glass molding.

JON SPANGENBERG (DTU Mechanical Engineering, 15 minutes)

Prediction of the impact of flow induced inhomogeneities in Self Compacting Concrete (SCC).

SCC is nowadays a worldwide used construction material. However, heterogeneities induced by casting may lead to variations of local properties and hence to a potential decrease of the structure's load carrying capacity. The heterogeneities in SCC are primarily caused by static and dynamic segregation. The presentation reports property maps for a beam based on particle distributions at the end of casting derived from numerical flow simulations. A finite volume based numerical model is used to predict particle distributions at the end of casting, which are then converted into property maps using semi-empirical relations from literature.

MICHAEL WENANI NIELSEN (DTU Mechanical Engineering, 15 minutes)

Thermomechanical model of curing and residual stress development during wind turbine blade moulding

A 1D thermomechanical model is programmed in MATLAB to model the curing behaviour of a glass/polyester composite laminate, representing part of the Vacuum Assisted Resin Transfer Moulding (VARTM) process used in the manufacture of wind turbine blades. The curing behaviour of the resin is modelled such that the exothermic reaction during polymerization is taken into account as well as volumetric chemical shrinkage. This is done by solving Fourier's governing heat conduction equation, reduced to one dimension, where the heat generation term is a function of the resin cure degree. This is implemented using the control volume finite difference method (CVFDM) with a through-thickness spatial domain discretization of the laminate. Using Classical Laminate Theory (CLT), in-plane transient and residual stresses are calculated during a typical cure cycle for different laminate thicknesses. This is done by taking the thermal and chemical strains into account in a micro-mechanics model and predicting the effective mechanical properties and process-induced strains of the composite during cure. Using CLT, effective plate loads are calculated, followed by ply strains and stresses.

A similar model is constructed in ABAQUS, using programmed subroutines in Fortran for the heat generation, chemical shrinkage and resin modulus evolution as a function of the cure degree. Results are compared with similar available work in literature.

SIAVASH TALEBI TAHER (M-TECH, AAU, 15 minutes)

Thermal degradation of polymer foam cored sandwich structures

The project deals with the experimental investigations of thermo-mechanical properties of polymer foam core materials, and the load response of foam cored sandwich panels subjected to combined mechanical and thermal loading over a wide range of temperatures.

Polymer foam cored sandwich structures are often subjected to severe service conditions which may include elevated temperatures. The mechanical properties of polymer foam cores degrade significantly with elevated temperatures, and significant changes in the properties may occur well within the operating range of temperatures. When mechanical and thermal loads act simultaneously, nonlinear interaction effects may occur and subsequently lead to a complete loss of structural integrity. Recent theoretical/numerical models have been used to investigate and quantify these thermal degradation effects, which are important for e.g. composite sandwich wind turbine blades, boat/ship structures as well as for applications in the ground and aerial transportation sectors.

A novel bidirectional apparatus (Danish paten No: PA201100050) has been developed to characterize polymer foam materials with respect to their tensile, compressive, shear and bidirectional mechanical properties at room and at elevated temperatures, and including the elastic coefficients and the stress-strain response to failure.

The purpose of this project is to provide foam core material data and a detailed experimental validation of the developed models, as well as to further develop and refine the modelling capabilities with a special focus on their adaptation for engineering design purposes. The experimental results will be used to inform the models, and thereby accurately define the load/temperature limits that mark the degradation onset.

14:30 – 18:00 Social Event

18:30 - Conference dinner

Programme for Wednesday morning, March 16th, 2011

6 – MODELLING AND ANALYSIS I
(Chairman: POUL HJORTH, DTU Mathematics)

09:00 – 10:20 FRANK SCHILDER (DTU Mathematics, 20 minutes)

Continuation guided experiments

Experiments, simulation and continuation are three established methods for response analysis of physical systems or models thereof, which we collectively refer to as dynamical systems (DSs). All three approaches can be used for producing a bifurcation diagram of a specific DS. However, each approach has distinctive advantages and disadvantages. While performing experiments is usually time- and resource intensive, it has the advantage that one investigates the actual system, which eliminates the possibility of modelling errors. Performing simulations on a computer implementation of a model of a DS, on the other hand, is considerably cheaper and it is much easier to change model parameters than in experiments. However, simulations of sophisticated models typically require substantial computational power. Furthermore, both methods share the drawback that they can only track stable responses, a restriction that is overcome by using continuation. The idea of continuation is to employ a path-following algorithm for specific types of states of a DS, for example, equilibrium states and periodic responses, and to monitor their stability, which allows to reproduce the global behaviour of a DS. While continuation can track stable as well as unstable responses, its application is most effective on carefully derived reduced models of relatively small dimension. A novel approach to overcome individual limitations of these methods is control based continuation, which aims at combining these methods in such a way that individual drawbacks are removed.

MORTEN ENEMARK LUND (M-TECH, AAU, 15 minutes)

Validation of patient specific gait models

The validity of the predictions from musculoskeletal models depends largely on how well the morphology of the model matches that of the patient. To address this problem, we present a novel method to scale a cadaver-based musculoskeletal model to match both the segment lengths and joint parameters specific to the patient. This is accomplished using optimisation methods to determine patient-specific joint positions and orientations, which minimise the least-squares error between model markers and the recorded markers from a motion capture experiment.

Functional joint positions and joint axis orientations are then used to morph/scale a cadaver based musculoskeletal model using a set of radial basis functions (RBFs).

Using the functional joint axes to scale musculoskeletal models provides a better fit to the marker data, and allows for representation of patients with considerable difference in bone geometry, without the need for MR/CT scans. However, more validation activities are needed to better understand the effect of morphing musculoskeletal models based on functional joint parameters.

EMIL BUREAU (DTU Mechanical Engineering, 15 minutes)

Experimental bifurcation analysis by using control based continuation

Control based continuation is an experimental method for tracking out stable and unstable branches of bifurcation diagrams for dynamical systems. The method bypasses the use of mathematical models, and systematically explores the nonlinear dependency of vibrations on parameters directly on the physical system, even tracking unstable vibrations that are not normally observed in the lab. This is done by actively stabilizing periodic orbits of the system by applying a control scheme that makes the control e_ort vanish once the system settles onto its stable or unstable periodic vibration. The method o_ers a way to obtain valuable information on parameter dependencies in cases where the complexity of a system does not allow for a description by simple models, or when computational burden of conducting a parameter study on a detailed computer model is too big. The talk will focus mainly on the ongoing work of implementing and applying the method on a forced nonlinear exible pendulum controlled by electromagnetic actuators.

NIELS FUGLEDE (DTU Mechanical Engineering, 15 minutes)
Roller chain drive analysis: simplified modeling and dynamic effects of meshing
Transverse vibration of a roller chain and the effects of sprocket interaction are examined. Meshing of a roller chain with a sprocket causes noise and vibration, owing to sprockets forming polygons instead of circles. A method for analyzing the dynamical effects of meshing is introduced. The chain is modeled as a moving uniform string subjected to excitation at the boundaries typical of roller chain drives. Results obtained so far, of applying perturbation methods to predict dynamical responses, are presented.

ALEJANDRO C. VARELA (DTU Mechanical Engineering, 15 minutes.)
Mechatronics Applied to Fluid Film Bearings: Towards More Efficient Machinery
Rotating machines like turbo-generators, compressors, turbines, and pumps, are often vital elements in the production process, for example in the oil, gas or power generation industry. In many situations, the availability of these machines depends on their adaptation capability to fast changing demands or to eventual failure of any of its mechanical components. Such requirement can be fulfilled by modifying the basic design of some machine elements, in order to make them capable of modifying their characteristics according to the current operational requirements.
Fluid film bearings are widely used on rotating machinery due to their ability of withstanding high load and speed operational requirements. Tilting pad journal bearings are particularly suitable for high rotational speed requirements, due to their superior stability characteristics. It is possible to increase even further the versatility of these devices, by including the feasibility of injecting pressurized oil directly into the bearing-journal clearance. If the injection pressure is dynamically modified by the association of electronics, control design and hydraulics, then one obtains an active lubrication bearing (ALB), capable of inducing controllable forces over the rotor, allowing to extend the operational range of the machine and making it adaptable to different operational conditions.
This presentation is aimed at presenting the state of the art of the active lubrication bearings technology. The basis for the mathematical modellation of such bearings, the Modified Reynolds Equation, is presented, as well as its possible extensions in order to take into account different effects, as oil film temperature build-up and elastic deformations of the pads. Theoretical and experimental results are exposed, in order to show the feasibility of using these devices to increase the operational range of rotating machinery.

10:20 – 10:45 Coffee break

7 – MODELLING AND ANALYSIS II
(Chairman: SØREN R.K. NIELSEN, CIVIL, AAU)

10:45 – 11.45 SUBRATA BHOWMIK (DTU Mechanical Engineering, 15 minutes)

Real-Time Implementation of Semi Active Control Strategies for Structural Vibration Mitigation with Magneto-Theological Damper

A number of control strategies based on semi-active devices for civil structures, subject to base excitations, have been proposed in recent years. A rotary type Magneto-Rheological (MR) damper has in the present study been used as a semi-active damping device. The direct and inverse models of the MR damper have both been identified by feed-forward back-propagation neural networks trained and validated by experimental data sets. Three different control strategies are developed and verified by simulations and experiments. The methods adopted are optimal viscous damping, viscous damping with negative stiffness and amplitude proportional friction damping with negative stiffness. The displacement and acceleration are directly measured by a laser sensor and an accelerometer, respectively. The Kinematic Kalman Filter (KKF) is used to estimate the velocity of the damper using displacement and acceleration as simultaneous input. This is a robust and accurate alternative to e.g. differentiation of displacement data, which may introduce excessive noise, or integration of acceleration, which is difficult to measure in the low-frequency range. For tracking of the desired optimal control force the inverse neural network model of the MR damper provides the corresponding control current, which in the experimental setting is passed on to the actual MR damper. The data acquisition and real-time control is handled by a Matlab/dSPACE® system. The results from the three control strategies are compared and it clearly demonstrates that adding negative stiffness gives better performance compared to classic pure viscous damping.

LAI ZHANG (DTU Mathematics, 15 minutes)

Bifurcation analysis of a size structured population model

By our developed numerical continuation of equilibrium, we study the cannibalistic effects on the population dynamical behavior of a size-structured population model. Species in our model is trait-based, uniquely characterized by the asymptotic body size. Varying trait value allows us to trace the reaction of different species to cannibalism. Our numerical continuation of equilibrium proves easy and robust, and it is not only able to locate all steady states but also able to demonstrate the equilibrium stability. With this approach, we find that our model experiences the reported cannibalistic effects including the life boat effect and recently observed 'Hansel and Gretel' effect. For small species there is a unique positive steady state which is globally stable while for large species cannibalism can induce alternative steady states. Among the recognized three steady states two are stable. A fold bifurcation is identified, but the occurrence of fold bifurcation is not confined to large species. When the bifurcation takes places is strongly correlated with the species spectrum, size-dependent cannibalism and food-dependent individual growth.

MOHAMED A. ABDELRAHEEM (DTU Mathematics, 15 minutes)

Lightweight Cryptography

Lightweight Cryptography is a new research field that has emerged to resolve the security problems in tiny computing devices that have low computing power such as RFID tags. In this talk, we will describe the authentication and privacy security problems that arise in RFID and discuss the currently proposed solutions and the remaining challenges in these problems.

MAZIYAR NESARI ZADEH (M-TECH, AAU, 15 minutes)
Analysis of Wave Propagation in Curbed Elastic Layers
In industrial applications where material grinding is part of a production line, vertical roller mills are often employed as the process equipment. The grinding technology in vertical roller mills is based upon having several rollers actuated on a rotational table where the raw materials are ground between the rollers and the table. This operation can generate large-amplitude vibrations, which should be investigated during the PhD-project.
The analysis of wave guide properties of a grinding bed is one of the issues to be considered. This presentation is concerned with circumferential wave propagation in an elastic layer of the constant curvature. The exact solutions of equations of elasto-dynamics for such a layer in the plane and the anti-plane formulations are compared with their counterparts for a straight elastic layer (in the former case, a classical Rayleigh-Lamb solution). The out-of-plane wave motion of a straight and a curves layer is considered within the classical Kirchhoff plate theory.

11:45 – 12.45 Lunch

Programme for Wednesday afternoon, March 16th, 2011

8 – OPTIMIZATION II
(Chairman: NIELS OLHOFF, M-TECH, AAU)

12:45 – 14:25 YURIY ELESIN (DTU Mechanical Engineering, 20 minutes)
Time-domain topology optimization of nanophotonic waveguides
A methodology for obtaining optimized designs for 1D optical signal filters, diodes and logical switches is presented. Gradient-based topology optimization method coupled with a nonlinear finite difference dime domain solver is utilized. The optimization is performed with respect to an envelope of the transmitted signal extracted using the Hilbert transform. The recorded signal is filtered using an FFT filter to simulate a receiver with limited bandwidth sensitivity and also to avoid interference with the control signal in the case of a photonic switch. A standard approach for designing logical switches involves a weak probe beam operating near the band edge and a strong pump beam capable of altering the index of refraction of the nonlinear bandgap structure. The pump beam controls the position of the band edge of the nonlinear bandgap structure and controls whether the probe beam is transmitted or not. Such effect can be achieved by using a pump beam, which has intensity several orders of magnitude higher compare to the probe beam, combined with simple periodic bandgap structure. On the other hand, the topology optimization approach presented here results in certain topologies of the logical switch which do not have a periodic bandgap structure. At the same time a logical switch with the optimal topology can be very efficient even when the energy of the control pulse has the same order as the probe pulse. This opens up the possibility for such devices to be used in ultrafast nanophotonic systems. The presented methodology can be extended to be applicable for mechanical devices such as acoustic diodes and switches.

FENGWEN WANG (DTU Mechanical Engineering, 15 minutes)
Robust design of photonic crystal waveguides for slow light
It has been experimentally demonstrated that photonic crystal waveguides, generated by introducing a line-defect in 2D periodic photonic crystals, can facilitate slow light propagation with high confinement in the line defect. However, slow light in photonic crystal waveguides usually displays high group-velocity-dispersion (GVD), high sensitivity to manufacturing imperfections. In this study, we aim to design photonic crystal waveguides for high confinement slow light with low GVD and to realize design robustness with respect to manufacturing imperfections using topology optimization. We have previously demonstrated the use of a topology optimization algorithm for designing robust photonic crystal waveguides with low group velocity and small GVD. Recently, this work has been extended to generate slow light modes with enhanced filed confinement. Confinement constraints are implemented to enhance the field confinement of designed slow light modes. Additionally, we plan to include loss mechanisms in the model in order to reduce losses in designed waveguides. This formulation can ensure that the optimized structures still possess good performances when they are slightly under- or over-etched. Based on this formulation, we realize novel photonic crystal waveguides for slow light with high group index of ng=80 and ng=150. A normalized delay-bandwidth product around 0.43 can be achieved in both cases and all the confinement ratios of designed modes are bigger than 50%. Compared with the results obtained from geometrical perturbations, the

GVD of designed slow light modes has been reduced by at least one order of magnitude.

JACOB ANDKJÆR (DTU Mechanical Engineering, 15 minutes)
Topology optimized acoustic and low-contrast all-dielectric optical cloaks
In order to hide a given object for a specific frequency range in the acoustic or electromagnetic spectrum it is necessary to obtain the material properties of these so-called acoustic or electromagnetic cloaks and be able to realize the properties. All the theoretical work and realizations of electromagnetic and acoustic cloaks are to the author's knowledge based on anisotropic material parameters. Several simplified realizations of electromagnetic cloaks have been achieved. In the acoustic case, realizations are more cumbersome due to the anisotropic mass density, which is not common in naturally occurring materials. In this work we have systematically addressed the intriguing question: "How efficiently can we cloak when using conventional simple isotropic media readily available in nature?" Results show that gradient-based topology optimization can be used to find the permittivity distribution for a low-contrast all-dielectric optical cloak that hides an ideal metallic cylinder in a limited frequency range for up to 4 symmetrical distributed angles of incidence. The physics of time-harmonic acoustic waves and time-harmonic E- or H-polarized electromagnetic waves are governed by the scalar Helmholtz' equation, in which only the material properties and state variable are different for the three wave problems. Thus with a limited reformulation, the initial methodology of designing optical cloaks can also be used to design an acoustic cloak with isotropic material properties to circumvent the problems of anisotropic mass density.

CASPER S. ANDREASEN (DTU Mechanical Engineering, 15 minutes)
Topology Optimization of Poroelastic Structures
In this presentation a multi scale approach is used to model and optimize the performance of a saturated poroelastic actuator. Two individually sealed slabs of porous material are layered such that the actuator will deflect when one of the slabs are pressurized. In order to increase the performance of the actuator, topology optimization is applied to the design of the material micro-structure such that the macroscopic properties, extension and deflection, can be optimized. The method is based on a two-scale asymptotic expansion which allows for separate solutions at each of the scales. At the micro-scale the material properties for a given micro structure is extracted by homogenization of a periodic unit cell. This is a material distribution problem and it is well suited for topology optimization. The macro scale solution, based on the homogenized properties, then gives the extension and deflection of the actuator.

BIN NIU (M-TECH, AAU, 15 minutes)
Design Optimization of Foundation for Rotating Machinery Against Standing-wave Vibration in a Building
This paper deals with the problem of optimum design of a foundation for rotating machinery in a building with a view to minimize the level of standing-wave vibration in the building. Rotating machinery in buildings is usually applied in central heating and ventilation systems, and larger machinery of this type including a pump is normally mounted on a foundation that is placed on one of the storeys of the building. The foundation is usually designed as a base plate for the machinery, with some resilient elements fixed

to the bottom of the base plate and supported by the floor of the storey in order to provide a suitable level of vibration isolation of the building.

Due to variable service speeds and the existence of non-balanced masses, the rotating machinery may be considered a source that within a given range of excitation frequencies excites forced vibration of the foundation, and thereby the floors and walls, etc. of the building. The transmission of such vibrations through the building may result in undesirable sound emission and unsatisfactory comfort conditions for the people in dwellings and offices of the building. To remedy this, the objective of this work is to develop and implement a method of sizing and topology optimization to determine optimum stiffness and damping values of resilient elements, and optimum dimensions and topology of the base plate subject to constraints on availability of physical properties of material and amounts of materials to be used. The design objective is chosen as minimization of the dynamic force excitation on the floor of the building where the foundation with the rotating machinery is mounted, over the range of excitation frequencies (corresponding to the service speeds) of the machinery.

At the current stage of our project, this problem is only carried out for a given, quite simplified model of a building. However, for this building model, the design and performance of the optimized machinery foundation will be illustrated and discussed using several numerical examples.

In the next stage of our work, a multi-material, parameterized building model will be developed with detailed dimensions and connections of components, and the current problem will be extended to encompass simultaneous design optimization of both the building and the foundation for the rotating machinery in order to minimize the level of standing-wave vibration in the building.

JONAS DAHL (M-TECH, AAU, 15 minutes)

Topology optimization of compliant mechanisms made from non-linear elastic materials

Compliant mechanisms are flexible bodies that transfer force from one or more (input) points to other (output) points via elastic deformation. For certain applications compliant mechanisms offer several advantages over conventional mechanisms in terms of for example less friction, no assembly, and no backlash. Topology optimization has been used with great success by, e.g., Pedersen et. al. (2001) and Bruns and Tortorelli (2001), to synthesize compliant mechanisms. The aim of this study is to extend topology optimization of compliant mechanisms to include non-linear elastic materials. The specific elastic material used in this study is typical for rubbers and some polymers and is described by an Ogden model. It displays linear stress-strain characteristic for small strains, followed by softening for intermediate strains, ending with significant hardening at large strains. Many compliant mechanisms are formed by flexible links/joints and stiffer beam-like members. The performance of such compliant mechanisms is largely determined by the deformation in the joints. This study focuses on the effects of material non-linearity on the size and shape of these joints.

14:25 Coffee

15:45 Departure from the hotel