PROGRAM, LIST OF PARTICIPANTS, and ABSTRACTS

DCAMM

12th Internal Symposium

Monday, March 23 to
Wednesday, March 25, 2009

SØRUP HERREGÅRD
RINGSTED

TECHNICAL UNIVERSITY OF DENMARK
and AALBORG UNIVERSITY

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

Technical Assistance:
Christina Sparre Andersen

Organization:
DCAMM and the DCAMM Research School

Important information:

The language of presentation is English.

First year Ph.D. students present in the poster session. The posters should be in A0 format (wide or tall format equally good). Please include a picture of yourself in the poster. Second year Ph.D. students are given 10 minutes for their presentation and 5 minutes for discussion. Third year Ph.D. students and all others are given 15 minutes for their presentation and 5 minutes for discussions.

All presenters are requested to send the electronic presentations to Erik Lund (el@me.aau.dk) no later than 12.00 on Wednesday March 18, 2009. 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.

Presenters who do no deliver their electronic presentations to Erik Lund are referred to use transparencies and an overhead projector.

Please note that there is an indoor swimming pool and nice jogging tracks outside.

Programme for Monday afternoon, March 23rd, 2009

11:30	Arrival
12:00 - 13:00	Lunch
13:00 - 13:05	Welcome and practical information, OLE SIGMUND (DTU Mechanical Engineering, 5 minutes)
	1 – FLUID MECHANICS AND FLUID STRUCTURE INTERACTION (Chairman: MORTEN BRØNS, DTU Mathematics)
13:05 – 15:00	KNUD ERIK MEYER (DTU Mechanical Engineering, 20 minutes) POD analysis of PIV measurements
	SAJJAD HAIDER (DTU Mechanical Engineering, 15 minutes) PIV Study of In-Cylinder Confined Swirling Flow
	JOHAN RØNBY PEDERSEN (DTU Mathematics, 15 minutes) Analysis of idealized body-vortex systems
	SOIZIC JONCQUEZ (DTU Mechanical Engineering, 20 minutes) Validation of Added Resistance of ships with a Boundary-Element Method
	HARVEY A. ZAMBRANO-RODRIGUEZ (DTU Mechanical Engineering, 20 minutes) Atomistic Simulations of Thermophoretic Motion of Water Nanodroplets in Carbon Nanotubes
	STEPHANIE ENZ (DTU Mechanical Engineering, 15 minutes) Phase shift effects for vibrating pipes conveying pulsating fluid
15:00 - 15:30	Coffee break
	2 – INVITED PRESENTATION AND GEO (Chairman: ERIK LUND, ME, AAU)
15:30 – 17:00	JENS HORORE WALTHER (DTU Mechanical Engineering, 45 minutes) Multiscale simulations using particles
	SØREN MIKKEL ANDERSEN (CIVIL AAU, 20 minutes) Material-point method for geotechnical engineering
	LARS ANDERSEN (CIVIL AAU, 20 minutes) Modelling of sectioned tunnels under earthquake loading: Shortcomings of the Winkler approach
	3 – POSTER SESSION
17:00 – 19:00	(1) REZA AZIZI (DTU Mechanical Engineering) Multi-scale modeling of composites
	(2) CASPER S. ANDREASEN (DTU Mechanical Engineering) Topology Optimized Crash Protection

(3) NIELS AAGE (DTU Mechanical Engineering)
Topology optimization of devices for wireless energy transfer - The design parameterization

(4) SUBRATA BHOWMIK (DTU Mechanical Engineering)
Semi-Active Control of Magneto-Rheological Dampers with Negative Stiffness

(5) STEFANO MOROSI (DTU Mechanical Engineering)
Magnetic Foil Bearings – Theory and Experiments

(6) RENÉ MATZEN (DTU Mechanical Engineering)
Design of Optical Circuit Devices Using Transient Topology Optimization

(7) JOHANNES TOPHØJ RASMUSSEN (DTU Mechanical Engineering)
Determining the aerodynamic admittance of bridge sections by use of the discrete vortex method

(8) ULRIK MARK ANKERGREN (DTU Mechanical Engineering)
Rock Mechanics Model for Enhanced Oil Recovery

(9) TRINE COLDING LOMHOLT (DTU Mechanical Engineering)
Microstructure Evolution during Friction Stir Welding

(10) JACOB ANDKJÆR (DTU Mechanical Engineering)
Design of grating couplers using topology optimization for the efficient excitation of surface plasmons

(11) MUSTAFA ASLAN (Risø DTU)
Characterisation and micromechanical modelling of wood fibers and composites

(12) KRISHNA K. KRISHNAN (Risø DTU)
Residual stresses of advanced thick fibre composites

(13) ZUZANA ANDRLOVA (Risø DTU)
Structural Design of large Future Wind Turbine Blades under Combined Loading

(14) MAHDI TEIMOURI SICHANI (CIVIL AAU)
Estimation of Extreme Responses of Wind Turbines under Normal Operations by Means of Controlled Monte Carlo

(15) LELAI ZHOU (ME AAU)
Energy Analysis of Human Arm Motions in ADL (Activities of Daily Living)

(16) CHRISTIAN GAMMELGAARD OLESEN (ME AAU)
Validation of a Seated Human AnyBody Model Using an Instrumented Chair

(17) ALF SØE-KNUDSEN (ME AAU)
Stop-band Analysis on Periodic Structures containing Spatial Curved Pipe Segments

(18) MARTIN KLITGAARD LEONG (ME AAU)
The influence of defects on the failure of wind turbine blades

(19) SØREN EMIL SØRENSEN (ME AAU)
Dynamic Effects in Large Scale Sortation Systems

(20) NIELS HØJEN ØSTERGAARD (ME AAU)
Lateral buckling of the tensile armor layers of flexible pipes

(21) VICTOR ZERMENO (DTU Mathematics)
Computation of superconducting wind turbine generators

(22) VALERIE GAUTHIER (DTU Mathematics)
Post-quantum cryptography

(23) LAI ZHANG (DTU Mathematics)
Community assembly

(24) PETER NØRTOFT NIELSEN (DTU Mathematics)
Iso-geometric analysis in structural vibrations

(25) NGUYEN DANG MANH (DTU Mathematics)
Iso-geometric analysis and shape optimization in electromagnetism

19:00 - Dinner

Programme for Tuesday morning, March 24th, 2009

08:00 - 09:00	Breakfast
	4 – OPTIMIZATION (Chairman: JOHN RASMUSSEN)
09:00 - 11:00	CHRISTIAN GRAM HVEJSEL (ME AAU, 15 minutes) Interpolation Schemes in Multi-Material Optimization Problems
	EDUARDO MUNOZ (DTU Mathematics, 15 minutes) Global Optimization for Multi-material Design of Composite Structures
	ESBEN LINDGAARD OLESEN (ME AAU, 15 minutes) Optimization of Composite Structures subjected to Compression Loads considering “Worst” Shape Imperfections
	ODED AMIR (DTU Mathematics, 15 minutes) Topology Optimization for Crashworthiness Design Using Approximate Procedures
	BOYAN S. LAZAROV (DTU Mechanical Engineering, 20 minutes) Sensitivity filters in topology optimisation as a solution to Helmholtz type differential equation
	MARIE B. DÜHRING (DTU Mechanical Engineering, 20 minutes) Improving acousto-optical interaction by high aspect ratio electrodes
	BIN NIU (ME AAU, 20 minutes) Design optimization of vibrating laminated composite plates for minimum sound radiation
11:00 - 11:30	Coffee break
	5 - BIO (Chairman: POUL SCHEEL-LARSEN, DTU Mechanical Engineering)
11:30 - 13:05	NINA ANDERSEN (DTU Mathematics, 15 minutes) In Silico Models of Blood Coagulation
	MICHAEL SKIPPER ANDERSEN (ME AAU, 20 minutes) Musculoskeletal Modeling of Rectus Femoris Tendon Transfer in Kids With Hemiplegic Cerebral Palsy
	RUNE KAASEN (DTU Mathematics, 20 minutes) Evolution within supercolonies
	KIM KNUDSEN (DTU Mathematics, 20 minutes) Mathematical aspects of Electrical Impedance Tomography
	PETER RØGEN (DTU Mathematics, 20 minutes) Some (DC) AMM problems in computational structural biology
13:05 - 14:00	Lunch

Programme for Tuesday afternoon, March 24th, 2009

	6 – WELDING AND FRACTURE (Chairman: Christian Niordson, DTU Mechanical Engineering)
14:00 - 16:30	MIKKEL MELTERS PEDERSEN (ME AAU, 15 minutes) Increasing Performance of Welded High Strength Steel Structures Subjected to Fatigue Loading
	JESPER HATTEL (DTU Mechanical Engineering, 20 minutes) Thermomechanical modelling of Friction Stir Welding
	CEM C. TUTUM (DTU Mechanical Engineering, 20 minutes) A Multi-Objective Optimization Study on Residual Stresses in Friction Stir Welding
	ANDERS ASTRUP LARSEN (DTU Mathematics, 20 minutes) Optimization of the material hardness distribution in friction stir welds
	KIM LAU NIELSEN (DTU Mechanical Engineering, 15 minutes) Effect of Specimen Geometry on Ductile Failure of RSW Shear-lab Specimens
	ANDERS LIBAK HANSEN (ME AAU, 20 minutes) On Buckling Induced Delamination of Plates
	BRIAN N. LEGARTH (DTU Mechanical Engineering, 20 minutes) Debonding failure in micro-composites
	LARS P. MIKKELSEN (Risø DTU, 20 minutes) Biomechanical Investigation of Scull Fracture
17:00 - 18:00	Social Event
18:30 -	Conference dinner

Programme for Wednesday morning, March 25th, 2009

08:00 - 09:00	Breakfast
	7 – WIND TURBINES AND MATERIALS (Chairman: Lars P. Mikkelsen, Risø DTU)
09:00 - 10:45	VLADIMIR A. FEDOROV (DTU Mechanical Engineering, 15 minutes) Investigation of Structural Behavior due to Bend-twist Couplings in Wind Turbine Blades
	KIM BRANNER (Risø DTU, 20 minutes) Ultimate Strength of Wind Turbine Blades
	KASPER KOOPS KRATMANN (ME AAU, 20 minutes) Determination of Mechanical Properties Governing Compressive Failure of UD CFRP
	MIRZA KARAMEHMEDOVIC (DTU Mathematics, 20 minutes) Application of the Method of Auxiliary Sources in Characterisation of Micro and Nano Structures by Optical Diffraction Microscopy
	MARTIN NYMANN SVENDSEN (DTU Mechanical Engineering, 15 minutes) Modal Control of Wind Turbines
	NIELS OLHOFF (ME AAU 10 minutes) About IUTAM
10:45 - 11:15	Coffee break
	8 – MACHINE ELEMENTS AND ENGINES (Chairman: Jon Juel Thomsen, DTU Mechanical Engineering)
11:15 - 13:00	EDGAR ESTUPINAN PULIDO (DTU Mechanical Engineering, 15 minutes) Active Lubrication Applied to Reciprocating Engines – Control Strategies
	RUNE PEDERSEN (DTU Mechanical Engineering, 15 minutes) Time-Varying Modal Analysis Applied to Spur Gear Pairs Taking Into Account Tooth Profile Modifications
	MARTIN ASGER HAUGAARD (DTU Mechanical Engineering, 15 minutes) Modelling of Hybrid Fluid Film Bearings
	MICHAEL VINCENT JENSEN (DTU Mechanical Engineering, 15 minutes) Heat transfer in two stroke diesel engines for large ship propulsion
	CASPAR ASK CHRISTIANSEN (DTU Mechanical Engineering, 15 minutes) Experimental Investigation of Heat Transfer in Two-Stroke Diesel Engines
	TROELS DYHR PEDERSEN (DTU Mechanical Engineering, 20 minutes) Acoustic resonance in HCCI combustion
	MORTEN BRØNS (DTU Mathematics, 10 minutes) About DCAMM Research School
13:00 - 14:00	Lunch
14:00	Departure from the hotel

List of Participants

DTU Mechanical Engineering-MPP:
Hattel, Jesper
Tutum, Cem C.*

DTU Mechanical Engineering-MTU:
Lomholt, Trine Colding*

DTU Mechanical Engineering-FM:
Cavar, Dalibor
Christiansen, Caspar Ask*
Haider, Sajjad *
Jensen, Michael Vincent*
Meyer, Knud Erik
Mikkelsen, Robert
Pedersen, Troels D.*
Rasmussen, Johannes T.*
Scheel-Larsen, Poul
Sørensen, Jens Nærkær
Walther, Jens Honore
Zambrano-Rodriguez, Harvey A.*

DTU Mechanical Engineering-SKK:
Ankergren, Ulrik Mark *
Bhowmik, Subrata*
Blasques, Jose Pedro*
Fedorov, Vladimir A.*
Høgsberg, Jan
Joncquez, Soizic*
Pedersen, Preben T.

DTU Mathematics:
Andersen, Nina*
Amir, Oded*
Brøns, Morten
Brander, David
Canh, Nam Nguyen
Duun, Marie Bro*
Gauthier, Valerie*
Gravesen, Jens
Kaasen, Rune*
Karamehmedovic, Mirza
Knudsen, Kim
Larsen, Anders Astrup*
Lahaye, Domenico
Manh, Nguyen Dang*
Markvorsen, Steen
Munoz, Eduardo*
Nielsen, Peter Nørtoft*
Pedersen, Johan Rønby*
Røgen, Peter
Starke, Jens
Stolpe, Mathias
Zhang, Lai*
Zermeno , Victor*

DTU Mechanical Engineering-FAM:
Aage, Niels*
Andersen, Christina Sparre
Andkjær, Jacob*
Andreasen, Casper S.*
Azizi, Reza*
Dühring, Marie B.*
Enz, Stephanie*
Gersborg, Allan Roulund
Haugaard, Martin Asger*
Jensen, Jakob S.
Lazarov, Boyan S.
Legarth, Brian N.
Matzen, René*
Morosi, Stefano*
Nielsen, Kim Lau*
Niordson, Christian
Niordson, Frithiof
Pedersen, Niels L.
Pedersen, Pauli
Pedersen, Rune*
Pulido, Edgar Estupinan*
Sigmund, Ole
Svendsen, Martin Nymann*
Thomsen, Jon Juel

§8-medlemmer:
Andrlova, Zuzana*
Aslan, Mustafa*
Back-Pedersen, Andreas
Branner, Kim
Buhl, Thomas
Graeme, Keith
Hansen, Morten H.
Krishnan, Krishna K.*
Mikkelsen, Lars P.
Nielsen, Jan Balle
Sørensen, Bent K.

ME-Aalborg University:
Andersen, Michael S.*
Andreasen, Jens H.
Bai, Shaoping
Hansen, Anders L.*
Hvejsel, Christian G.*
Kratmann, Kasper Koops*
Leong, Martin Klitgaard*
Lund, Erik
Niu, Bin*
Olesen, Christian G.*
Olesen, Esben L.*
Olhoff, Niels
Pedersen, Mikkel M.*
Pyrz, Ryszard
Rasmussen, John
Rauhe, Jens C. M.
Schjødt-Thomsen, Jan
Sorokin, Sergey
Søe-Knudsen, Alf *
Sørensen, Søren Emil*
Østergaard, Niels Højen*
Zhou, Lelai*

CIVIL-Aalborg University:
Andersen, Lars
Andersen, Søren Mikkel*
Nielsen, Søren R. K.
Sichani, Mahdi Teimouri*

	Ph.d.	andre
FM	6	6
SKK	5	2
MTU	1	0
MPP	1	1
MAT	12	11
FAM	13	11
§8	3	8
CIVIL	2	2
ME	13	9
	56	50
I alt		106

* Ph.D.-student

Programme for Monday afternoon, March 23rd, 2009

1 – FLUID MECHANICS AND FLUID STRUCTURE INTERACTION
(Chairman: MORTEN BRØNS, DTU Mathematics)

13:00 – 15:00 KNUD ERIK MEYER (DTU Mechanical Engineering, 20 minutes)

POD analysis of PIV measurements

Particle Image Velocimetry (PIV) provides instantaneous measurements in a plane. Such "snap-shots" of a flow often give new insights in flow dynamics. However, since flows are three-dimensional and often have chaotic behavior (turbulence), additional data processing is often needed to extract information about dynamic flow structures in a statistical sense. The Proper Orthogonal Decomposition (POD) is a candidate for this type of analysis. In the talk, the application of POD on PIV will be shown for several different types of flow.

SAJJAD HAIDER (DTU Mechanical Engineering, 15 minutes)

PIV Study of In-Cylinder Confined Swirling Flow

Large 2-Stroke marine diesel engines with uni-flow scavenging process are employed with air in-take ports on the cylinder liner close to the bottom dead centre (BDC). The scavenging ports are grooved at an angle to impart tangential velocities and thus creating a swirling flow confined in the cylinder. In order to characterize this flow, an experimental down-scale and simplified model of the engine cylinder is developed to investigate the swirling flow during the scavenging process. The transparent acrylic cylinder and the bottom piston provide optical access to the flow. PIV is used to measure the 2D velocity distribution in a cross sectional plane at 5 different positions along the cylinder length.

JOHAN RØNBY PEDERSEN (DTU Mathematics, 15 minutes)

Analysis of idealized body-vortex systems

We explore the class of dynamical systems consisting of a body and N point vortices in an ideal, unbounded, planar fluid. The body is represented by a closed curve and is free to move in response to the fluid motion. The vortices have fixed strengths and are intended to model vortices that have been shed by the body or elsewhere in the flow field. The flow at any given time and position is determined by the instantaneous vortex and body positions together with the instantaneous velocity of the body. The equations of motion for this kind of system are reasonably well in hand. They can be analyzed using techniques from the theory of dynamical systems with a finite number of degrees of freedom. The simplest such system, a single point vortex and a circular body, is integrable. If we add vortices, or change other features of the system such as the body shape, the motion may become chaotic. Various solutions are shown and analyzed with an emphasis on the transition to chaos and its physical meaning. The motion of passively advected fluid particles is also of interest. This class of systems provides a rich family of few-degree-of-freedom systems that capture essential fluid-body interaction physics.

SOIZIC JONCQUEZ (DTU Mechanical Engineering, 20 minutes)

Validation of Added Resistance of ships with a Boundary-Element Method

Added resistance of vessel is of importance as it affects both economical performance and operational range. Second-order forces have been widely investigated using 2D methods and more recently, also using 3D methods.

The present work uses the 3D, time-domain, high-order boundary element code AEGIR to calculate the second order forces. Results for added resistance using both pressure integration and conservation-of-momentum methods are presented and compared with published data and experimental measurements. Both Neumann-Kelvin and Double-Body Flow linearization are used.
The two methods give consistent results for simple geometries like a sphere and the Wigley hull. More complex geometry such as a bulk carrier is also calculated. Results demonstrate the accuracy and flexibility of the momentum conservation method which is not overly sensitive to the details of the geometry for the Neumann-Kelvin flow. Results obtained from the pressure integration method are slightly more sensitive to the geometry. On the contrary, the Double-Body Flow linearization is really sensitive to the geometry which implies simplification of the hull for the bulk carrier, in order to have both pressure integration and momentum conservation methods converged.

HARVEY A. ZAMBRANO-RODRIGUEZ (DTU Mechanical Engineering, 20 minutes)
Atomistic Simulations of Thermophoretic Motion of Water Nanodroplets in Carbon Nanotubes
We perform molecular dynamics simulations to study the thermophoretic motion of water nanodroplets confined inside carbon nanotubes cf. Fig 1. We find that the water nanodroplets move in the direction opposite the imposed thermal gradient with a terminal velocity that is linearly proportional to the gradient.
(Fig 2a). The translational motion is associated with a solid body rotation of the water nanodroplet corresponding to the helical symmetry of the carbon nanotubes (Fig 2b). The thermal diffusion displays a weak dependence on the wetting of the water-carbon nanotube interface (Fig 2a). We introduce the use of the Moment Scaling Spectrum (MSS) in order to determine the characteristics of the motion of the nanoparticles inside the carbon nanotube. The MSS indicates that affinity of the nanodroplet with the walls of the carbon nanotubes is important for the isothermal diffusion, and hence for the Soret coefficient of the process.
Fig. 1. Molecular dynamics simulation of a water nanodroplet confined inside a carbon nanotube. A thermal gradient is imposed by heating the end sections (in red) of the carbon nanotubes. (a) (b)
Fig 2 (a) The center of mass velocity $\left(V_{com}\right)$ of a water nanodroplets as a function of the thermal gradient imposed along the axis of the carbon nanotube for different degree of wetting: red: strongly hydrophilic, green, hydrophobic, blue: strongly hydrophobic. (b) The time average tangential velocity profile $\left(V_t\right)$ of the water nanodroplets: the red line represents the measured velocity profile and the green line the best fit to a solid body rotation.

STEPHANIE ENZ (DTU Mechanical Engineering, 15 minutes)
Phase shift effects for vibrating pipes conveying pulsating fluid
How do perturbations related to the fluid flow influence the dynamic behaviour of fluid-conveying pipes? This is relevant to know, e.g., when exploiting flow-affected oscillations of pipes to determine the fluids mass flow rate or density, as done with Coriolis flow meters (CFM). The CFM working principle is based on a phase shift between transversely vibrating

points along the pipe, which under certain ideal circumstances is proportional to the fluid mass flow rate. Available studies concerning flow pulsation effects on CFM are valuable but lack a systematic perturbation analysis to fully uncover the importance of the involved parameters. Computational models for numerical simulation of real flowmeters are available but offer little insight into the essential physical
phenomena taking place. In this work a simple model of a CFM with simplifying approximations, e.g. a single, straight, supported pipe, allows a clearer understanding of how the phase shift depends on variations of the amplitude and oscillating frequency of the fluid velocity. Possible future extensions of the model may include, e.g., a bended pipe, clamped pipe ends, non-uniform mass distribution of the pipe material or non-uniform flow profile. A systematic perturbation analysis involves solving the fluid conveying pipe's equation of motion using, e.g., the method of multiple scales. This can be used to derive analytical expressions for how the phase shifts are affected by flow pulsation. The suggested analysis procedure further enables a more general application and adaption to different configurations. Also the results for simplified systems may be used to create hypotheses on the effect of flow pulsations for more complicated, realistic systems, which can be tested against, e.g., experimental results or computational fluid dynamics simulations.

15:00 - 15:30 Coffee break

2 – INVITED PRESENTATION AND GEO
(Chairman: ERIK LUND, ME, AAU)

15:30 – 17:00 JENS HONORE WALTHER (DTU Mechanical Engineering, 45 minutes)

Multiscale Simulations Using Particles

We are developing particle methods as a general framework for large scale simulations of discrete and continuous systems in science and engineering. The specific application and research areas include:
discrete element simulations of granular flow, smoothed particle hydrodynamics and particle vortex methods for problems in continuum fluid dynamics, dissipative particle dynamics for flow at the meso scale, and atomistic molecular dynamics simulations of nanofluidic systems. We employ multiscale techniques to breach the atomistic and continuum scales to study fundamental problems in fluid dynamics.
Recent work on the thermophoretic motion of water nanodroplets confined inside carbon nanotubes, and multiscale techniques for polar liquids will be discussed in detail at the symposium.

SØREN MIKKEL ANDERSEN (CIVIL AAU, 20 minutes)

Material-point method for geotechnical engineering

The focus of the PhD project is the generalized interpolation material-point (GIMP) method applied to geotechnical problems. The GIMP method is a new numerical method for modelling dynamic problems involving large strains and displacements. The physical domain is discretized into a set of sub-domains. The material properties and any state variables are referred to so-called material points placed at the centre coordinates of these sub-domains. The governing equations are solved on a background grid. The mapping between the material points and the grid is performed using interpolation functions, obtained by integrating nodal shape functions associated with the grid nodes over particle characteristic functions associated with the material points. This dual description has the advantage that mesh entanglement is avoided, as the mesh does not carry any physical properties and can be reset at each time step. Further, convection issues associated with pure Eulerian methods are avoided as the material points are tracked in time. The PhD work presents an extension to very large strain problems by obtaining the GIMP interpolation functions by numerical integration of the particle characteristic functions over the volume of the material points in the deformed configuration. The method is applied to geotechnical problems, including the dynamic behaviour of landslides and cone penetration test. It is concluded that the new method provides a tool for studying problems involving large strains, where the application of finite element of finite difference schemes is problematic.

LARS ANDERSEN (CIVIL AAU, 20 minutes)
Modelling of sectioned tunnels under earthquake loading: Shortcomings of the Winkler approach
A Winkler model is often applied in the design of tunnels subject to seismic loading. In spite of its simplicity it has been found to provide reasonable results; but the Winkler model significantly underestimates the stiffness at the joints in sectioned tunnels. According to the present analysis, this leads to an over prediction of the joint openings resulting in a conservative design. A case study is carried out for an immersed 6-lane road tunnel in Thessaloniki, Greece. Horizontal input motion is assumed at the bedrock, and a one-dimensional wave-propagation model transfers to the vibrations to the ground surface as horizontally polarised shear waves. The incoherency of the ground vibration along the tunnel is modelled by an apparent propagation velocity of 1500 m/s, and different angles of incidence are studied. The response obtained by the Winkler model is compared with the results of a full three-dimensional finite-element model of the tunnel and the surrounding soil. Analyses show that the Winkler model provides openings at the gaskets of more than 200 mm. The corresponding result of the continuum finite-element model is 20 mm, i.e. an order of magnitude lower. However, if the joints are not included in the two tunnel models, nearly identical results are obtained. Hence, it is concluded that the Winkler model is useful for continuous tunnels with a homogeneous cross section, but it should be used with extreme caution for the design of sectioned structures.

3 – POSTER SESSION

17:00 – 19:00 REZA AZIZI (DTU Mechanical Engineering)
Multi-scale modeling of composites
The overall properties of micron to sub-micron scale reinforced metal matrix composites are studied. The focus of the study is on effective yield surfaces and the overall hardening behavior. A recent strain gradient plasticity theory, based on energetic contributions due to the gradient of the plastic strain tensor, is employed to model relevant size-effects in the matrix material. Numerical studies are carried out using a finite element method, where the components of the plastic strain tensor appear as free variables in addition to the displacement variables. Due to the higher order nature of the theory, higher order boundary conditions must be imposed. These non-conventional boundary conditions give enhanced modeling capabilities, that are important to micron-scale applications such as micron reinforced materials, and in the present study they are used to model dislocation blocking at the interface between fibers and the matrix material. The results show increased hardening

for micron scale reinforcement, over that predicted by conventional models. The results are in accordance with experimental observations, which cannot be modeled by conventional scale independent plasticity theories. Plane strain yield surfaces are determined based on analyses using general periodic boundary conditions. Furthermore, it is shown that the material model is capable of accounting for Baushinger effects under reversed loading, due to back-stresses originating from the plastic gradient contributions to the free energy. The results are presented with a view toward multi-scale modeling of materials with reinforcement on different length scales, such as the micron and sub-micron scales.

CASPER S. ANDREASEN (DTU Mechanical Engineering)

Topology Optimized Crash Protection

Topology optimization has proven a very successful method for obtaining optimized designs without a priori design considerations for a variety of mechanical problems. This includes among others both solid and fluid mechanical problems. Topology optimization has earlier been applied for crashworthiness applications by the use of truss and frame models but here a continuum model is used. Considering a protection material consisting of a fluid saturated porous material with spatially varying microstructure the effect of internal dissipation can be utilized for energy absorption.

The goal is to design for instance auto mobile bumpers or crash barriers where reversible crash protection for impact is needed, meaning that the deceleration limitation does not origin from plasticity. Such an energy absorbing mechanism can be designed using a porous fluid saturated material which in its optimized configuration limits the deceleration during crash due to the dissipation and furthermore regains its original outer shape afterwards due to the elastic skeleton.

The poster sketches the concept of energy absorption and how topology optimization can be applied to this coupled problem

NIELS AAGE (DTU Mechanical Engineering)

Topology optimization of devices for wireless energy transfer - The design parameterization

This work concerns the solution to the computational issues associated with topology optimization of metallic electromagnetic (EM) devices operating in the radio frequency range, i.e. the range from 3 Hz to 300 GHz. Such optimization problems can be reduced to determining the optimal distribution of a good conductor, e.g. copper, which minimizes a given measure. Such an optimization setting could be used for e.g. antenna design and the design of magnetic resonators for wireless energy transfer. The computational issues arise from the numerical modelling of the good conductor. The problem is due to the skin depth phenomenon, i.e. the distance an EM wave penetrates into the good conductor, and results in the need for extremely refined meshes to capture the physics. This makes the state problem very time consuming to solve, if possible at all, and thus renders the EM problem unfit for topology optimization. To remedy this limitation a novel design parameterization is introduced. The interpolation scheme is based on SIMP, and interpolates both PDE and an impedance boundary condition for each design element. This approach is shown to resolve the skindepth/FEM issue. Finally a number of antenna and resonator designs are presented, and the paper is concluded with a discussion of the strength and weaknesses of the proposed design parameterization

SUBRATA BHOWMIK (DTU Mechanical Engineering)

Semi-Active Control of Magneto-Rheological Dampers with Negative Stiffness

Effective damping of large and flexible structures by semi active dampers relies greatly on the control strategy applied, which should combine the robustness of passive devices and the increased damping performance often available from active control. For structural control the Magnetorheological (MR) damper is among the most popular and promising devices due to its low power requirement, high dynamic range, high force capacity and robustness. The objective of this paper is to formulate semi active feedback control methods based on simple linear filters, which lead to increased damping performance by introduction of apparent negative damper stiffness. For linear control strategies the influence of stiffness, and in particular negative stiffness, has been illustrated by e.g. Høgsberg and Krenk [1]. The control gain of the MR damper is the applied voltage or current, depending on the associated electrical setup, and the governing equations are of phenomenological type, for instance some modified version of the classic Bouc-Wen hysteretic model [2]. The design of the control strategy aims at maximizing the damping ratio of the critical mode of the structure. Explicit solutions for the complex valued natural frequency of the damped structure and the associated damping ratio are obtained by the two-component system reduction technique introduced by Main and Krenk [3], which has also been used for calibration of linear control methods in [1]. It follows from the expression for the damping ratio that an increase in the real part of the damper transfer function, which represents the apparent stiffness of the damper, leads to a decrease in damping efficiency. Conversely, a potential increase in damping is associated with a similar reduction of stiffness, or even with the introduction of negative stiffness. For linear control strategies negative stiffness can only be realized by active control, which is limited by stability [1].

This actually means that the optimal passive device is the pure viscous damper without any stiffness component. For the semi-active MR damper to perform better than the pure viscous case, the underlying control strategy should introduce apparent negative stiffness. In the present paper this is realized by having the MR damper force follow simple linear control strategies with negative stiffness, e.g. the lag compensator or the Kelvin model, which have been optimized with respect to maximum modal damping. The gain of the semi-active damper should then be controlled in such a way that the desired control force is followed sufficiently accurate. This is done by letting the desired force be the input parameter of an inverse Bingham model, which provides the corresponding optimal gain (voltage) for the MR damper. The inverse Bingham structural model calculates desired voltage given to MR damper and the MR damper is introduced as a supplemental damping device. It should be noted that the MR damper is an energy-dissipative device that can not add mechanical energy to the structural system. Therefore, the proposed control strategy is fail-safe, in that it guarantees the bounded-input, bounded output stability of the controller structure. Numerical simulations are conducted to demonstrate the performance of the proposed semi-active control strategy with apparent negative stiffness.

STEFANO MOROSI (DTU Mechanical Engineering)

Magnetic Foil Bearings – Theory and Experiments

The relative maturity of many traditional technologies within different technical areas implies little or no potential for improvements. Consequently, to deal with the technical challenges associated with some requirements of safety, quality, cleanness, reduced height, low vibration and noise levels, reduction of fuel consumption, non-conventional techniques have to be introduced where the conventional ones have already reached their limits. Present-day foil bearing and magnetic bearing technologies are fully matured and separately have been utilized in a wide variety of high speed turbomachinery. Both types of bearings have significant advantages compared to conventional bearings (ball bearing and hydrostatic bearing). One major advantage is that they do not require an external lubrication system, which leads to a more robust and reliable system. Magnetic bearings, however, require back up bearings to support the rotor and to prevent damage in the event of electrical power disruption or when the unit is in transit. Gas bearings are an excellent choice as backup bearings for applications where very low bearing start torque and power loss are required.

A gas bearing of bump foil type comprises an underlying structure made of one or several strips of corrugated sheet metal covered by a top foil surface. The fluid film pressure needs to be coupled with the behavior of the structure for obtaining the whole bearing characteristics. Due to the strong coupling that exists between the fluid film and the foil structure the static and dynamic bearing properties of foil bearings becomes a function of many design parameters. Over the past twenty years considerable advancements have been achieved in the solution of the compressible Reynolds equation for fluid film bearings. Recent sophisticated analytical models found in the literature estimate the foil flexibility quite well once they consider the important interactions between bumps.

The idea of the magnetic bearing and its use in exotic applications has been conceptualized for many years, over a century, in fact. Patented, passive systems using permanent magnets date back over 150 years. More recently, scientists of the 1930s began investigating active systems using electromagnets for high speed ultracentrifuges. However, passive magnetic bearings are physically unstable and active systems only provide proper stiffness and damping through sophisticated controllers and algorithms. This is precisely why, until the last decade, magnetic bearings did not become a practical alternative to rolling element bearings. Today magnetic bearing technology has become viable because of the advances in microprocessing controllers that allow for confident and robust active control. Further technological advances have and will put magnetic bearing on the forefront of advanced, lubricated free support systems

RENÉ MATZEN (DTU Mechanical Engineering)

Design of Optical Circuit Devices Using Transient Topology Optimization

The design of ultra-compact optical devices based on two-dimensional photonic crystal (PhC) structures has recently received much attention. Some of the optical components of concern are *filters*, *bends* and *splitters*. In the two latter cases the method of topology optimization based on steady-state analysis have already been used to obtain structures exhibiting optimized wave propagation behavior. A great interest in applying topology optimization to problems dealing with full transient behavior has recently emerged. This is due to the fact that optical structures can be optimized for broader frequency ranges by using modulated Gaussian wave pulses. Additionally, optimization of pulse shaping structures is a possibility.

This work considers the design of optical circuit devices using transient topology optimization. The method is aimed towards the design of tunable devices using mechanical actuation. A first step towards this goal is to design a channel drop filter only allowing the transmission of light for a specified frequency (band). The filter is based on a two-dimensional PhC for transverse-electric (TE) modes with a point defect cavity. The gradient-based optimization technique is applied to predict the material distribution in the vicinity of the cavity such that the cavity field energy is maximized. We use the finite-element time-domain (FETD) method for spatial and temporal discretization. The transient problem is solved by an explicit integration scheme with mass lumping. The optimization algorithm has been implemented in the parallel programming environment provided by PETSc.

JOHANNES TOPHØJ RASMUSSEN (DTU Mechanical Engineering)
Determining the aerodynamic admittance of bridge sections by use of the discrete vortex method
The meshless Discrete Vortex Method (DVM) has been widely used, academically and in the industry, to model 2D flow around blu_ bodies. The implementation _DVMFLOW_ has been used by COWI to determine and visualise the flow field around bridge sections, as well as determining aerodynamic forces and the corresponding _utter limits. The current version of DVMFLOW treats the oncoming flow as smooth (laminar) and the present project involves the extension to a turbulent oncoming flow. The turbulence is modelled by seeding the upstream flow with vorticity particles synthesized from prescribed atmospheric velocity spectra. The admittance of the structure, i.e. how the instantaneous lift force is correlated to vertical velocity _uctuations in the turbulent wind flow field, is determined by sampling vertical velocities and lift forces. Finally the admittance of the bridge section can be used to improve the _line-like_ modelling of the bridge in a 3D simulation including its surroundings, thereby increasing the accuracy of the model.
The method will be validated against an analytic solution for the admittance of a flat plate and subsequently used to investigate the admittance of existing bridge sections.

ULRIK MARK ANKERGREN (DTU Mechanical Engineering)
Rock Mechanics Model for Enhanced Oil Recovery
Today only approximately 30 % of the oil in reservoir consisting of chalk is recovered. To increasing the recovery Enhanced Oil Recovery, EOR, methods can be used. The application of EOR methods will interact with the chalk and thereby influence the mechanical behaviour of the chalk. For that reason a material model must be developed that account for the material behaviour, like deformation characteristics, as well as the influence from the specific EOR processes.
The workflows for the model start with formulation of an elastic-plastic model for a porous geological material. Then the effect of fluid filled pores is taking into account by using an internal variable formulation. Finally, time-dependent behaviour is considered and modelled, e.g. by a viscoplastic formulation.

TRINE COLDING LOMHOLT (DTU Mechanical Engineering)
Microstructure Evolution during Friction Stir Welding
Friction stir welding (FSW) is a solid-state process whereby two metals can be joined. In FSW a rotating tool is transversed along the joint line of two

materials and the combined action of frictional heating and mechanical deformation produced by the rotating tool will joint the materials. A novel variant of the linear FSW process is the friction stir spot welding (FSSW) were the tool is not moved along the joint line but instead a spot, lap-weld is created.

During FSW the microstructure in the weld and the surrounded heat affected zone are changed dramatically. This study involves characterisation of the microstructure after FSSW of selected high strength steels. The material characterization involves investigation of the microstructure and associated properties and will be performed on the welds, the heat affected zones (HAZ) and their immediate surroundings. Reflected light microscopy as well as scanning (SEM) and transmission electron microscopy (TEM) will be applied for the determination of grain size and grain shape distributions and identification of the morphology. In particular, 3D characterisation of welds is expected to yield unique results. X-ray diffraction and electron diffraction techniques will be applied for identification of the phases constituting the microstructure. Also texture development in and around the welds will be determined, primarily with Electron Backscatter Diffraction (EBSD) techniques. Residual stress distributions (both micro and macro stress) in and around the welds will be determined with X-ray diffraction. The microstructural details will be compared to micro-hardness distributions, which are a measure for the distribution of mechanical properties around the weld.

JACOB ANDKJÆR (DTU Mechanical Engineering)

Design of grating couplers using topology optimization for the efficient excitation of surface plasmons

A surface plasmon grating coupler has the ability to couple the energy of an incident beam in the visible frequency range into an electromagnetic wave mainly traveling at the interface between a metal and a dielectric. In the work for master thesis a 2D topology optimization problem is formulated and implemented in order to design grating couplers for the efficient excitation of surface plasmons at a Ag-SiO2 interface. Optimized designs for both input and output grating couplers are achieved. The highest efficiency based on the power flux (Poynting vector) for an optimized input grating coupler reported in the literature is 50%. In this work an efficiency of 65.9% for an optimized input coupler is achieved using topology optimization. An optimized design for an output coupler yields an efficiency of 34.9%.

The current research as first year Ph.D.-student is the optimization of metamaterials.

MUSTAFA ASLAN (Risø DTU)

Characterisation and micromechanical modelling of wood fibers and composites

Wood fibers have potential for use as a load bearing constituent in composite materials due to properties such as high stiffness and strength to weight ratios that make composite structures ideal for many applications. There is thus a growing interest among the manufacturers of inexpensive low-weight wood fiber composites. Wood and other cellulosic fiber reinforced composites are renewable and recyclable materials that have emerged due to environmental concerns as cost effective alternatives to oil based fiber reinforced polymer composites that currently have the largest market share for composite applications. However, use of wood fiber composites for structural applications is limited by drawbacks such as dimensional instability in humid

environment resulting in property degradation, lack of well defined fiber properties due to many variations on the fiber morphology and low fiber-matrix adhesion resulting in inefficient stress transfer. Therefore, a better understanding of the mechanical performance of these composites is important to develop the composites to reach their full potential.
The PhD study deal with several important subjects related to the use of wood fibres in composite materials. The emphasis is on the relationship between the structure of wood fibres and the mechanical properties such as strength and fracture toughness, and the influence of humidity on these properties. The study involves characterization of wood fibre structure and prediction of mechanical properties of wood fibers and composites by micromechanical models. The study is part of an international research project (Woodfibre3D) aiming at increasing the fundamental knowledge of wood fibres and their behavior as reinforcements in composite materials.

KRISHNA K. KRISHNAN (Risø DTU)

Residual stresses of advanced thick fibre composites

Fibre reinforced polymer (FRP) composites are used for larger structures such as wind turbine blades which require thick fibre composite laminates with thicknesses varying approximately between 5mm and 50mm. Processing thick composite structures based on fibre reinforced thermosetting or thermoplastic polymers can lead to large residual stresses. These residual stresses can lead to defects and failure in the structures. Residual stresses are present in thick laminates due to elevated process temperature and the difference in coefficient of thermal expansion of different types of fibres and the matrix material. In addition, curing shrinkage of the matrix also contributes to the residual stresses using thermosetting polymers. Primarily, experimental investigation of residual stresses carried out to discover manufacturing-induced residual stresses factors. The experimental works cover residual stresses induced using different types of fibres (hybrid fibres) and formation of cracks/delaminations during manufacturing or appear after machining of holes and free edges. The fibre orientations and the stacking sequence of the different fibre orientations (laminate specification) have influence on the level and distribution of residual stresses and thereby the formation of defects. In conjunction of that, FEM model will be developed for predicting formation of residual stresses whereas used to investigate the influence of laminate specification and shape of the free edge on the formation of cracks/delaminations and experiments will be performed to evaluate the model. It is important to control the amount of residual stresses by selection of fibre and matrix materials; and process conditions to produce reliable thick fibre composites component. A better understanding of the mechanism will help to control the amount of residual stresses, in order optimising thick fibre composite design.

ZUZANA ANDRLOVA (Risø DTU)

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 can be expected for a future 120 m long blade (20MW wind turbine). The recent development in numerical simulations, together with the inclusion of more complex and realistic load cases could provide a new possibility to take a large step forward in the optimization of current and future wind turbine blades. The work presented is the initial study of aeroelastic and structural behavior of up scaled model of the wind turbine blade. The up scaling method is based on existing finite element model of 34 m long blade validated with experimental test. The Risø DTU aeroelastic code HAWC2 is used to design a initial wind turbine model for the 34 m blade. This code considers the blades of wind turbine as finite number of 3D Timoshenko beam elements. The stiffness and weight parameters are found in the numerical model of the blade. To analyze aeroelastic and structural response of the upscaled design both models of the blade are scaled to 120 m. The final aeroelastic analysis is expected to give an overview of the critical load cases and combination of loads. Subsequent application of the critical load cases is used for the determination of structural requirements for the new 120 m blade design.

MAHDI TEIMOURI SICHANI (CIVIL, AAU)

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

Extreme value predictions for application in wind turbine design are often based on asymptotic results. This is typically done by assuming the epochal extremes in a 10 minute interval are distributed according to some asymptotic extreme value distribution with unknown parameters to be estimated based on simulated low order statistical moments, or it is assumed that the exceedance probability above high thresholds follows a Pareto distribution with parameters to be estimated. The results obtained by an extrapolation of the extreme values to the stipulated design period of the wind turbine depend strongly on the relevance of these adopted extreme value distributions. The problem is that this relevance cannot be decided from the data obtained by the indicated so-called crude Monte Carlo method. With failure probabilities of the magnitude 10−9 during a 10 min. sampling interval the tails of the distributions are never encountered during normal operations. To circumvent this problem the application of variance reduction Monte Carlo methods i.e. importance sampling method might be used, which suffer from strict requirement on the so called simulation density for a high dimensional parameter vector. Finally splitting methods are lately reported to be more promising for efficient estimation of extreme responses of wind turbines. Firstly they support certain level of accuracy in results and secondly they are more efficient in computation since they have a less strict constraint on margins of the safe domain. This approach will be followed in the project. In the presentation some preliminary results are presented on rational ARMA modeling of turbulence field.

THOMAS HEEGAARD LANGER (ME, AAU)

Off-road tyres in vehicle dynamics simulation

To be able to evaluate the comfort of Construction Machinery by simulation it is vital to know the forces acting on the wheels when passing rough tracks. Research in the field of tyre models has mainly been dedicated to car tyres and until about 20041 no commercial tyre models were able to handle uneven and rough ground.

Needed is a tyre model, which is able to calculate the reaction forces between tyre and ground when passing rough terrain or obstacles. It shall be formulated such it can be implemented in a 3D computer simulation and have an accuracy which allow us to evaluate comfort at the driver seat with a satisfactorily precision.

This approach is combining the well known slip theory2 and a buoyancy model which calculates the intersection volume between the wheel and the ground. An effective road plane is determined to make the slip theory

operable. The model is a steady-state model and doesn't include alignment torque. The model has been used for a specific tyre. The characteristics of this tyre have been obtained by comparing forces between axle and wheel from simulation and measurements.
The tyre model is able to handle rough terrain and obstacles and is based on a non iterative geometric formulation. The model is documented for a semi-large off-road tyre and has an accuracy that makes it possible to evaluate the comfort by simulation.
A simple model for off-road tyres is formulated with the aim of being able to evaluate forces and comfort in 3D vehicle simulations. The model only needs a few parameters to be measured. The approach is different from the commercial tyre models though the idea of the effective road plane is similar to cam model in SWIFT. Like some of the commercial tyre models a matrix giving the elevation of the terrain describes the ground.

LELAI ZHOU (ME, AAU)
Energy Analysis of Human Arm Motions in ADL (Activities of Daily Living)
This paper presents the experimental study of energy consumption with human arm motions in ADL (Activities of Daily Living). The purpose is to reveal the relationship between the energy consumption and the trajectory of arm motion, and further, to identify the optimal trajectory in terms of energy, which are essential to the design and control of robotic arms for service applications.
Experiments on human arm motion performing selected ADL are conducted by virtue of Qualisys motion capture system. The method of motion data collection and processing is described. Preliminary results on the arm motion kinematics, dynamics and energy consumption, are included.

CHRISTIAN GAMMELGAARD OLESEN (ME, AAU)
Validation of a Seated Human AnyBody Model Using an Instrumented Chair
Pressure ulcers are a frequent complication to spinal cord injured patients. The disease can have various etiologies and is in general poorly understood. The type of pressure sore we are particularly interested in is the sitting acquired deep tissue injury that wheel chair users, i.e. paraplegic and quadriplegic patients are susceptible to.
It is well acknowledged that pressure sores are primarily caused by sustained mechanical loading of the soft tissues. The soft tissue stresses have been investigated using Finite element models. (Oomens et al. 2003, Linder-Ganz et al. 2007) The models have been developed based on MRI scans of human buttocks, and estimated material properties. When modeling a seated posture, true boundary conditions are important in order to produce a valid model. However non known publications have applied shear force on the buttocks, which has been suggested as one of the most important risk factors for developing pressure ulcers. In other words a tool is needed for calculating forces between the chair and the human buttocks in order to apply them to a FE model.
The Seated Human AnyBody model calculate contact forces based on different seated postures. (Rasmussen, Tørholm & de Zee) However it has not been validated with respect to the contact forces, therefore the objective of this stud was to validate the model with respect to the contact forces.
An instrumented chair was developed and experiments with three healthy subjects sitting on the chair in different postures were carried out. The

subjects had markers places at bony landmarks, in order to setup the AnyBody model, the same way as the subject in the experiment was sitting. The measured forces from the chair and the calculated forces from the model could be compared.
Preliminary results from one subject indicate that the model overshoots the absolute values, however the trends, when fx. Changing the seat angle, match very well with the model. The difference in absolute values could be due to normal variation, however that will be revealed when more experiments have been carried out.

ALF SØE-KNUDSEN (ME, AAU)
Stop-band Analysis on Periodic Structures containing Spatial Curved Pipe Segments
Spatial piping systems are widely used in virtually all industrial and domestic applications, from gas- and oil-transporting pipelines to household heating and water supply systems. A by-product of the operational effect of pumps and valves, on such structure, is generation of vibro-acoustic energy, which may be transmitted in the pipeline over a long distance and emit undesirable noise, for example, from a distant radiator. Because a spatial piping system often consists of both straight and curved segments it is of interest to analyze if a given periodic combination of these segments could work as a stop-band filter for some of the energy flux carrying frequencies.
In the low-frequency range straight and curved fluid-filled pipes can be modeled with Bernoulli-Euler beam theory and theory for plan torsion and axial deformation where inviscous fluid inside pipes can be modeled as added mass. An appropriate methodology for implementing the slender structures is boundary integral equations method. These boundary integral equations are obtained by use of Greens matrix and reciprocity theorem.
The presented work is focused on periodic repeated substructures containing of the above mentioned segments.
An example of stop-band analysis by employing Floquet theory on a boundary integral equation formulation for fluid filled pipes is presented. Filter effects obtained by a finite number of the same substructures repeated on an infinitely long pipe are also illustrated and compared with predictions from standard Floquet stop-band analysis.

MARTIN KLITGAARD LEONG (ME, AAU)
The influence of defects on the failure of wind turbine blades
Siemens Wind Power (SWP) manufactures wind turbine blades made of polymer-based composite materials in a so-called closed infusion process. Compared to the competition, the blade is thus manufactured in one single piece, by using the unique production technology called IntegralBlade®. This process gives certain structural advantages, since there are no sub-components which have to be assembled by gluing. One of the few disadvantages of the IntergralBlade process is the possibility of production-induced defects such as wrinkles.
The sandwich elements in a wind turbine blade are primarily loaded in-plane during normal operation and the most common failures are failure of the face sheets (e.g. by kink band formation), wrinkling (local form of buckling with a characteristic short wave length), global buckling or failure of core material. In the case of production-induced defects such as wrinkles, the governing failure mode is often wrinkling.
It is therefore imperative to be able to judge whether a wrinkle-defect requires a repair operation on the blade. In order to make such a judgment, it

is necessary to be able to estimate the redistribution of deformations and local stress concentrations, as well as the strength reduction at a given wrinkle, in any location of the wind turbine blade

SØREN EMIL SØRENSEN (ME, AAU)

Dynamic Effects in Large Scale Sortation Systems

Designing large-scale sortation systems is a huge task that involves several design iterations before reaching a final design. Even with a huge effort in the design phase, some inappropriateness might appear when the sortation system is installed and working. One problematic inappropriateness that may occur is denoted the *jab-effect*. This dynamic effect entails increased wear on critical parts and causes unwanted noise from the sortation system. The high complexity of these systems induces that only very few options are available to reduce or remove the jab-effect without using massive amounts of funds and resources. Therefore, indentifying and removing the jab-effect in the design phase would lead to massive cost savings in terms of reduced mending and service of the sortation systems. The goal of this PhD-project is to develop an optimization tool capable of identifying and removing/reducing the jab-effect during the design phase. Due to the complex nature of the jab-effect, part of the project concerns developing a method that can identify the jab-effect and its magnitude. Based on previously conducted measurements and experiments it has been ascertained that the jab-effect cannot be identified through simple measuring methods such as noise or force measurements. A new measuring system is therefore developed. This system samples from 16 different transducers, that simultaneously collect data in terms of forces, velocities, angles, accelerations and temperatures. These large amounts of data will hopefully, lead to a new method that definite indentifies the jab-effect.

NIELS HØJEN ØSTERGAARD (ME, AAU)

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 or to a subsea reservoir containing oil and/or gas. A flexible pipe is in general a complex composite structure comprised by several layers with different properties.

The project deals with the tensile armor layers, which are constituted by a large number of metal wires wrapped around the inner layers of the flexible in helical formations. In most known designs, two layers of tensile armor are applied, stabilizing each other so no coupling between bending- and torsion effects occur.

In the past ten years by installation at water depths larger than a 1000 meters, a failure mode has been observed, by which the inner layer of tensile armor becomes unstable and moves into a non-helical configuration. This failure mode is usually denoted ‘lateral buckling’ and is known to occur when a pipe is exposed to repeated bending cycles and compressive loads (known as reverse end cap effect) in the installation scenario. Furthermore, lateral buckling is known to occur when the pipe is empty and the outer sheath of the pipe sample has been damaged, so hydrostatic pressure does not provide the sufficient normal force for frictional stabilization of the tensile armor layers.

The project aims at investigating the physics of lateral buckling by means of full scale tests in order to determine the limit number of bending cycles for a given pipe sample under given load conditions. The obtained results will be attempted reconstructed by analytical and numerical modeling. Key-issues in this phase of the project will be non-linear structural stability and friction-modeling, especially stick-slip effects. Furthermore, attempts will be made to simulate and study the lateral buckling trigger-mechanism by small scale experiments.

VICTOR ZERMENO (DTU Mathematics)

Computation of superconducting wind turbine generators

The wind power industry continuously looks to reduce the price per kWh by introducing new technologies. Use of permanent magnets allows reducing the size of direct drive generators in the low MW class, but for future off-shore turbines with power ratings well above 10 MW, introduction of superconducting coils may proof feasible for reducing size and weight by up to 50 % of conventional direct drive generators [1,2]. By using superconducting racetrack coils it is possible to generate magnetic field strength several times the magnitudes of current permanent magnets, thereby increasing the power output per mass of generator. The stator uses traditional copper coils and only the permanent magnets in the rotor are replaced by superconducting racetrack coil magnets.

Although superconducting synchronous machines have being successfully tested for other power applications, no wind turbine has implemented this technology so far. One of the main issues to be considered is the fact that wind turbines are inherently subject to dynamic power loads. AC losses are therefore expected in the superconducting coils of the rotor. Basic calculations of AC losses in superconducting wires using the Finite Element Method are presented here as a first step towards a full scale simulation of a complete 10KW test superconducting wind turbine to be installed at Risø DTU. A further feasibility study of larger generators will be carried out as e.g. for the 8 MW wind turbine generator planned to be completed by American Superconductor Corporation

VALERIE GAUTHIER (DTU Mathematics)

Post-quantum cryptography

The fundamental objective of cryptography is to enable two or more people to communicate over an insecure channel in a safe way (i.e any third party cannot neither understand or modify the message). The main idea is to modify the message into a new one such that no body, apart from the receiver, can understand its meaning; we will call this new message the cipher text. One way to cipher a plain text is that the sender and the receiver agree on a secret key, we call this symmetric cryptography.

Nevertheless we also want that two people (who may not even have met each other) that are far from each other and cannot agree on the same secret key can communicate (for example for electronical commerce). In these cases we use a public key cryptosystem, where the encryption function does not reveal the decryption function. The public key cryptosystems used until now are secure if the prime factorization of a number and the discreet logarithm problem are “hard” to solve.

In 1994 peter Shor showed that these two problems are not anymore “hard” to solve using a quantum computer. In 2007 a 16-qubit quantum computer was demonstrated and the prediction of the physicists is that in 10 or 20 years this quatum computer will be sufficiently powerful to break all our cryptosystems.

We need to find new ideas for alternative public key cryptosystems that can be used in ordinary computers, and remain secure in quantum computers, this is what we call post-quatum cryptography.

LAI ZHANG (DTU Mathematics)
Community assembly
Community assembly consisting of species is essentially a process concerning the succession of species. During this process the species coexist, compete for a common resource, predation takes place, and the community is subject to the invasion of alien species. The investigation of this process aims to figure out the intrinsic mechanisms regulating the assemblage, i.e. how a community can be developed from basic resource to a fully trophic-level structure together with the properties of the corresponding community. In the presentation, I will first give a brief description of the model, which is actually in the form of a Lotka-Volterra system, and then mimic the process of turnover of the species. Finally some general questions will be proposed for the future study.

PETER NØRTOFT NIELSEN (DTU Mathematics)
Iso-geometric analysis in structural vibrations
Iso-geometric analysis offers a new way to exactly represent shapes in the numerical solution of mechanical problems, to easily refine the mesh in the numerical model, and to use the same basis to describe both the geometry and the physics in the problem. In this presentation the fundamentals of iso-geometric analysis is briefly outlined, and tentative results from an application of the method to a 1-dimensional problem of structural vibrations are sketched. Using this simple example, the iso-geometric approach is compared to the standard finite element method. Although the full powers of iso-geometric analysis to represent geometries in an exact way are not utilized in this simple application of the method, it still shows a marked improvement in the computed spectra when compared to the standard finite element method, thus pointing towards the great potential of iso-geometric analysis.
Finally some future challenges for iso-geometric analysis and its applications are identified.

NGUYEN DANG MANH (DTU Mathematics)
Iso-geometric analysis and shape optimization in electromagnetism

Programme for Tuesday morning, March 24th, 2009

4 – OPTIMIZATION
(Chairman: JOHN RASMUSSEN)

09:00 - 11:00 CHRISTIAN GRAM HVEJSEL (ME, AAU, 15 minutes)

Interpolation Schemes in Multi-Material Optimization Problems

Optimal design of composite laminate lay-ups is complicated due to the non-convexity of the objective if ply orientations are used as design variables in e.g. compliance minimization. Alternatively, the lay-up design problem may be formulated as a material selection problem using a different parameterization, and in this paper the so-called Discrete Material Optimization (DMO) approach is applied. This approach is based on ideas from multi-phase topology optimization where the discrete material selection problem is relaxed to a continuous equivalent problem by expressing intermediate material properties as weighted sums of user-defined candidate material properties.

In this paper we will investigate the behaviour of different multi-material interpolation schemes. The stiffness and strength of mixtures will be deduced from physical interpretations of the mixing rules. The aim is to obtain consistent failure criteria for the mixture rules on basis of the failure behaviour of the individual constituent phases. First a mechanical interpretation of two interpolation schemes is given, followed by the formulation of consistent first-constituent failure criteria.

In a material selection problem, the concern is not the microstructural realisation of intermediate densities, but rather the physical behaviour that a given mixture rule represents and that it eventually leads to a distinct material selection in order to enable a manufacturable physical interpretation of the final result. Also, interpolations should be reasonably simple and computationally efficient since the resulting optimization problems are very large-scale. Various formulations fulfilling these requirements exist and will be presented.

EDUARDO MUNOZ (DTU Mathematics, 15 minutes)

Global Optimization for Multi-material Design of Composite Structures

The Optimal Design of composite material is a rising research area, having applications in several areas of engineering, for example, in Aeronautics, or directly at the industry, such for example the wind turbine industry.

The increasing size of wind turbines, and consequently if wind turbine blades, has rendered blade design still more sophisticated in order to reduce weight while maintaining high stiffness and strength. Blades are today made from both glass and carbon fiber reinforced polymers as well as sandwich core materials, such as balsa wood and polymeric foam, for local reinforcement. Obtaining a rational design by proper choice of distribution and orientation of these different materials is a very challenging design task - one that calls for advanced computer based analysis and design methods. Development of new such methods is the topic of this project.

One of the major challenges in the work is to provide tools that are manageable in industry, and on present day computers, while still providing valuable improvements for multiple design criteria such as the global criteria stiffness and stability together with local strength criteria. To meet this challenge, the discrete material optimization approach is used, which in

principle makes it possible to optimize both the material selection and orientation, when including orthotropic materials in the models.
The objective of the project is to develop new models and methods for optimum design of multi-material composite structures by locally choosing the material properties, such that specified design criteria are met.
In particular, we are interested in developing optimization models and methods capable of reliably solving large-scale discrete composite design problems to global optimality.
There exists a vast number of available point stress/strain failure criteria. We aim to study these failure criteria from the mathematical point of view. We expect to be able to include some of these failure criteria in our model, specially those with best mathematical and numerical properties.
In the project we will do research on the implementation of modern optimization methods based on linear and nonlinear brand and bound and decomposition methods exploiting the mathematical nature of the design problems. The developed global optimization methods will be used to solve well-known benchmark examples as well as providing interesting solutions to new composite design problems.
The platform for the numerical developments is the general purpose design optimization system MUST.

ESBEN LINDGAARD OLESEN (ME, AAU, 15 minutes)

Optimization of Composite Structures subjected to Compression Loads considering "Worst" Shape Imperfections

Nowadays, multilayered composite structures are popular in the fields that require low weight and high performance. In order to continually improve the performance of these structures, it is a necessity that the material utilization is pushed to the limit. A consequence hereof is that the structures are becoming thin-walled and local buckling becomes an issue in compressively loaded regions. A down side of thin-walled buckling critical structures is the risk of a relative high sensitivity to geometric imperfections. A geometric imperfection is a deviation from the perfect structure and is present in all real-life structures. Neglecting imperfections in the design phase can lead to unsafe structures that fail at a load level much lower than the estimated buckling load. It is therefore essential both to consider imperfections in the analysis and design of thin-walled compression loaded structures.
This work will focus on the development of a method that efficiently considers geometric imperfections. Both the shape and size of geometric imperfections need to be considered in the formulation, since they have major influence on the structural response. Most important is the imperfection shape that yields the lowest performance of the structure. This is denoted the "worst" imperfection shape, thus the failure load can be considered as a lower bound of the real failure load.
A method for determining the "worst" imperfection shape is developed. During numerical studies the method demonstrates the ability to determine the "worst" imperfection shape. Several numerical studies are carried out to, respectively, determine the importance of imperfections in analysis and design of compression loaded thin-walled composite structures, and investigate the interaction between optimal laminate design and "worst" imperfection.

ODED AMIR (DTU Mathematics, 15 minutes)

Topology Optimization for Crashworthiness Design Using Approximate Procedures

This project focuses on topology optimization for crashworthiness design. The objective is to further develop the density based approach to topology optimization for crashworthiness design, in order to take it one step closer to fulfilling industrial demands.

The main goal of the project is to reduce the computational effort involved in topology optimization for nonlinear, transient problems by integrating accurate-efficient approximations into the procedure. In the first stage, the integration of an approximate reanalysis procedure into the framework of topology optimization of continuum structures was investigated. The nested optimization problem was re-formulated to accommodate the use of an approximate displacement vector and the design sensitivities were derived accordingly. It was shown that relatively rough approximations are acceptable since the errors are taken into account in the sensitivity analysis. In the next stage, an effort will be made to extend the suitability of such approximate procedures also for nonlinear transient problems, such as maximization of energy absorption due to elasto-plastic response.

BOYAN S. LAZAROV (DTU Mechanical Engineering, 20 minutes)

Sensitivity filters in topology optimisation as a solution to Helmholtz type differential equation

The focus of the study is on the use of Helmholtz differential equation as a filter for topology optimisation problems. Until now various filtering schemes have been utilised in order to impose mesh independence in this type of problems. The usual techniques require topology information about the neighbour cells, which is difficult to obtain when the mesh program is separated from the computational code, especially for irregular meshes. The problem becomes even tougher in parallel environment, where the domain is decomposed on multiple non-overlapping partitions. Obtaining information about the neighbour sub-domains is an expensive operation. The proposed filtering technique requires only mesh information necessary for the finite element discretisation of the problem. The main idea is to define the filtered variable implicitly as a solution of a Helmholtz type differential equation with homogeneous Neumann boundary conditions. The properties of the filter are demonstrated for various 3D topology optimisation problems in linear elasticity solved on sequential and parallel computers.

MARIE B. DÜHRING (DTU Mechanical Engineering, 20 minutes)

Improving acousto-optical interaction by high aspect ratio electrodes

In recent years experiments have shown that optical waves in waveguides can be modulated by mechanical stresses from surface acoustic waves (SAW), which have most of their energy density concentrated at the surface. In these experiments the SAWs are generated in piezoelectric materials by conventional interdigital transducers consisting of thin electrodes deposited at the surface. In this work the finite element method is employed to investigate if the acousto-optical interaction can be enhanced by generating the SAWs by interdigital transducers consisting of high aspect ratio electrodes. With a periodic model it is first shown that these tall electrodes introduce several new confined SAW modes with slow phase velocities because of mechanical energy storage in the electrodes. The periodic model is then extended to a finite model by using perfectly matched layers at the substrate borders and is furthermore coupled to an optical model of the light in an optical waveguide at the substrate surface. By calculating the SAW introduced change in effective refractive index, which is a measure of the acousto-optical interaction, it is shown that the interaction is increased more than 300 times using these new types of SAWs compared to using the waves generated by the conventional interdigital transducer with thin electrodes. Thus, this indicates a way to improve acousto-optical interaction for integrated modulators, which have important applications such as optical phase shifters.

BIN NIU (ME, AAU, 20 minutes)

Design optimization of vibrating laminated composite plates for minimum sound radiation

Composite materials like fiber reinforced polymers (FRPs) are being used increasingly for structural applications where high strength, high stiffness and low weight are important properties. In such applications, the FRPs are usually stacked in a number of layers, each consisting of strong fibers bonded together by a resin, to form a laminate. In addition, laminated sandwich structures also consist of layers made of foam material. Since laminated composite structures are frequently used in dynamic environments, design optimization of laminates against vibration and noise has become a problem of great technical significance. In the present paper, this design objective will be considered in the form of minimizing the sound radiation from a laminated composite plate that is subjected to forced vibration by external time-harmonic mechanical loading [1]. Due to the often large number of layers in a laminate, the proper choice of materials, stacking sequence and fiber orientations is a complicated large-scale, essentially discrete optimization problem.

An efficient and reliable numerical design tool is therefore very important in order to realize the optimization of vibrating laminated composite plates, and the novel discrete material optimization (DMO) method [2] has been applied to achieve this goal. DMO lends itself to the methodology of topology optimization, and has proven to avoid well-known difficulties with local optimum solutions for fiber orientations, and to be able to solve simultaneously the optimization of materials, stacking sequence and fiber orientations, using a predefined set of discrete candidate materials and fiber angles as design variables at element level.

The vibration of the laminated plate is excited by time-harmonic external mechanical loading with prescribed frequency and amplitude, and the design objective is to minimize the total sound power radiated from the surface of the laminated plate to the surrounding acoustic medium, e.g., air. Instead of solving Helmholtz equation for evaluation of the sound power, advantage is taken of the fact that the surface of the laminated plate is flat, which implies that Rayleigh's integral approximation can be used to evaluate the sound power radiated from the surface of the plate. This implies that the computational cost of the structural-acoustical analysis is substantially reduced. Several numerical examples are implemented, including optimization of fiber orientations in a single-layer plate, and design optimization of fiber angles, stacking sequence and selection of material for a multi-layer sandwich laminate plate.

5 - BIO

(Chairman: POUL SCHEEL-LARSEN, DTU Mechanical Engineering)

11:30 - 13:05 NINA ANDERSEN (DTU Mathematics, 15 minutes)

In Silico Models of Blood Coagulation

Blood coagulation is a complex biochemical system involving activation of blood platelets and proteins, and it is important for preventing leakage from blood vessels. Blood coagulation has been studied predominantly as a fully stirred system, but blood flow and diffusion are also important factors in blood coagulation. The aim of this project is to study the influence of the blood flow and diffusion on blood coagulation by means of mathematical modelling of the nonlinear reaction convection equations. An experimental system has been set up at Novo Nordisk to study the influence of blood flow on platelet activation and adhesion to a collagen surface. A mathematical model of this experimental system has been developed consisting of reaction convection equations in 2D with a boundary condition in 1D, describing adhesion of platelets on the collagen surface. This partial differential equation system is solved using multiphysics finite element method. We present results comparing simulations with data from the experimental system.

MICHAEL SKIPPER ANDERSEN (ME, AAU, 20 minutes)

Musculoskeletal Modeling of Rectus Femoris Tendon Transfer in Kids With Hemiplegic Cerebral Palsy

Spastic Hemiplegic Cerebral Palsy (CP) is a neurological brain decease developed in infants or early after birth in kids. This dysfunction can cause severe spasticity, large bone deformity due to asymmetric loading of bones by affected muscles or muscle groups, muscle weakness and lack of control over muscles.

A frequently occurring lower extremity dysfunction in kids with mild CP is spasticity and tightness of the Rectus Femoris (RF) muscle. RF is a bi-articular muscle with its origin on pelvis and its insertion on patella. Mechanically, RF works as a hip flexor as well as a knee extensor.

Clinically, three tests are performed to determine if RF is dysfunctional; 1) Gait analysis is performed to determine if the patient is walking with a so-called stiff knee. 2) Electromyography (EMG) is measured to determine if there is abnormal activity of RF during the swing phase of gait. 3) An Ely test is performed to determine if RF asserts spastic behavior. If all of these tests are positive, a surgical procedure is normally suggested where RF is transferred from its insertion on patella to a muscle on the back of the thigh, e.g. the Semitendenosus, to eliminate its effect on the knee. This procedure is called Rectus Femoris Tendon Transfer (RFTT).

However, in kids that have undergone RFTT, it is seen that for approximately half of the patients, their gait pattern is improved post-operatively while the rest are either not improved or worse. Additionally, in the positive outcome patients the initial improvement has often disappeared more or less after 4-5 years, sometimes even to the extent that the stiff knee gait has returned.

Currently, it is not understood why some patients have a good outcome while others do not. Moreover, it is not understood why good outcomes tend to degenerate over the years.

Therefore, in this study, we created musculoskeletal models of gait, both pre- and post-operatively, for good and bad outcome RFTT patients to gain a deeper understanding of the muscle forces.

The musculoskeletal models indicate that large RF passive forces may be present in patients with a bad outcome RFTT while patients with a good outcome have much smaller RF passive forces. Additionally, for one of the bad outcome patients, it was decided to do a new surgery since he still had a stiff knee. In this surgery, it was planned to lengthen the Vastii muscles since it was believed that tightness of these, in the absence of the RF, were the cause of the persistent stiff knee gait. However, it was found that over the years, scar tissue had developed where RF had been removed and the part of RF that had been transferred had vanished, which had completely neutralized the original surgery.

From this it can be concluded that musculoskeletal analysis to some extent is capable of predicting internal muscular conditions and that the outcome for RFTT patients may be determined by formation of scar tissue after the surgery rather than differences in the patients pre-operatively.

RUNE KAASEN (DTU Mathematics, 20 minutes)

Evolution within supercolonies

Several species of ants have great success as invasive species, creating massive supercolonies consisting of thousands of nests and billions of workers. Within such a supercolony, the theory regarding kin selection seems not to apply. As a consequence, it has been argued that these hypersocial structures ought to break down in evolutionary time. We seek to gain insights into the possible routes evolution might take within a supercolony by modelling populations and introducing mutations of different kinds.

KIM KNUDSEN (DTU Mathematics, 20 minutes)

Mathematical aspects of Electrical Impedance Tomography

Electrical Impedance Tomography is a novel technology for medical imaging. The idea is from electrostatic measurements taken through electrodes at the boundary of the domain of interest (i.e. by measuring voltage potentials arising from induced currents trough electrodes attached to the body) to compute the interior conductivity. The underlying mathematical problem is severely ill-posed and non-linear, but anyway it is possible to compute regularized reconstructions and obtain reasonable images. In this talk I will give a brief introduction to the problem, outline the regularized reconstruction algorithm and show some computations based on an implementation of the method.

PETER RØGEN (DTU Mathematics, 20 minutes)

Some (DC)AMM problems in computational structural biology

From Wikipidia: “Structural Biology is a branch of molecular biology, biochemistry, and biophysics concerned with the molecular structure of biological macromolecules, especially proteins and nucleic acids”. In Computational Structural Biology bio-molecules are studied “in silico” and in the talk I will shortly introduce some of the mechanical/mathematical problems in this field. The main concern of the talk will be to examples from my current research where optimization plays an important role. One is to optimize the metric properties of a map of the known protein universe. The other is to optimize a geometric energy function on proteins to have “nice” local minima around the native structure of proteins.

Programme for Tuesday afternoon, March 24th, 2009

6 – WELDING AND FRACTURE
(Chairman: CHRISTIAN NIORDSON, DTU Mechanical Engineering)

14:00 - 16:30 MIKKEL MELTERS PEDERSEN (ME, AAU, 15 minutes)

Increasing Performance of Welded High Strength Steel Structures Subjected to Fatigue Loading

New ultra high strength weldable steels with a yield strength up to 1300MPa are primarily used in mobile machinery, such as cranes, trucks, trailers and construction equipment, but also in long spanning bridges and slender architectural details. Using these new steels, plate thicknesses can be reduced and higher stresses allowed, thereby creating strong and lightweight welded structures.

However, the gap between the static strength of the base material and the fatigue strength of the welded joints increases significantly, since the fatigue strength of welded joints does not increase with increasing base material strength.

This often causes the relatively low fatigue strength of the welded joints to become the dominating factor in a design and makes it difficult to fully exploit the static strength of the base material.

This project therefore investigates methods for increasing the fatigue strength of welded joints in order to ensure better utilization of ultra high strength steel.

JESPER HATTEL (DTU Mechanical Engineering, 20 minutes)

Thermomechanical modelling of Friction Stir Welding

Friction Stir Welding (FSW) is a fully coupled thermomechanical process and hould in general be modelled as such.

Basically, there are two major application areas of thermomechanical models in the investigation of the FSW process: i) Analysis of the thermomechanical conditions such as e.g. heat generation and local material deformation (often referred to as flow) during the welding process itself. ii) Prediction of the residual stresses that will be present in the joint structure post to welding. While the former in general will call for a fully-coupled thermomechanical procedure, however, typically on a local scale and explicitly formulated, the latter will very often be based on a semi-coupled, global implicit procedure where the transient temperatures drive the stresses but not vice-versa.

However, in the latter, prior knowledge about the heat generation must be obtained somehow, and if experimental data are not available for the FSW process at hand, the heat generation must either be prescribed analytically or based on a fully coupled analysis of the welding process itself. Along this line, a new thermal-pseudo-mechanical model is proposed in which the temperature dependent yield stress of the weld material controls the heat generation. Thereby the heat generation is still numerically predicted but the cumbersome fully coupled analysis avoided.

The formulation of all three mentioned modelling approaches are presented briefly and discussed together with some selected modelling results including prediction of material flow during welding, prediction of heat generation with the thermal-pseudo mechanical model as well as residual stress and deformation analysis combined with in-service loads.

CEM C. TUTUM (DTU Mechanical Engineering, 20 minutes)

A Multi-Objective Optimization Study on Residual Stresses in Friction Stir Welding

In the present paper, optimum process parameters in Friction Stir Welding (FSW), i.e. tool rotational speed and traverse welding speed, have been investigated using genetic algorithms considering thermomechanical issues and production efficiency, simultaneously. The welding process is simulated in 2-dimensions with a sequentially coupled transient thermo-mechanical finite element model. The thermal-pseudo-mechanical (TPM) heat source model, which is governed by the temperature dependent yield stress, is the main driver for the simulation of residual stresses in the workpiece. Two optimization scenarios have been investigated. In both of these, the minimization of the residual stresses is the main focus. This is combined with objectives regarding welding time in the first case and tool wear in the second.

ANDERS ASTRUP LARSEN (DTU Mathematics, 20 minutes)

Optimization of the material hardness distribution in friction stir welds

Friction stir welding (FSW) is a solid state welding process in which a rotating tool is moved along the weld line to join the two parts through heating and subsequent plastic deformation of the material. The process is well suited for welding aluminium and other materials that are hard to weld by conventional methods like arc welding. FSW is being used in the maritime, automotive and aerospace industry where aluminium alloys are used extensively.

A characteristic of FSW is the low temperatures that are below the melting temperature of the material to be welded. Still many materials, e.g. some aluminium alloys, experiences significant decreases in hardness and strength due to the heating during the welding process. The extent of this softening and the size of the region depends on the temperature field in the plate that in turn depend on the choice of welding parameters such as heat input and welding speed. In this work we optimize the welding parameters with the objective of obtaining a desired hardness distribution. The hardness is calculated by integration of analytical expressions over the full thermal history. Due to the high temperatures around the tool the changes will be largest in this region and decay with distance from the tool.

KIM LAU NIELSEN (DTU Mechanical Engineering, 15 minutes)

Effect of Specimen Geometry on Ductile Failure of RSW Shear-lab Specimens

Ductile plug failure of resistance spot welded shear-lab specimens is studied by full 3D finite element analysis, using an elastic-viscoplastic constitutive relation that accounts for nucleation and growth of microvoids to coalescence (the Gurson model). A parametric study for a range of weld diameters as well as specimen widths is carried out, making it possible to relate these parameters to the tensile shear force and the associated displacement, respectively. Here, a reasonable agreement was found with already published experimental work in the literature. Main focus in the present study is on modelling the localization of plastic flow and the corresponding damage development in the vicinity of the spot weld, near the HAZ. However, for decreasing weld diameter, plastic flow was found to localize in the weld nugget. Due to these competing mechanisms a critical transition radius of the weld may be found. The localization in the weld nugget occurs under significant shearing, hence the original Gurson model only predicts void nucleation, while limited void growth occurs. To study the shear failure mode a phenomenological shear modification of the Gurson model is applied.

ANDERS LIBAK HANSEN (ME, AAU, 20 minutes)

On Buckling Induced Delamination of Plates

In this work buckling of plates coupled with delamination growth in fibre reinforced laminates is studied. A general framework is proposed in which a hierarchical modelling technique is utilized to effectively generate 3D layered solid shell finite element models in which interlaminar fracture is simulated using cohesive interface finite elements. Mesh refined regions are identified by physically based failure criteria for inter- and intralaminar fibre/matrix failure. Along non-conform element boundaries, compatibility of displacements is enforced using the Lagrange multipliers method. Initialization and propagation of delamination is investigated for different imperfection configurations of the plate under uni-axial compressive loading. For this purpose, a fracture mechanics approach is utilized in which a damage mechanics constitutive model for a cohesive finite element is established based on piecewise linear traction-separation relations. The structural effect of R-curve behaviour due to fibre bridging is studied numerically by testing different mixed-mode traction-separation relations.
Experimental data are used for comparison with numerical results.

BRIAN N. LEGATH (DTU Mechanical Engineering, 20 minutes)

Debonding failure in micro-composites

Failure in micro-fiber composites is investigated numerically using the strain-gradient plasticity theory of Gudmundson (J. Mech. Phys. Solids f 52(6), 1379-1406, 2004) in a plane strain viscoplastic formulation.
Biaxially loaded unit cells are used and failure is modeled using a cohesive zone at the fiber-matrix interface. During debonding a sudden stress drop in the overall average stress-strain response is observed.
Adaptive higher-order boundary conditions are imposed at the fiber-matrix interface for realistically modelling the restrictions on moving dislocations as debonding occurs. It is found that the influence of the imposed higher-order boundary conditions at the fiber-matrix interface is minor. Strain gradient plasticity significantly affects the deformation mode as a smooth shaped void develops at the fiber-matrix interface, while a void having a sharp tip nucleates if strain gradient effects are excluded. Using orthogonalization of the plastic strain gradient with three corresponding material length scales, it is found that the first length scale dominates the evaluated overall average stress-strain response, the second one only has a small effect and the third one has an intermediate effect. Finally, studies of fibers having elliptical cross sections show an increased overall drop in the load carrying capacity for fiber cross-sections elongated perpendicular to the principal tensile direction.

LARS P. MIKKELSEN (Risø DTU, 20 minutes)

Biomechanical Investigation of Scull Fracture

An important issue in forensic medicine is to determine how a certain skull fracture arose. This information can be critical in establishing if a criminal offense has taken place. Even though all suspicious death cases as a standard already now is proceed through a CT-scan, the achieved data is mainly used as a visualisation and documentation tool. Today, the medical examiner chiefly relies on his experience since only a few scientific methods are known, and these are not considered sufficiently reliable. Nevertheless,

during the latest decade computers and finite element codes have reached a stage where accurate numerical finite element predictions of complex fracture cases are possible, e.g. in a full 3-D finite element simulation of a skull fracture. In addition, tools are available transfer CT-scan data to a 3-D finite element model. In the presented work, this procedure is demonstrated using a CT-scan from a specific forensic
case. Based on these scans, a 3-D finite element model of the skull is extracted. Using a simple element removing algorithm the fracture process in the specific skull are simulated using a commercial dynamic finite element code, ABAQUS/Explicit. The skull is exposed for a short dynamic impact from a blunted object. Based on the simulations, large sensitivity of the fracture modes is found for small changes in the initial speed of the incoming object. As a first step, the skull is the present study modeled as a homogeneous isotropic material model. A more realistic simulation would take into account the influence of the actually sandwich structure build up by a spongy bone layer with a low density between two compact bone layers and including the effects of the sutures between the bones contributing to the skull.

Programme for Wednesday morning, March 25th, 2009

7 – WIND TURBINES AND MATERIALS
(Chairman: LARS P. MIKKELSEN, RISØ DTU)

09:00 - 10:50 VLADIMIR A. FEDOROV (DTU Mechanical Engineering, 15 minutes)

Investigation of Structural Behavior due to Bend-twist Couplings in Wind Turbine Blades

One of the problematic issues concerning the design of future large composite wind turbine blades is the prediction of bend-twist couplings and torsion behaviour. Current work is a continuation of a previous work performed in MEK DTU, and it examines different finite element modelling approaches for predicting the torsional response of the wind turbine blades with built-in bend-twist couplings. Additionally, a number of improved full-scale tests using an advanced bi-axial servo-hydraulic load control have been performed on a wind turbine blade section provided by Vestas Wind Systems A/S.

In the present work attention was aimed specifically at shell element based FEA models for predicting torsional behaviour of the blade. Three models were developed in different codes: An ANSYS and ABAQUS model with standard section input and an ANSYS model with matrix input. All models employed the outer surface of the blade cross section as the defining surface, off-setting the location of the shell elements according to the specified thickness.

The experimental full-scale tests were carried out on an 8 m section of a 23 m wind turbine blade with specially implemented bend-twist coupling. The blade was tested under considerably larger load levels compared to earlier tests and showed linear-elastic response during flap-wise bending and combined bending-torsion tests which made it possible to employ the principle of superposition to extract the torsional characteristics of the blade from these tests. Additionally, pure torsion and other tests with different load cases were carried out on the blade employing a more advanced bi-axial servo-hydraulic load application control.

The use of shell-solid models for the prediction of torsional response was recommended based on earlier investigations. However as these models in practise are cumbersome to apply in design, the numerical models mentioned above were compared with previous experiments and the new experiments presented in this paper. Additionally, the models were verified against two older MSC.Nastran models. All shell models performed well for flap-wise bending, but performed poorly in torsion with deviations in the range of 15 to 35%, when employing the section input for the off-set definition. However, the ANSYS model generated using matrix input for the off-set definition was found to perform adequately.

KIM BRANNER (Risø DTU, 20 minutes)

Ultimate Strength of Wind Turbine Blades

We currently see a substantial growth in the wind energy sector world wide and this growth is expected to be even faster in the coming years. By the end of 2006 almost 1% of the world's electricity generation was produced by wind turbines. According to BTM Consult the forecast for 2011 is 2% of world's electricity generation and the estimation for 2016 is 4% of world's electricity generation. This means that a massive number of wind turbine

blades will be produced in the coming years and therefore there is a very large potential for saving material in these structures.
Full-scale tests of wind turbine blades have shown substantial damage in the webs after ultimate failure. It is often difficult to make solid conclusions on the failure sequence. However, there are indications that the ultimate failure in some cases is initiated by collapse of the sandwich structure of the webs. In this presentation some now results are shown concerning ultimate strength of wind turbine blades. Also results from a resent study are presented. In that study it was investigated how the sandwich properties of the webs influence the ultimate strength of the box girder and therefore the ultimate strength of the whole blade. A parameter study with different core densities was performed using a highly detailed finite element (FE) model. The numerical results are compared with a full-scale test of the box girder from a 34m wind turbine blade using one particular sandwich web design.

KASPER KOOPS KRATMANN (ME, AAU, 20 minutes)
Determination of Mechanical Properties Governing Compressive Failure of UD CFRP
The use of polymer based carbon fibre reinforced composites (CFRP) is rapidly increasing. The use of CFRP has spread from aerospace industry to a wide range of industries such as automotive, wind turbines, offshore and civil engineering.
The advantage of CFRP is its weight specific strength and stiffness in tension, which is superior to most other materials. Compressive strength of unidirectional (UD) CFRP, however, can often be the limiting design factor, as it is typically around 60% of the tensile strength. It is today widely accepted that the failure mechanism governing compressive strength of UD CFRP is plastic micro buckling in kinkband formations.
Plastic micro buckling is primarily governed by fibre misalignment, the composite’s shear modulus and shear yield strain. In the present project the fibre misalignment is determined with Fourier Transform Misalignment Analysis (FTMA), which is briefly reviewed. The shear properties are determined with the Iosipescu shear test combined with digital image correlation (DIC). These properties are determined for several cross-sections of a pultruded profile to see if there is any correlation between cross-sectional position, fibre misalignment, shear properties and compressive strength.

MIRZA KARAMEHMEDOVIC (DTU Mathematics, 20 minutes)
Application of the Method of Auxiliary Sources in Characterisation of Micro and Nano Structures by Optical Diffraction Microscopy
The design process, quality control and industrial use of functional materials with embedded micro and nano structures require rapid and non-destructive techniques of characterisation of these structures. One such technique is the Optical Diffraction Microscopy, where features of the sample under investigation are reconstructed from the measured optical power in the scattered far field, or from ellipsometric data obtained in the far field. Since the structures of interest are typically comparable to the wavelength of the illuminating light, it is advantageous to approach the inverse scattering problem using the full classical electromagnetic model, rather than asymptotic formulations. The Method of Auxiliary Sources (MAS) is an efficient, non-asymptotic numerical technique applicable to forward and inverse electromagnetic scattering. We illustrate the use of a simple MAS implementation in the approximation of solution of relevant inverse problems which arise in Optical Diffraction Microscopy. In particular, we demonstrate

that even small deviations in the topology or in the material composition of a model scatterer can be identified efficiently and with good accuracy using the MAS

MARTIN NYMANN SVENDSEN (DTU Mechanical Engineering)
Modal Control of Wind Turbines
Fatigue loading associated with structural vibrations is a key parameter for the lifetime of many components in a modern wind turbine. Thus, damping of dynamic structural response will add effective robustness and allow for even lighter designs than those known today. This project deals with design, modelling and analysis of control strategies for adding damping to the dominant vibration modes of an operating wind turbine.
Prerequisites for the investigation are a good numerical model of the wind turbine, a representative load model and an adequate description of the combined aero-elastic system of actuators and structure. Initially a model of a single blade is developed. The structural model is based on high-accuracy finite beam elements accounting for general, varying cross-section properties. Aerodynamics is represented in a linear formulation including state-proportional and unsteady terms accounting for realistic operating conditions. Centrifugal forces are included due to blade rotation, and non-linear geometric effects are represented via an initial stress formulation.
The main objective of the project is the development of general strategies for damping of vibrations described in terms of vibration modes, utilizing a finite number of local or distributed actuators. Based on continuous identification of a few modes of importance, resonance-based actuator forces can be efficiently distributed. Recent research at DTU Mechanical Engineering has lead to accurate methods for analysis of passively and actively damped systems which will be adapted and further developed in this project.

10:50 - 11:15 Coffee break

8 – MACHINE ELEMENTS AND ENGINES
(Chairman: JON JUEL THOMSEN, DTU Mechanical Engineering)

11:15 - 13:00 EDGAR ESTUPINAN PULIDO (DTU Mechanical Engineering, 15 minutes)
Active Lubrication Applied to Reciprocating Engines – Control Strategies
In dynamically loaded fluid film bearings, the behavior of important operational parameters, such as, the minimum fluid film thickness, the maximum fluid film pressure and the center journal position will depend on the instantaneous load condition. In this work, it is studied the feasibility of modifying the dynamics of the thin fluid films of this type of bearings, by using active lubrication techniques in order to allow for significant reduction in the vibration levels, wear and power friction losses. Particularly, the focus of this study is on the analysis of main crankshaft journal bearings, where the conventional hydrodynamic lubrication is modified, by injecting oil at actively controllable pressures, through orifices circumferentially located around the bearing surface. Several bearing configurations, working under different oil injection control rules are analyzed. The fluid film pressure distribution is computed for each load condition, by numerically solving the modified Reynolds equation, which includes the active lubrication terms. The fluid film forces are coupled to the set of nonlinear equations that describes the dynamics of the reciprocating engines and the global system of equations is solved in the time domain, giving some insights into the behaviour of the

maximum fluid film pressures, minimum fluid film thickness, maximum vibration levels, friction losses and oil injection pressures.

RUNE PEDERSEN (DTU Mechanical Engineering, 15 minutes)

Time-Varying Modal Analysis Applied to Spur Gear Pairs Taking Into Accout Tooth Profile Modifications

The dynamical analysis of a spur gear pair based on time-varying modal analysis is the purpose of this work. A simplified torsional model with a reduced number of degrees-of-freedom is used in order to investigate the potential of the technique. A gear mesh stiffness function, which takes into account the effects of tooth profile modifications and the time-dependency, is introduced and expanded in a Fourier series. The necessary number of Fourier components is determined for various tooth profile modifications. The method of the time-variant modal analysis is applied, and the changes in the fundamental and the parametric resonance frequencies, due to the tooth profile modifications and the operational conditions, are found. Thus, for both the original and the modified tooth profiles, the importance of the parametric resonances relative to the fundamental resonance frequencies is investigated.

The stationary and parametric parts of the time-depending modes shapes are obtained and physically explained. The advantages and drawbacks of applying the methodology to wind turbine gearboxes will be addressed and elucidated.

MARTIN ASGER HAUGAARD (DTU Mechanical Engineering, 15 minutes)

Modelling of Hybrid Fluid Film Bearings

The dynamic properties of tilting-pad journal bearings with controllable radial oil injection are investigated theoretically. The system is essentially comprised of solid structures separated by an oil film. No solid to solid contact is made under nominal conditions. However, at typical operating speed, the stiffness of the oil film approaches the structural stiffness, making the problem strongly coupled. The tilting pads are modeled as flexible structures and their behavior is described using a three dimensional finite element framework and linear elasticity. The oil film pressure and flow are considered to follow the modified Reynolds equation, which includes the contribution from controllable radial oil injection. The Reynolds equation is solved using a two dimensional finite element mesh.

The rotor is considered to be rigid in terms of shape and size, but lateral movement is permitted. The servo-valve flow is governed by a second order ordinary differential equation, where the right hand side is controlled by an electronic input signal.

The constitutive flow-pressure relationship of the injection orifices is that of a fully developed laminar velocity profile and the servo-valve is introduced into the system of equations by a mass conservation consideration. The Reynolds equation is linearized with respect to displacements and velocities of the nodal degrees of freedom. When all nodal points satisfy static equilibrium, the system of equations is dynamically perturbed and subsequently condensed to a 2 by 2 system, keeping only the lateral motion of the rotor. This method is well proven, and has been used for "conventional" hydrodynamic bearings for many years. It provides the equivalent stiffness and damping coefficients of the bearing. Tables of these coefficients can be used directly as design and calibration tools, or can be implemented into global rotordynamic models in a look-up fashion.

MICHAEL VINCENT JENSEN (DTU Mechanical Engineering, 15 minutes)
Heat transfer in two stroke diesel engines for large ship propulsion
A considerable amount of the vessels in todays global merchant fleet is using large two stroke diesel engines for propulsion. Constantly the engine manufactures seek to optimize and further develop the engines in terms of increased thermal efficiency, reduced emissions and higher specific power output. In the development process understanding of the in-cylinder heat transfer is an important factor. The piston surface experiences a severe thermal load during the combustion part of the engine cycle. At the same time, the piston is the most difficult combustion chamber part to cool. The peak surface heat flux at the piston occurs during flame impingement, but knowledge about it is very limited in large marine diesel engines. In order to gain more insight into the magnitude and distribution of this heat flux, the heat transfer process is simulated using CFD by imitating the flame impingement on the piston surface by a hot gas jet impinging onto a flat plate.

CASPAR ASK CHRISTIANSEN (DTU Mechanical Engineering, 15 minutes)
Experimental Investigation of Heat Transfer in Two-Stroke Diesel Engines
Today, about 90% of the world’s goods are transported by ship. Though the method is the cheapest and most environmental friendly, the diesel consumption is about 289 Mton per year. Thus, even small improvements of the engine efficiency will have a great impact on the environment. In this work, focus is on the heat transfer aspects of the two-stroke diesel engine.
Both simulations and experiments are performed to better understand the heat transfer processes. The main area of investigation is the zones with highest heat transfer rates such as the surfaces exposed to highly turbulent and very hot combustion gas.
The DCAMM presentation will focus on the measurement techniques of surface temperatures and heat transfer in a two-stroke engine and hopefully results will be presented.

TROELS DYHR PEDERSEN (DTU Mechanical Engineering, 20 minutes)
Acoustic resonance in HCCI combustion
The Homogeneous Charge Compression Ignition (HCCI) combustion process utilises lean premixed combustion of Dimethyl Ether (DME) to avoid formation of harmful pollutants such as soot and nitric oxides. In the HCCI process the charge ignites spontaneously in multiple locations and thus burns all fuel in the cylinder simultaneously. As the process is not ideal however, large pressure gradients occur followed by the excitation of the natural resonance frequencies in the combustion chamber. The energy from both the initial pressure wave and the subsequent resonance is mostly reflected and damped out, but some of the energy is transmitted through the engine structure to the surroundings. This has been investigated through experiments with different combustion chamber geometries, where the cylinder resonance frequencies and engine structure vibrations have been measured. Eventually, by reducing the amount of noise transmitted it is hoped that the engine load can be increased while engine noise is kept at acceptable levels