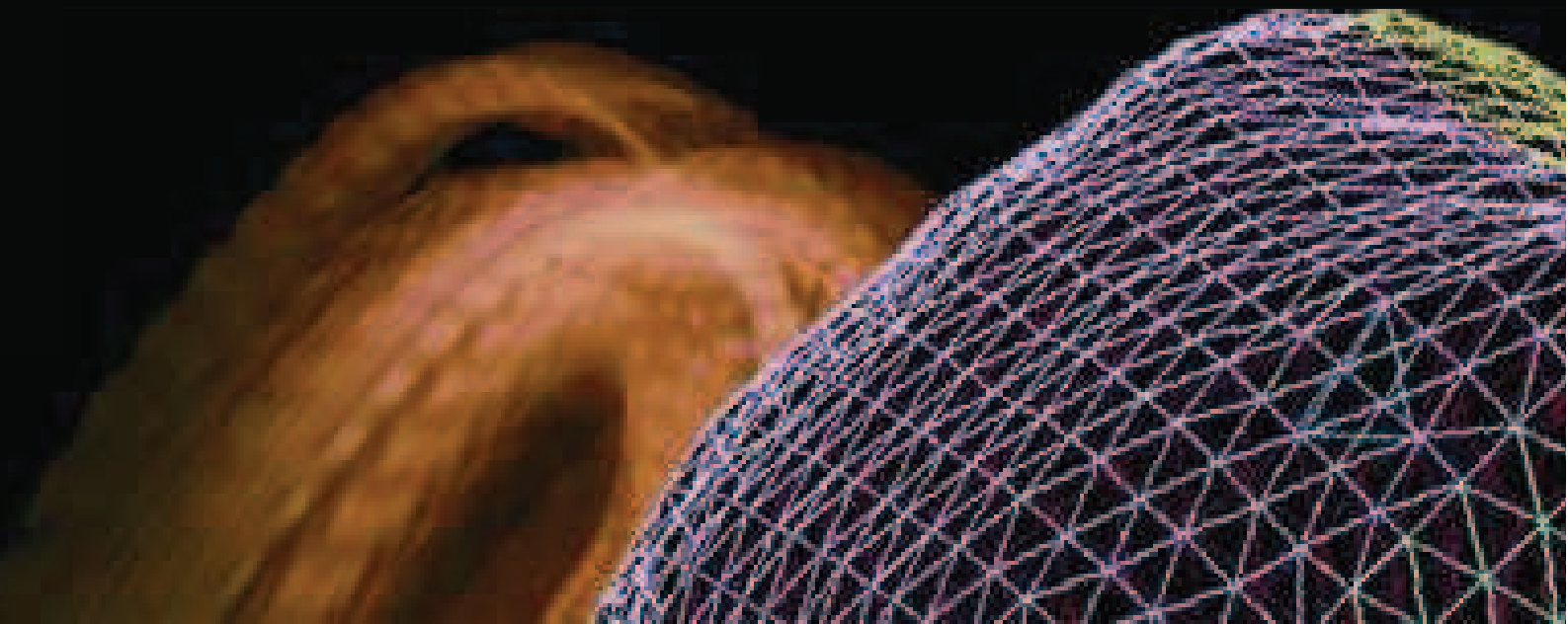


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# **MULTIPHYSICS**

# **2008**

**10 - 12 December 2008**  
**Narvik, Norway**



# **MULTIPHYSICS 2008**

**10-12 December 2008**

**Narvik, Norway**

## **Conference Board**

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Zeguer T, Jaguar, UK

## General Information

### Scope of Conference

Understanding real physics and performing multiphysics simulation are extremely important to analyse complex systems in order to better design and manufacture engineering products.

The objective of the conference is to share and explore findings on mathematical advances, numerical modelling and experimental validation of theoretical and practical systems in a wide range of applications.

The scope of the conference is to address the latest advances in theoretical developments, numerical modelling and industrial application which will promote the concept of simultaneous engineering. Typical combinations would involve a selection from subject disciplines such as Acoustics, Electrics, Explosives, Fire, Fluids, Magnetic, Soil, Structures and Thermodynamics.

### Registration Pack – Collection Hours

Registration packs should be collected from the Registration Desk. Collection Hours are as follows:

Wednesday, 10 <sup>th</sup> December	09:00-18:00
Thursday, 11 <sup>th</sup> December	08:00-17:00
Friday, 12 <sup>th</sup> December	08:00-17:00

### Special Events

- Wednesday 18:00  
*Welcome Reception*
- Thursday 19:00  
*Conference Banquette*  
*(Sponsored by Forskningsparken i Narvik - Narvik Research Park)*

### Timing of Presentations

Each paper will be allocated 20 minutes. A good guide is 15 minutes for presentation with 5 minutes left for questions at the end.

Good timekeeping is essential, speakers are asked to keep strictly to 20 minutes per presentation.

### Language

The official language of the conference is English.

### Audiovisual

The lecture room will be preset with the following:

One laptop, one LCD projection and cables, one screen, and one microphone.

Delegates are requested to bring presentations on CD or memory stick.

### Paper Publication

Selected papers are reviewed and published in 'The International Journal of Multiphysics'.

### Sponsorship

The Conference Board would like to thank the sponsors for their support.

## Keynote Speaker

Professor S Itoh  
Kumamoto University, Japan

### **BIOGRAPHY**

Shigeru Itoh, Professor of Kumamoto University, received the M.Eng. degree from Kyushu University, Japan, in 1971 and D.Eng. degree from Tokyo Institute of Technology, Japan, in 1981.

Professor Itoh joined the Department of Mechanical Engineering of Kumamoto University in 1990 as a lecturer. In 1995, he was promoted as Associate Professor and became Professor in 1999. He is the Director of the Shock Wave and Condensed Matter Research Centre, Kumamoto University, since 2003.

Professor Itoh started his career in shock related research with his study, "On the transition between regular and Mach reflection in truly non-stationary flows", for which he received D.Eng. degree. He has then extended his work on the materials processing using explosives and the dynamics of shock waves using numerical simulation and experimental techniques. His current areas of interest are: numerical simulation and visualization of explosion and shock-wave propagation phenomena, development of food processing technology using shock wave, development of wood and textile processing technology using shock wave, rare metal recovery from electronic components using underwater shock wave, glass recycling using underwater shock wave, explosive forming and shearing using underwater shock wave and explosive welding technique using underwater shock wave for difficult to bond materials.

Professor Itoh is an Executive member of the Japan Explosives Society. He has been the host and organizer/coorganizer of several workshops, symposia and international conferences including Explosion, Shock Wave and Hypervelocity Phenomena held in Kumamoto University, Japan, and ASME – Pressure Vessel and Piping Conference held in USA. He has many publications in Journals and proceedings. He has contributed a book chapter in Handbook of Shock Waves [Academic Press, 2001] and in Shock Waves Handbook [Springer Verlag, Tokyo, 1995, in Japanese].

Professor Itoh received the Pressure Vessels and Piping Division (PVPD) Conference award by the American Society of Mechanical Engineers in 2006; the Academic Plaza Award by the Japan Food Machinery Manufacturer's Association in 2005; Certificate of Recognition by the American Society of Mechanical Engineers in 2004; the Discourse Award by the Japan Society for Technology of Plasticity in 2004; and the Japan Explosives Society award in 1995.

**MULTIPHYSICS 2008****Programme**

<b>Time</b>	<b>Wednesday 10 Dec 08</b>	<b>Thursday 11 Dec 08</b>	<b>Friday 12 Dec 08</b>
<b>09:00 – 10:30</b>	<b>Registration</b>	<b>Session 2.1 <i>Numerical Algorithms</i></b>	<b>Session 3.1 <i>Eletrophysics</i></b>
	<b>Keynote Address</b>		
<b>10:30 – 11:00</b>	<b>Coffee Break</b>		
<b>11:00 – 12:30</b>	<b>Session 1.2 <i>Optimisation</i></b>	<b>Session 2.2 <i>Material Physics</i></b>	<b>Session 3.2 <i>Modelling Advances</i></b>
<b>12:30 – 13:30</b>	<b>Lunch</b>		
<b>13:30 – 15:00</b>	<b>Session 1.3 <i>Heat Transfer and Thermodynamics</i></b>	<b>Session 2.3 <i>Flow Modelling and Simulations</i></b>	<b>Session 3.3 <i>Fluid Mixtures</i></b>
<b>15:00 – 15:30</b>	<b>Tea Break</b>		
<b>15:30 – 17:00</b>	<b>Session 1.4 <i>Micromechanics</i></b>	<b>Session 2.4 <i>Impact and Explosions</i></b>	<b>Session 3.4 <i>Fluid Structure Interaction</i></b>
<b>18:00</b>	<b>Welcome Reception</b>		
<b>19:00</b>		<b>Conference Banquette</b>	

**Full Programme**

**Wednesday 10 December 2008**

**09:00                    Registration**

**09:30-10:30          Keynote Address**

*Chair: M Moatamedi, Cranfield University, UK*

**Multiphysics in Food Processing Using Underwater Shock Wave**

S Itoh

*Shock Wave and Condensed Matter Research Centre*

*Kumamoto University, Japan*

**10:30-11:00          Coffee Break**

Wednesday 10 December 2008

11:00-12:30      **Session 1.2 Optimisations**

*Chair: T Rahulan, University of Salford, UK*

Multiphysics Analysis and Numerical Optimisation of Polymer Curing with Dual-Section Microwave Systems

T. Tilford, K.I. Sinclair, G. Goussetis, C. Bailey, M.P.Y. Desmulliez,  
A.K. Parrott and A.J. Sangster  
*University Of Greenwich and Heriot Watt University, UK*

Notes on the optimal design of a long and slender compressive strut

J. Byström  
*Narvik University College, Norway*

Optimal Sensor Placement in a Multiphysics system using IRIS Explorer

M. Soufian  
*Oxford University, UK*

Mathematical optimization of a plate volume under a p-Laplace partial differential equation constraint by using standard software

G. Scharrer, S. Wolkwein and T Heubrandtner  
*University of Graz and vif, Austria*

Optimising microwave drying conditions for production of peat-based oil absorbent

R. F. Wakelin  
*Norut Narvik A.S., Norway*

12:30-13:30      **Lunch**



Wednesday 10 December 2008

**13:30-15:00      Session 1.3 *Heat Transfer and Thermodynamics***

*Chair: PA Sundsbø, Narvik University College, Norway*

Numerical Modelling of Jet Gas Freeing in Marine Crude Oil Tanks

K. Chow, A. E. Holdø

*Narvik University College and Coventry University, Norway and UK*

Computational Fluid Dynamics on Natural Convection Heat Transfer in High-Viscosity Oil

A.F.Polupanov, V.I.Galiev, A.N. Kruglov

Janyalertadun, W. Lumdoun, M. Pusayatanont and AE Holdø

*Ubonratchathani University and Coventry University, Thailand and UK*

Scaling of Icing on Wind Turbines

M. C. Homola, T. Wallenius, L. Makkonen, G. Beeri, P. J. Nicklasson  
and P. A. Sundsbø

*Narvik University College and VTT Technical Research Centre,  
Norway and Finland*

Determination of energy quality for hydronic heating systems

T. T. Harsem and B. A. Borresen

*Norconsult, Norway*

**15:00-15:30      Tea Break**

Wednesday 10 December 2008

15:30-17:00      **Session 1.4 Micromechanics**

*Chair: AE Holdø, Coventry University, UK*

Application of fuzzy arithmetics to assess variation of dynamic properties of MEMS resonator

A. Martowicz, I. Codreanu, T. Uhl

*AGH University of Science and Technology and Laboratory of Modelling and Simulation, Poland and Romania*

Validation of Inductively Coupled Plasma Models at large Knudsen Numbers with Chlorine Chemistry

K. Shah and M. Megahed

*ESI Group, Germany*

Simulation of Filtration Processes in Deformable media - Non-Spherical dirt particle modelling

G. Boiger, M. Mataln, W. Brandstätter

*ICE Strömungsforschung GmbH and Montanuniversität Leoben, Austria*

Comparative study of nonlinear and linear analysis of piezo-composite beams subject to static and dynamic loading

V. Arabzadeh, M. Darvizeh and A. Darvizeh

*Guilan University, Iran*

18:00              **Welcome Reception**

Thursday 11 December 2008

**09:00-10:30      Session 2.1 Numerical Algorithms**

*Chair: M Soufian, Numerical Algorithms Group, UK*

Multigrid dynamic programming and expo-rational B-splines for optimal control of constrained dynamical systems

L.T. Dechevsky

*Narvik University College, Norway*

High Performance Computing and Parallel Multiphysics

M. Soufian and V. Chakkerla

*National Algorithms Group and Oxford University, UK*

The simulator BEDSIM of LKAB and scientific visualization for dynamical systems with multidimensional phase space

O. Gundersen

*Narvik University Colleg, Norway*

IRIS Explorer for Multiphysics Applications

M. Soufian and J. Walton

*National Algorithms Group and Oxford University, UK*

**10:30-11:00      Coffee Break**

Thursday 11 December 2008

11:00-12:30      **Session 2.2 *Material Physics***

*Chair: LT Dechevsky, Narvik University College, Norway*

Coupled thermo-mechanical analysis of PLC deformation bands in the AA5083-H116 aluminium alloy

A. Benallal, T. Børvik, O.S. Hopperstad and R. Nogueira de Codes  
*Université Paris 6 and NTNU Trondheim, Norway*

Dynamic Property of Silicone Rubber Using as Pressure Transmitting Medium

K. Nishi, A. Mori, K. Iwasa, M. Moatamedi, M. Souli, S. Itoh  
*Kumamoto University, Cranfield University and University of Lille, Japan, UK and France*

Tensile and Dynamic Mechanical properties of Thermoplastic Natural Rubber Nanocomposite Reinforced with Carbon Nanotube

M. A.Tarawneh, S.H. Ahmad, R. Rasid<sup>1</sup>, S.Y.Yahya  
*Universiti Kebangsaan and Universiti Teknologi Mara, Malaysia*

Synthesis and Characterization of Cow Dung Charcoal

S. Sanongraj, C. Sangwijit, W. Sanongraj, A. Janyalertadun  
*Ubonratchathani University, Thailand*

The Effect of Adhesive Thickness on Spot Weld-Bonded Joints of Dissimilar Materials Using Finite Element Model

E. A. Al-Bahkali  
*King Saud University, Saudi Arabia*

12:30-13:30      **Lunch**

Thursday 11 December 2008

**13:30-15:00      Session 2.3 *Flow Modelling and Simulation***

*Chair: H Iyama, Yatsushiro National College, Japan*

Optimizing the Hydrocyclone for Ballast Water Treatment using Computational Fluid Dynamics

D. K. McCluskey and A. E. Holdø  
*Coventry University, UK*

Study on control of underwater shockwave by PMMA

A. Osada, H. Hamashima, S. Itoh  
*Kumamoto University and Kumamoto Industrial Research Institute, Japan*

Lethal effects of hydrodynamic forces from hydrocyclones

M. Slack, D. Cokljat, A.E. Holdø, A. Cokljat, M. Pecarevic, J. Mikus, A.B. Cetinic, E. Marcelja and J. Lovric  
*ANSYS Fluent Europe Ltd, Coventry University and University of Dubrovnik, UK and Croatia*

Effect of second phase flow on single phase flow meter in steam industry

M. Pusayatanont, P J Unsworth and A. Janyalertadun  
*University of Sussex and Ubonratchatani University, UK and Thailand*

**15:00-15:30      Tea Break**

Thursday 11 December 2008

15:30-17:00      **Session 2.4 *Impact and Explosion***

*Chair: DK McCluskey, Coventry University, UK*

Dynamic Analysis of Pedestrian Impact with a Vehicle

W. Tiu

*Hertfordshire University, UK*

Explosion Effect of Metallized Explosive

T. Mihara, M. Otsuka, E. Hida, M. Moatamedi, S. Itoh

*Kumamoto University, Asahi Kasei Chemicals Co. and Cranfield University, Japan and UK*

Protection of Oil-Filled Transformer against Explosion: Experiments & Numerical Simulations

S. Muller, G. Périgaud

*SERGI Holding, France*

Study on Shock Loading Pre-processing for Freeze-drying

Y. Yamashita, D. Sawamura, S. Itoh

*National Fisheries University and Kumamoto University, Japan*

19:00              **Conference Banquette**

Friday 12 December 2008

09:00-10:30      **Session 3.1 *Electrophysics***

*Chair: V Damic, University of Dubrovnik, Croatia*

Performance analysis of an intermediate temperature PEM fuel cell having a perforated gas distributor

M. S. Virk, A. E. Holdø  
*Coventry University, UK*

Coupled Mechanical Thermal Electromagnetic Simulations in LS-DYNA®

P. l'Eplattenier, N. Aquelet, A. Shapiro  
*Livermore Software Technology Corp., USA*

Numerical Investigation of the Magnetic Flux Static Distributions in Layered Josephson Junctions

I.G. Christov, S.N. Dimova, and T.L. Boyadjiev  
*Sofia University, Bulgaria*

Optimization of Micro-Fluidic Valve Dimensions using Finite Element Methods

H. A. Khawaja, I. Rauf, K. Parvez  
*NUST, University of Cambridge and CALTECH, Pakistan, UK and USA*

10:30-11:00      **Coffee Break**

Friday 12 December 2008

11:00-12:30      **Session 3.2 *Modelling Advances***

*Chair: M Mataln, ICE Strömungsforschung GmbH, Austria*

Multi-physics Modelling with Bond Graphs

V. Damic

*University of Dubrovnik, Croatia*

The Numerical Analysis of Food Processing using Shock Wave

Y. Yamashita, A. Oda, H. Maehara, M. Moatamedi, T. Watanabe  
and S. Itoh

*Kumamoto University, Cranfield University and National Fisheries  
University, UK and Japan*

Target Reference Generator for the European Student Moon Orbiter  
Satellite

R. Schlanbusch, T. M Steihaug and P. J. Nicklasson

*Narvik University College, Norway*

Numerical Simulation and Experiment on Explosive Forming Using a  
Pressure vessel

H. Iyama, S. Itoh,

*Yatsushiro National College of Technology and Kumamoto  
University, Japan*

Preparation of Terrain and Landscape data for Multiphysics Simulations

William P Tiu and Per Arne Sundsbø

*Hertfordshire University and Narvik University College, UK and  
Norway*

12:30-13:30      **Lunch**



Friday 12 December 2008

**13.30-15:00      Session 3.3 *Fluid Mixtures***

*Chair: M Souli, University of Lille, France*

Mass Flow Determination in Flashing Openings

G. Polanco, A.E. Holdø, G. Munday  
Coventry University, UK

Development and Application of the Indoor Air Adsorption Design  
Software Model

W. Sanongraj, E.J. Oman, C. Zhao, D. Hokanson, D. W. Hand, J.  
Crittenden  
Ubonratchathani University, Michigan Technical University and  
Arizona State University, Thailand and USA

On study of emulsification by the shock wave processing

A. Takemoto, H. Maehara, T. Watanabe and S. Itoh  
Kumamoto University and National Fisheries University, Japan

Requirement of ventilation in rail tunnel: How to take a correct decision

B. A. Borresen and S. Chakraborty  
Norconsult, Norway

**15:00-15:30      Tea Break**

Friday 12 December 2008

**15.30-17:00      Session 3.4 *Fluid Structure Interaction***

*Chair: T Watanabe, National Fisheries University, Japan*

ALE and Fluid Structure Interaction

M. Souli  
*University of Lille, France*

Fluid-Structure Interaction in LS-DYNA®

N. Aquelet, F. Del Pin, L. Olovsson  
*Livermore Software Technology Corp. and Impetus AFEA AB, USA  
and Sweden*

Systematic evaluation of control volume method suitability for stress-  
analysis in conjunction with fluid-structure interaction

D. Cokljat, A. Ivankovic and A.E. Holdø  
*ANSYS Fluent Europe Ltd., University College Dublin and Coventry  
University, UK and Ireland*

Free vibration analysis of Dragonfly wings with Finite Element Method

M. Darvizeh, A. Darvizeh, H. Rajabi, A. Rezaei  
*Guilan University, Iran*

**17:00                      Close of Conference**



***SESSION 1.1***

**Keynote Address**

WEDNESDAY 10 DECEMBER 2008  
09:30 - 10:30

CHAIR

M Moatamedi  
Cranfield University  
UK

Wednesday, 10 December 2008

09:30 – 10:30

## Keynote Address

### **Multiphysics in Food Processing Using Under Water Shock Wave**

Professor Shigeru Itoh  
*Shock Wave and Condensed Matter Research Centre  
Kumamoto University, Japan*

The shock wave is defined as the discontinuous pressure wave generated by the propagation of pressure disturbance caused by events such as high speed collision caused by detonation, electrical discharge etc., that exceeds the speed of sound. The high energy of shock wave is used in the field of materials processing. The applications of shock wave include explosive forming and explosive cladding. Similarly the strength of wood can be improved by selectively destroying the structure of wood using shock wave. Also, the wood can be made to non flammable by infiltration of chemicals into the wood.

In this research, an underwater shock wave was processed on the apple as an example of food processing and the amount of the nutritional content including the hardness change, and the change in the fruit juice was verified. Moreover, the numerical analysis of the food processing of apple was done using analysis software, LS-DYNA3D.

*SESSION 1.2*

**OPTIMISATIONS**

WEDNESDAY 10 DECEMBER 2008

11:00 – 12:30

CHAIR

T Rahulan  
University of Salford  
UK

## Multiphysics Analysis and Numerical Optimisation of Polymer Curing with Dual-Section Microwave Systems

T. Tilford (1), K.I. Sinclair (2), G. Goussetis (2), C. Bailey (1), M.P.Y. Desmulliez (2), A.K. Parrott (1) and A.J. Sangster (2)  
*(1) Centre for Numerical Modelling and Process Analysis (CNMPA), University Of Greenwich, UK, (2) MicroSystems Engineering Centre (MISEC), School of Engineering & Physical Science, Heriot Watt University, UK*

The curing of a thermosetting polymer material in an idealised microelectronics package placed within a dual-section microwave system is simulated numerically using a multi-domain coupled solver approach. The numerical model utilises a Finite-Difference Time-Domain (FDTD) electromagnetic solver coupled to an unstructured Finite-Volume Method (UFVM) multi-physics solver using a cross-mapping algorithm. Two overlapping numerical domains are defined; the simplified microelectronics package is described by the UFVM domain while the internal geometry of the microwave system is described by the FDTD domain. The FDTD solver is used to obtain a solution to the distribution of electric field intensity and power density within the microwave system. The UFVM solver is used to obtain a solution to temperature distribution, degree of cure and stresses within the microelectronics package. The two solution domains are linked using a cross-mapping routine which adopts a spatial sampling approach to transfer necessary data between domains.

The numerical model is able to determine the variation in residual stresses within the package in response to variation in heating profiles. A response surface optimisation approach is used to numerically optimise the temperature process. Presented results illustrate development of temperature, cure rate, degree of cure and stresses within the microelectronics package throughout the heating process. Numerical optimisation results showing critical parameters and optimal temperature profile are presented. Results suggest that microwave processing systems are capable of rapidly and evenly curing thermosetting polymer materials. Numerical optimisation results show that there is a trade-off between cure quality, peak temperature and process duration.

Keywords: Microwave, Polymer, Optimisation, Multiphysics, Simulation

## Notes on the optimal design of a long and slender compressive strut

Johan Byström

*Narvik University College, Narvik, Norway*

This paper deals with redesign of aluminum struts used on airplanes to carry airborne radar systems. The main objective is to minimize the mass of the struts under non-failure constraints. A quantitative goal is to increase the maximal load to mass ratio by at least 30 %.

First, an analysis of possible failure modes is undertaken, where it is showed that the dominating failure mode of the struts is Euler buckling. In addition, the struts should also be able to withstand a bird collision at high speed. Using Cambridge Material Selector, the optimal material choice for the strut is determined from the points of view of failure strength, stiffness, Euler buckling and toughness against impact.

The results clearly show that the struts should be constructed from unidirectional carbon fiber composites. Mathematical homogenization of composite materials is then used to compute the effective elastic properties of the resulting strut. To be able to take into account the random microstructure of a composite material, a Monte Carlo type simulation procedure to generate pseudorandom periodic unit cells has been developed. A total of 1000 individual cells are generated in MATLAB, each with 64 randomly placed inclusions arising from 2000 Metropolis iterations. Finally, numerical computation of the effective elastic tensor for the chosen carbon fiber/epoxy composite is performed using Comsol Multiphysics for each unit cell, followed by computation of the average elastic properties for the material.

Summing up, the resulting struts are shown to have increased the maximal load to mass ratio with up to 120% (depending on geometry).

Keywords: Homogenization, Monte Carlo simulation, random microstructure, material indices, failure modes



## Optimal Sensor Placement in a Multiphysics system using IRIS Explorer

Majeed Soufian  
*Oxford University, UK*

Multiphysics systems are by nature multi-dimensional system where the quantity and quality variables of the product such as density, basis weight, and temperature vary in both time and space dimensions. Considering the fact that in 1-D systems where time is the only independent variable, there is only one way to scan the data therefore only one sensor per desired variable is sufficient for the measurement and the location of sensor(s) doesn't affect the open-loop dynamics and the closed-loop performance of the system. Whereas in higher dimensions the signal measurement can be preceded in any arbitrary order and the variation of each specific variable at each point in the time-space coordinate is relevant for measurement. However having more than one sensor per specific variable will usually exceed number of actuators and consequently can cause the problem of transmission zeros.

System engineers and designers usually ignore the importance of the transmission zeros of open-loop systems, the role of these zeros in description of such systems, and the dependence of the transmission zeros on the actuators and sensor locations even for automation purposes where it is quite vital. Experience has shown when the system is uncontrollable or unobservable for a particular actuator and sensor placement, it could turn out to be controllable or observable by moving an actuator or a sensor by a small amount. Then a question logically arises as to how these locations could be estimated or predicted to take delivery of a satisfactory system performance or to achieve an optimal response.

In this paper, the effects of sensor location and optimal sensor placement for Nuclear Magnetic Resonance (NMR) imaging (or MRI) system has been considered. The MRI system performance is limited by imperfections such as mechanical deformations and geometrical changes because of temperature, interaction and non-homogeneity in magnetic fields. With the aid of simulations in IRIS Explorer® the effects of sensor location on dynamics response and its optimisation is presented.

Keywords: Modelling, Simultaneous Simulation, Sensor location, MRI

## Mathematical optimization of a plate volume under a p-Laplace partial differential equation constraint by using standard software

Georg Scharrer (1), Stefan Volkwein (2) and Thomas Heubrandtner (1)

(1) *Das Virtuelle Fahrzeug Forschungsgesellschaft mbH (vif), Austria*, (2) *University of Graz, Austria*

The work was motivated by the research field of pedestrian safety where researchers are trying to decrease head injuries caused by car collision. A simplified problem, a bonnet like plane trapezoidal plate with static load was defined. To solve this problem it was necessary to find a partial differential equation (PDE) which describes the bending behavior of the plate. Then an optimization problem was defined which got solved finally. The main goal in this investigation was to determine a new approach for the optimization problem by using standard software applications (Matlab, COMSOL Multiphysics) and combine them regarding a strong mathematical background. First of all it was necessary to find the PDE which describes the problem from a physical and mathematical point of view. This was needed to have an entire mathematically described model to work with to have full control on the problem. A PDE, which satisfies the demands, belonging to the p-Laplace family was found. Then Matlab and COMSOL Multiphysics were used to solve a linear modification of the initial problem for a static load case. Next it was examined how to get the solution of the initial p-Laplace problem. This was done by using a fixed point iteration which is efficient in terms of implementation costs. At this point the work on the optimization topic of this problem was started. First a mathematical formulation of the optimization problem was done, where the implementation with Matlab and COMSOL Multiphysics was kept in mind. The state constraints were realized by a penalty approach. Because of the PDE being in the restriction part of the optimization problem it was needed to use Lagrange functions to achieve the adjoint problem which, of course, is a PDE too. By using variational calculus it was possible to state the variational equation and furthermore to get the optimality system for the linear problem. From that the gradient information for the objective function was derived, which is essential for an efficient implementation and execution of the optimization problem by using modified Matlab functions.

Keywords: nonlinear optimization, partial differential equation, p-Laplace

## Optimising microwave drying conditions for production of peat-based oil absorbent

Ross F. Wakelin  
*Norut Narvik A.S., Narvik, Norway*

Sphagnum peat moss, in a partially degraded form, can be used to produce absorbents for oil spill response. The key process step is the drying of the peat from a starting moisture content of around 80% to 15%. If this is done correctly the absorbent have good oil absorption and binding capacity and low absorbance of water giving good floatability. About half of the water can be removed by pressing and draining, while the remainder requires forced evaporation. Microwave heating gives the opportunity for better control of the drying process, but requires detailed understanding of the mechanisms involved, including the electromagnetic - dipole interactions, and heat and mass transfer in a substrate with changing moisture content.

The objective for the drying is to achieve energy efficient drying with temperatures high enough to melt the peat wax/fatty acids to impart hydrophobicity to the peat particle surfaces, while avoiding temperatures that cause evaporation of the fatty acid or charring of the surface. Excessive drying can cause damage to the cells and loss of absorption capacity.

The advantage of microwave drying is that the energy can be applied to the water component in the particle interior, avoiding the need for convective heat transfer through already dried outer layers. The dipole heating effect ensures the heat is directed towards the wetter areas. As the drying proceeds the sample mass reduces, raising the specific power, while at the same time the dipole effect reduces as the moisture content reduces. The optimisation of the microwave drying process requires knowledge of the electromagnetic dipole effect as well as description of the heat and mass transfer relations for particles which in effect are drying from the inside-out, unlike the traditional convective drying approach.

This article describes the experimental examination of the effect of specific power, sample geometry and moisture content on the drying rate. By fitting the results to theories of electromagnetic dipole interaction and drying kinetics the process can be optimised and calculations made for the scale up.

Keywords: microwave drying absorbent heat mass transfer

*SESSION 1.3*

**HEAT TRANSFER AND**  
**THERMODYNAMICS**

WEDNESDAY 10 DECEMBER 2008  
13:30 – 15:00

CHAIR

PA Sundsbo  
Narvik University College  
Norway

## Numerical Modelling of Jet Gas Freeing in Marine Crude Oil Tanks

Kevin Chow, Arne. E. Holdø  
*Høgskolen i Narvik, Narvik, Norway*

Marine gas freeing concerns the ventilation of large cargo holds, and has been subject to a small number of studies in the twentieth century. However, in comparison to ventilation of buildings, marine gas freeing with respect to large crude-oil carriers, the process of ventilation is subject to a number of extremes and adverse conditions. Tank sizes on the largest crude carrying vessels can have volumes of around 30,000m<sup>3</sup>, and are commonly 30m deep. In addition, the tanks are likely to contain a large number of potentially explosive volatile organic gases (VOCs) of varying densities which must be removed from the tank and a breathable atmosphere restored to allow work inside the tank. In the vast majority of cases, this is done by mechanical ventilation from deck level using a high-powered fan, which can cause difficulty if heavier vapours are in a stratified condition at the base of the tank. Accurate numerical simulation of such a scenario is subject to a large number of challenges which will be presented in this paper. These challenges are related to the thermal, radiative and densimetric conditions as well as turbulence modelling in order to simulate appropriate physics. The effects of the different physical models and different inlet boundary conditions have been studied with a view to determining a suitable level of accuracy, and the impact of engineering assumptions examined with regard to the gas freeing process as a whole.

Keywords: RANS, simulation, ventilation, tanker, gas-freeing

## Computational Fluid Dynamics on Natural Convection Heat Transfer in High-Viscosity Oil

A. Janyalertadun (1,2), W. Lumdoun (1), M. Pusayatanont (2,3) and A. E. Holdø (4)

*(1) Department of Mechanical Engineering, Faculty of Engineering, Ubonratchathani University, Warinchumrap, Ubonratchathani, THAILAND*

*(2) National Center of Excellence for Environmental and Hazardous Waste Management, Ubonratchathani Node, Warinchumrap, Ubonratchathani, THAILAND, (3) Department of Electrical Engineering, Faculty of Engineering, Ubonratchathani University, Warinchumrap, Ubonratchathani, THAILAND*

*(4) Faculty of Engineering and Computing, Coventry University, UK*

The objective of this research is to study the behavior of temperature distribution in the high viscosity oil storage tank. The heat transfer is laminar natural convection from the horizontal cylinder heater in the heavy fuel oil storage tank. The laminar model appears in the range of Rayleigh number (Ra). The computational fluid dynamics (CFD) that is the finite volume method is employed to solve the problem to compare with the experimental from literature. From fluent application the laminar model and constant heat flux source are implemented the results of the temperature distribution against times from CFD have a good agreement compare to the reference experimental results that is the temperature at the top of the storage tank is increase rapidly more than the bottom.

Keywords: Natural convection, High-Viscosity Oil, Computational Fluid Dynamics

## Scaling of icing on wind turbines

Matthew C. Homola, Tomas Wallenius, Lasse Makkonen, Guy Beerli, Per J. Nicklasson and Per A. Sundsbø

*Department of Computer Science, Electrical Engineering and Space technology, Narvik University College, Norway, VTT Technical Research Centre of Finland, Finland*

Numerical simulations of ice accumulation on different wind turbine blade profiles have shown that atmospheric icing is dependent on turbine size. The simulations indicate that dry rime icing is less severe for larger wind turbines both in terms of local ice mass and in terms of ice thickness. Therefore energy losses due to icing can not be directly transferred from one wind turbine size to another. This also seems to correspond with field data from wind turbines operating in icing conditions. Some possible improvements to the simulation software are discussed.

Keywords: atmospheric icing, wind turbines, energy losses

## Determination of energy quality for hydronic heating systems

Trond Thorgeir Harsem and Bent A. Borresen  
*Norconsult, Oslo, Norway*

The quality of a hydronic energy system is influenced by supply and return temperatures. Instead of using the exergy term, a TEA (Temperature and Energy Accumulated) curve is introduced for evaluating an exemplified planned 100 GWh district heating system outside Oslo. Main focus is on normal running conditions off the design point. The following questions were raised when analyzing the energy system:

.how could we make a design that improves the use of low temperature energy?

. is a design with low flow rate, i.e. low pipeline costs, compatible with the use of low temperature energy?

. can we visualize the quality of the energy used through the distributed temperatures and the corresponding quantity of energy?

A spreadsheet analysis tool was developed and used for the heating plant design and optimization. This paper presents the TEA curve and shows how evaluations may be done. Different design temperatures ranging from 60 °C/50 °C to 110 °C/40 °C are included in the discussion.

Focus on low return temperatures is often more important than avoiding high supply temperatures at design conditions. The main findings are:

. The TEA curve demonstrates that it is a useful tool in order to consider the energy quality of a hydronic heating system.

. Temperature mixing with shunt valves and recirculation of supply water into the return water pipeline has a negative effect on the possibility to use low temperature energy sources. High temperatures should be utilized when possible.

. A 75 °C/40 °C design improves the level of energy use compared to a 60 °C/50 °C design.

Keywords: Hydronic Heating, Energy Quality, District Heating





*SESSION 1.4*

**MICROMECHANICS**

WEDNESDAY 10 DECEMBER 2008  
15:30 – 17:00

CHAIR

AE Holdø  
Coventry University  
UK

## Application of fuzzy arithmetics to assess variation of dynamic properties of MEMS resonator

Adam Martowicz (1), Irina Codreanu (2), Tadeusz Uhl (1)

(1) AGH University of Science and Technology, Poland, (2) National Institute for R&D in Microtechnologies (IMT-Bucharest), Romania

The variability of dynamic properties of microresonator in presence of technological uncertainties constitutes an object of undertaken study. Computer simulations of finite element model carried out within virtual prototyping have been used to evaluate analyzed characteristics. Microresonator has been chosen as one of most commonly manufactured and exploited microelectromechanical systems (MEMS). It is used e.g. in filters, accelerometers, clock and frequency reference applications. Microresonator with two comb drives and area-efficient folded flexures is studied. In performed simulations multiphysics approach has been considered and phenomena of air damping and electrostatic field have been modeled. As manufacturing processes of MEMS do not guarantee infinite repeatability of their characteristics, technological uncertainties have to be taken into account to make results of computer simulations as close to reality as possible. Performed uncertainty analyses enable more realistic ranges of variation of analyzed characteristics e.g. in terms of present geometry imperfections and changes of material properties of studied device. Selected operational microresonator resonance frequency has been studied because of its crucial influence on device performance. In present work, uncertainty analysis has been performed by means of fuzzy numbers theory combined with alpha-cut strategy. Output fuzzy numbers have been assembled with intervals obtained by applications of Monte Carlo Simulation, supported by Latin hypercube procedure of samples generation, and Genetic Algorithms. Additionally, a sensitivity analysis has been carried out to order given uncertainties according to their separate influences on analyzed frequency of vibration. All considered uncertain parameters have been modeled by fuzzy numbers with triangular shapes of membership functions. The set of uncertainties cover a number of geometry characteristics: length, width, location of comb drive fingers, length and width of flexure beams, thickness and angle of chamfer of the device. Moreover, some material properties have also been assumed to vary: Young's modulus, Poisson's ratio and density of polysilicon.

Keywords: *microelectromechanical systems (MEMS), resonator, FEA*

## Validation of Inductively Coupled Plasma Models at large Knudsen Numbers with Chlorine Chemistry

Kartik Shah and Mustafa Megahed  
*ESI Group, Germany*

The simulation of inductively coupled plasma processes involves the coupling of several disciplines including fluid mechanics, electromagnetism and plasma physics. The interaction of these models lead to a highly non-linear system of equations whose accuracy is largely dependant on the knowledge available about the plasma kinetics.

It is a continuous effort to gather and validate kinetic models for different plasma processes. In this paper a kinetic model for electronegative Chlorine chemistry is validated against measurements reported in the literature. The experimental setup and the boundary conditions were well documented to allow this work. The model includes all pertinent physics related to low pressure ICP plasma reactors. Special attention was paid to the large Knudsen numbers encountered in such processes. The electromagnetism, heat induction and coupling of the neutron and charged particle transport is addressed in a fully coupled manner.

The numerical ion, electron and energy distribution results compare well with reported measurements for the Gaseous Electronics Conference reference cell which was modified for inductively coupled plasma investigations. The influence of power on the species and energy distribution was investigated based on the validated model.

## Simulation of Filtration Processes in Deformable media Part 3: Non-Spherical dirt particle modelling

Gernot Boiger (1), Marianne Mataln (1), Wilhelm Brandstätter (2)  
(1) ICE Strömungsforschung GmbH, Austria (2) Montanuniversität Leoben,  
Austria

Using the C++ based OpenSource software OpenFOAM, a fluid–fibre-particle solver for CFD design of filter media for automotive lubrication was programmed. The present paper focuses on the deterministic, Lagrangian modelling of individual, large, non-spherical dirt particles in the vicinity of deformable filtration fibres.

The developed model traces the governing multi physics effects down to the occurrence of single force- and torque vectors. In order to go from an initial spherical particle model, to a more sophisticated, non-spherical model, the capabilities of a *Six Degrees of Freedom Solver* have been included in the programming. An innovative drag force implementation allows the consideration of rotational- and shear flow effects on particle motion. The concept of satellite help points on the ellipsoid particle surface is used to handle particles that encompass several fluid calculation cells.

Particle–fibre interactions, e.g. deposition, are being modelled in detail. Fibre forces acting on the particle and confining it, can be applied on a user defined basis. As soon as particles get entangled in the fibre structure, local calculation cells get plugged and so increase pressure drop over filter life time. Thus a two-way coupling is implemented.

Particle–particle interactions are considered as well. These interactions and those with the fluid result in the realization of an effective four–way-coupling. The filter fibre structure is being digitally reconstructed from computer tomography scans. A Fluid – Structure Interaction utility, handles fibre deformation effects.

In order to validate results like particle distribution densities and pressure drop over the filter fibre medium, extensive test runs are being conducted. An elaborate measurement facility as well as an innovative methode of result evaluation have been devised. Thereby particle laden flows can be imposed on fibre samples, experimental flow parameters can be monitored and three dimensional particle distributions can be optically analyzed and digitally reconstructed.

Keywords: Non-Spherical particles, filtration media, Lagrangian model, particle deposition, four way coupling

## Comparative study of nonlinear and linear analysis of piezo-composite beams subject to static and dynamic loading

V. Arabzadeh, M. Darvizeh and A. Darvizeh

*Department of Mechanical Engineering, Guilan University, Iran*

In recent decades, special attention has been paid to integrate piezoelectric materials which can be used for both sensors and actuators into base structures for structural control purpose. As a result of the increasing applications of piezoelectric materials, the accurate prediction of the performance of smart structures with sensing, actuating, and control functions becomes increasingly important. Cheng and Wang 2005, worked on the theoretical analysis of piezoelectric-composite anisotropic laminate with larger amplitude deflection, Wang 2005, carried out finite element model for the static and dynamic analysis of a piezoelectric bimorph, Narita and Shindo 2005, presented analytical and experimental study of nonlinear bending response and domain wall motion in piezoelectric laminated actuators under ac electric fields, Kapuria and Alam 2005, presented a finite element model for dynamic analysis of laminated piezoelectric beams, Narita and Shindo 2005, worked on Bending and polarization switching of piezoelectric laminated actuators under electromechanical loading, Ferguson and Li 2004 presented a Modeling and design of composite free-free beam piezoelectric resonators, Yi and Ling 2000, Studied on Large deformation finite element analyses of composite structures integrated with piezoelectric sensors and actuators. Mukherjee and Chaudhuri 2002, worked on large deformation static analysis of piezoelectric beams, Kermani and Moallem 2004, worked on Parameter selection and control design for vibration suppression using piezoelectric transducers, Zhou and Wang 2005, worked on vibration control of piezoelectric beam-type plates with geometrically nonlinear deformation.

In this paper, regarding to beams intergraded piezoelectric layer, we present a generalized formulation for linear and nonlinear analysis subject to both dynamic and static loading. Finite element formulations are derived on the basis of the updated Lagrangian formulation (U.L.F) and the principle of virtual work. Four-node solid elements including two displacement degrees of freedom and one electrical degree of freedom in each node are developed to analyze beams with piezoelectric sensors. Newton-Raphson method is used to check the equilibrium equations in every iteration. Also the results are computed by coding with MATLAB and are compared with other results.

**Keywords:** Composite materials, Nonlinear FEM, Piezoelectric sensors, Smart structures



*SESSION 2.1*

**NUMERICAL ALGORITHMS**

THURSDAY 11 DECEMBER 2008

09:00 - 10:30

CHAIR

M Soufian  
Numerical Algorithms Group  
UK



## Multigrid dynamic programming and expo-rational B-splines for optimal control of constrained dynamical systems

T. Dechevsky  
*Narvik University College, Norway*

This communication is intended for the Special Session on Numerical Algorithms in Multiphysics. In some references is developed a numerical algorithm for global constrained optimization in variational and optimal-control problems with possibly non-smooth cost functionals and complex sets of constraints. This algorithm is based on a multigrid dynamic-programming method which is global on coarse grids and local on fine grids. The range of applications of this approach is very broad. So far it has been implemented for the numerical solution of one theoretical and two industrial optimization problems, as follows: 1. for computation of geodesics; 2. for optimal design of railway layout (in difficult terrain conditions in the presence of fixed and dynamically variable forbidden zones, bridges and tunnels, etc.); 3. for optimal automated steering of heavy trucks in a network of mine tunnels (involving optimal trajectory, speed, acceleration/deceleration, in the presence of constraints related to curvature vs. speed, the size/shape of the vehicle and the tunnel, within a given route, as well as optimization between different routes). In the latter two cases, all technological constraints imposed within the respective prescribed data base of engineering normative standards were fulfilled. In the present communication we consider this algorithm in the general context of optimal control of discrete dynamical systems and for discretization of optimal-control problems for continual dynamical systems using numerical quadratures and the new expo-rational B-splines and their polynomial modifications to approximate possibly non-smooth (possibly non-Lipschitz) cost functionals and/or constraints. This approach offers simple modeling, possibly with fuzzy cost functional and constraints, straightforward discretization, high scalability, and is simple to parallelize. Moreover, it can be combined with a broad variety of other known approaches, resulting in enhanced performance. The capability to handle efficiently very spatially inhomogeneous cost-functionals within a very diverse range of types of inter-related constraints makes this approach a good algorithmic tool for optimal real-time interactive control and tuning of the numerical simulation of complex physical processes depending on one or several time scales.

## High Performance Computing and Parallel Multiphysics

Majeed Soufian and Vasu Chakkerla

*Numerical Algorithms Group and Oxford University, Oxford, UK.*

Increasing complexity of today's products and proposed systems that demand simultaneous engineering analysis and simulation for their design, requires their Multiphysics foundations to deal with physical computations of structures with a mesh of millions of elements over thousands of steps with tens of variables per element or cell. Achieving faster CPU to solve today's Multiphysics or any other complex problems in a reasonable time is limited by transmission speed in a single CPU, which can never be greater than the speed of light. On the other hand reducing computational time without increasing speed requires further miniaturisation, which is in turn limited by interactions of electrons' electromagnetic fields as well as economical and technological constraints to do so (although futuristic photonic processors can be used instead of current electronics devices to remove this barrier). Today, because of these major barriers, CPU and computer producer manufacture parallel computer architectures with substantial processing power and memory that are distributed/shared among processor units instead of building faster processors and serial computer architectures. Despite the recent attentions and developments in new hardware for parallel computer architectures, software and software issues as well as parallelisation strategies for parallel computing have significantly attracted less consideration and their developments lagging far behind the new hardware. These in turn have caused a number of challenging issues, which will be addressed in this paper. Also as a part of this paper, the effect of these advances in high performance computing on Multiphysics simulations and solutions will be discussed.

Keywords: High performance computing, Parallelisation and Multiphysics

## The simulator BEDSIM of LKAB and scientific visualization for dynamical systems with multidimensional phase space

Joakim Gundersen  
*Narvik University College, Norway*

We shall present an overview of the research done in the last several years on methods and software for scientific visualization of dynamically changing multidimensional geometric data sets describing the 'warm' part of the pelletizing process used in the iron-ore processing plants of LKAB ([www.lkab.com](http://www.lkab.com)), as modeled in LKAB's own simulator developed in the course of the last 28 years, BEDSIM. Since BEDSIM models the pelletizing process as a multi-dimensional dynamical system governed by a high-dimensional system of nonlinear ordinary differential equations, the visualization results discussed can also be considered in the more general context of scientific visualization of the phase space of a high-dimensional dynamical system. The volume of the 64-parameter data sets output by BedSim increases very fast over time, especially if local or global refinement in space and/or time is needed to recover important details. Moreover, the BedSim model contains both non-smooth and very smooth components. Due to this, data compression is a very important issue and represents considerable challenge, which will be one of the topics of this presentation. To compute intersections for level manifolds in 3D, 4D and higher dimensional subspaces of the 64-dimensional data set, we are considering the use of a "marching simplex" algorithm as a replacement of the less efficient "marching cube" algorithms. This is going to be a second topic of discussion in this presentation. Rather than using parallel computing architecture to boost up the computational performance, our approach is to resort to the cheaper alternative of GPU-programming - that is, programming the graphics card (graphics processing unit) of a PC to perform computational tasks in parallel with the PC's CPUs (central processing units) ). This is the third topic in the presentation, which will also be supported with numerous visualization screenshot examples of the processing and visualization of various subsets of the graphical output of BEDSIM.

**Keywords:** pelletization process, simulation, dynamical system, phase space, data compression, isocurve, isosurface, level manifold, multi-dimensional, parallel processing, GPU-programming

## IRIS Explorer for Multiphysics Applications

Majeed Soufian and Jeremy Walton  
*Numerical Algorithm Group and Oxford University, UK*

Multiphysics as opposed to 'single physics' make provision for many physical phenomena such as electromagnetic and thermodynamics that need to be considered simultaneously for dealing with physical behavior of real complex systems and applications, in which without them it wouldn't be possible to develop many of today's products. On the other hand design demands on high definition simulation, necessitate flexibility in integrating and taking into accounts some or all physical phenomena together so that to develop new models that describe and visualize desired aspects of the product under development better and to fulfill their purposes. Considering importance of graphical user interface in a simulation of multidisciplinary objects for its better understanding, it is obvious that better visualisation and simulation software tools help further inspiration in innovation. IRIS Explorer is a tool for developing customized visualization applications. Its users create applications by selecting and connecting together software modules via a visual programming interface. Each module is a routine that operates on its input data to produce some output; thus, a module may, for example transform the data into geometric objects that can be displayed (such as slices, lines, surfaces, etc.), or output data to a file, or render geometry to a display device. In addition to the interface to the module's computational function, it can call other libraries such as NAG libraries, interface to files or connect to external applications. This presentation will provide a background on use of IRIS Explorer for Multiphysics applications and visualisation.

Keywords: Multiphysics Modelling, Simultaneous Simulation, and Visualisation



***SESSION 2.2***

**MATERIAL PHYSICS**

THURSDAY 11 DECEMBER 2008

11:00 - 12:30

CHAIR

LT Dechevsky  
Narvik University College  
Norway

## Coupled thermo-mechanical analysis of PLC deformation bands in the AA5083-H116 aluminium alloy

A. Benallal (1), T. Børvik (2), O.S. Hopperstad (2) and R. Nogueira de Codes(1)

*(1)LMT-ENS Cachan/CNRS/Université Paris 6, France, (2) Structural Impact Laboratory – SIMLab, Centre for Research-based Innovation (CRI)/ Department of Structural Engineering, Trondheim, Norway*

An experimental, theoretical and numerical investigation of the Portevin-Le Chatelier (PLC) effect in the aluminium alloy AA5083-H116 has been undertaken. This effect, which causes irregular plastic flow and negative steady-state strain-rate sensitivity in a given range of strain rates and temperature, is generally understood as the consequences of solute-dislocation interaction at the microscopic level. To exhibit the effects of strain rate on the characteristics of the deformation bands and their propagation, five different tests at different overall strain rates have been carried out on smooth flat specimens. Both digital image correlation (DIC) and digital infrared thermography (DIT) were used during testing to capture and characterize the spatio-temporal features of the PLC behaviour. Inhomogeneous deformation with various localization bands caused by the PLC effect was observed in all tests and the formation, evolution and propagation of the deformation bands were visualized allowing their characteristics to be measured. An elasto-viscoplastic constitutive model, developed for metals exhibiting dynamic strain ageing, was used to represent the material behaviour. This model was finally used in 3D numerical simulations of the physical tests using explicit finite element analysis. In the simulations, full thermo-coupling was applied to take the heat transfer as a result of the plastic straining during deformation into account. The numerical results are compared with the experimental observations and the main deviations between tests and simulations will be discussed.

**Keywords:** Portevin-Le Chatelier effect; Digital image correlation; Digital infrared thermography; Negative strain-rate sensitivity; Elasto-viscoplasticity; Non-linear finite element methods; Thermo-coupling.

## Dynamic Property of Silicone Rubber Using as Pressure Transmitting Medium

K.Nishi (1), A.Mori (1), K.Iwasa (1), M.Moatamedi (2), M.Souli (3), S.Itoh (1)  
*(1) Kumamoto University, Japan, (2) Cranfield University, UK, (3) University of Lille, France*

Recently a method of the food processing using underwater shock wave and its advantages were reported. The use of underwater shock wave allowed easy control of the pressurizing conditions of a shock wave generated by the detonation of explosive. However, the detonation of explosive produces gases that dissolve in the water and special attention must be paid to not drench the food with contaminated water. A method to use a silicone rubber as a substitute pressure transmitting medium for water is proposed. Silicone rubber has a high toughness and a high heat-resistance. The silicone rubber of high hardness is damaged by the shock pressure, but the silicone rubber of low hardness can transmit pressure without destruction. In this investigation,  $U_s$ - $U_p$  (shock wave velocity – particle velocity) relation of silicone rubber determined by using high speed camera is reported to clarify pressure transmitting and attenuating conditions when a shock wave is applied to a silicone rubber sheet. Numerical analysis using LS-DYNA-3D is compared with the experimental results. In addition, applications of this technique for food processing are demonstrated.

Keywords: Shock wave, Food processing, Silicone rubber, High speed camera, Numerical analysis



## Tensile and Dynamic Mechanical properties of Thermoplastic Natural Rubber Nanocomposite Reinforced with Carbon Nanotube

Mou'ad.A.Tarawneh (1), Sahrim Hj. Ahmad (1), Rozaidi Rasid (1), S.Y.Yahya (2)

(1) *Universiti Kebangsaan Malaysia, Malaysia*, (2) *Universiti Teknologi Mara, Malaysia*

The effect of multi-walled carbon nanotubes (MWCNTs) on the mechanical and thermal properties of thermoplastic natural rubber (TPNR) nanocomposite were investigated. The nanocomposite was prepared using melt blending method. MWCNT were added to improve the mechanical properties of MWCNTs/TPNR composites in different compositions of 1, 3, 5, and 7 wt. %. Thermoplastic natural rubber (TPNR) nanocomposite were prepared in the ratio of (70:20:10) from polypropylene (PP), natural rubber (NR) and liquid natural rubber (LNR) as a compatibilizer, respectively. The composite samples were prepared using the indirect technique method (IDT) at 180°C with 80 rpm mixing speed and 11 minutes processing time. The effect of MWNTs additions on the mechanical and thermal behavior of TPNR were studied using dynamic mechanical analysis (DMA) and tensile tests. The result of tensile test showed that tensile strength and elongation at break increase in the presence of nanotubes and maximum value are obtained with 3 wt. % of CNT. On other hand, at higher MWNTs concentration in the composites resulted in the formation of aggregates but Young's modulus considerably increased with increases the percentage of MWCNT. The reinforcing effect of MWNT was also confirmed by dynamic mechanical analysis where, the addition of nanotubes has increase in the storage modulus  $E'$  was detected and the loss modulus  $E''$  also, compared with TPNR. The incorporation of MWNTs enhanced the mechanical properties of the thermoplastic natural rubber due to the presence of strong interfacial interaction between the polymer matrix and the nanotubes in the polymer composites. It also found that the glass transition temperature ( $T_g$ ) increased with increased of the amount of MWNTs.

**Keywords:** Multi-walled carbon nanotubes; thermoplastic natural rubber; Dynamic mechanical analysis; Mechanical properties.

## Synthesis and Characterization of Cow Dung Charcoal

Sompop Sanongraj, Chonyitree Sangwijit, Wipada Sanongraj), Adun Janyalertadun  
*Ubonratchathani University, Thailand*

Cow dung charcoal was synthesized using dried local cow dung burned at 550°C for 30 minutes under insufficient oxygen condition. The black powder of cow dung charcoal was obtained. The SEM reveals the change of the internal structure from a rod shape to a full of tiny holes. The results of the surface area and pore size analyzer showed that the BET (Brunauer, Emmett and Teller) surface area of 302.43 m<sup>2</sup>/g and the pore size distribution peak of micropore (diameter < 20 nm) were obtained. The cow dung charcoal had much higher BET surface area than the original cow dung (32.63 m<sup>2</sup>/g). Also the pore size distribution peak was different from the original cow dung (mesopore). In addition, the cow dung charcoal was found to be a potential adsorbent for heavy metal removal.

Keywords: Cow dung, Cow dung charcoal, Heavy metal removal, Adsorbent

## ***The Effect of Adhesive Thickness on Spot Weld-Bonded Joints of Dissimilar Materials Using Finite Element Model***

Essam A. Al-Bahkali  
*King Saud University, Saudi Arabia*

Resistance weld-bonding is one of the oldest cost effective, less labor and readily automated electric welding techniques that is used to join similar and dissimilar metals. Introduction of an adhesive layer in conjunction with a spot weld nugget helps strengthening welded joints and balancing stresses in the weld nugget area. In order to reach an optimum welding quality of a spot welded or a weld-bonded joints, different calibration trials have to be conducted to setup the optimum welding parameters, i.e. welding current, electrode force, and welding time. In predicting stress distribution, stress concentration and failure modes of a weld-bonded or a spot welded nugget, a finite element modeling does an excellent job in this regard.

In present work, the bonded and spot weld-bonding of dissimilar materials joints for three dimensional models using the finite element technique were first studied for a specific adhesive thickness layer. The models were also examined experimentally by welding steel sheet with Aluminum and Brass materials. The result of both theoretical and experimental models is compared. Then, the effect of different adhesive thickness on spot weld bonding of dissimilar materials joints for three dimensional models using the finite element technique were studied. The results show first that the stresses in adhesive bonded joints are concentrated at the ends of the overlap area. When the spot-welded is used together with the adhesive bonded, the stresses are concentrated at the overlap area and at both ends of the welding nugget. The results show also that the stresses are more concentrated towards the material of the lowest melting point. Changing the thickness of the adhesive layer for the various dissimilar materials models give us the optimal thickness for each case that one can use in designing lap joints of two dissimilar materials. The results in general shows that the thinner the adhesive is, the higher is the peak stresses developed in the weld-bonded joint.

**Keywords:** Adhesive thickness, Spot Weld, dissimilar material, Finite Element Model

*SESSION 2.3*

**FLOW MODELLING AND**  
**SIMULATIONS**

THURSDAY 11 DECEMBER 2008  
13:30 – 15:00

CHAIR

H Iyama  
Yatsushiro National College  
Japan

## Optimizing the Hydrocyclone for Ballast Water Treatment using Computational Fluid Dynamics

D. K. McCluskey and A. E. Holdø  
*Coventry University, UK*

Environmental concern related to the transfer of Invasive Aquatic Species by ships ballast water has given rise to the development of a vast array of ballast water treatment systems. The complex environmental challenges and tight operational characteristics of marine vessels limits the scope of technologies used for Ballast Water Treatment. As a result few technologies have progressed beyond the Research and Development stage; however one of the most promising technologies for ship board use is the Cyclonic Separator, or Hydrocyclone. While the hydrocyclone has been in use for many years in a wide variety of engineering applications it has yet to be successfully adapted towards the removal of suspended sediment and marine organisms from large volumes of ballast water. This paper details the operational characteristics of Ballast water Hydrocyclones, employing Computational Fluid Dynamics to model and identify the appropriate cut size for sea water/solid separation. Furthermore the Detached Eddy Simulation (DES) Turbulence model will be applied to the Rietema Optimised Hydrocyclone and its performance will be assessed in relation to experimental data.

## Study on control of underwater shockwave by PMMA

Akinori Osada (1), Hideki Hamashima (2), Shigeru Itoh (1)

*(1) Kumamoto University, Japan, (2) Kumamoto Industrial Research Institute, Japan*

Various processing methods of using shock waves generated by explosive and electric power have been studied and developed. It is well established that shock wave pressure propagates on a large range and duration of pulse can be long, depending on the processing techniques. Using water as the propagation medium, the influence of thermal effect can be minimized. However, in the processing techniques using underwater shock wave, it is difficult to control the underwater shock waves.

Hence, in this research, an attempt was made to control the underwater shock wave using PMMA. The shock waves propagating through PMMA and underwater shock wave are analyzed. In order to understand the behavior of underwater shock wave, a high speed camera was used for optical observation of shock waves.

The analysis was made on the attenuation characteristics of each shock wave and difference in the shock wave at the interface between PMMA and water. In addition, pressure measurement at the interface of PMMA and water was performed. The results of pressure measurement and optical observation were compared. And numerical analysis was performed to investigate the validity of data, and these results were compared with experimental results.

Keywords: underwater shock wave

## Lethal effects of hydrodynamic forces from hydrocyclones

M. Slack (1), D. Cokljat (1), A.E. Holdø (2), A. Cokljat (3), M. Pecarevic (3), J. Mikus (3), A.B. Cetinic (3), E. Marcelja (3) and J. Lovric (3)  
*(1) ANSYS Fluent Europe Ltd., UK, (2) Coventry University, UK, (3) University of Dubrovnik, CROATIA.*

The treatment of live organisms is of increasing interest in many biological processes. More often than not these organisms reside within a fluid environment, and one example is the directed use of organisms in a bioreactor to create a product. Excessive heat, radiation or fluid forces can be damaging. Contrary to the above example in which we want to aid an organisms survival by manipulating fluid environment, there are situations where we want to use hydrodynamic forces as the tool for the elimination of unwanted organism's. An important example for such applications would be in the treatment of ballast waters. In the system investigated here fluid forces in a cyclonic system are used in order to eliminate unwanted organisms.

However, regardless whether we want to use hydrodynamics forces for an organism's benefits or disadvantage, the understanding and control of such forces is essential. This study is focused on understanding the action of those forces through the use of Computational Fluid Dynamics (CFD) in order to evaluate the environmental parameters that contribute to cell damage. Data has become available that characterises the damage exerted by different cyclonic systems on sea water organisms when pumped into a ship's ballast tanks. The work therefore aims to identify lethal conditions in the flow and use CFD to explain the action. Reverse engineering of this technology will allow the design of better fluid handling systems for sensitive organisms.

## Effect of second phase flow on single phase flow meter in steam industry

M. Pusayatanont (1), P J Unsworth (2) and A. Janyalertadun  
(1) *Ubonratchatani University, Thailand*, (2) *University of Sussex, UK*

This paper presents results from an investigation of the two phase flow, especially liquid in gas phase, in most mainly used flow meter in steam industry namely differential pressure meter and vortex meter. As in general, a typical flowmeter is designed and employed to measure rate of single phase fluid flow. There are many types of meter available in the market characterize by their working principles, installed conditions and types of fluid. All meters represent their accuracies under the single phase flow condition. However, when they are working in unusual conditions especially under multiphase flow, most meters lose their accuracies significantly even there is small amount of second phase introduced into the system. To understand the deteriorated performance of the meter under two phase flow, additional study on the effect the second phase on the meter is required. The laboratory experiment is performed to simulate the wet steam by flowing compressed air in the 2inch pipe. Water droplet is generated using nozzle and spayed into the system within 2% by mass fraction. The sensor signal from each flowmeter is collected by digital computer and analyzed using FFT and power spectrum density. The results show that the presence of the second phase in the system causes high frequency fluctuation embedded in sensor signal which can be detected by sensor. This signal causes significant error on meter reading. Many manufacturers add low pass filter to remove this high frequency signal, however, this paper shows that the high frequency signal especially its amplitude in specific range is useful as it can be use to estimated the percentage of the second phase in the primary system.

Keywords: two phase, flow meter





***SESSION 2.4***

**IMPACT AND EXPLOSIONS**

THURSDAY 11 DECEMBER 2008

15:30 – 17:00

CHAIR

DK McCluskey  
Coventry University  
UK

## Dynamic Analysis of Pedestrian Impact with a Vehicle

William Tiu  
*University of Hertfordshire*

The pedestrian protection legislation that came out in 2005 requires all new cars produced since then to be compliant with the requirements stipulated in the regulations. Essentially the front end of the car has to be designed such that head contact with hard solid objects such as the top of the engine block is minimised. Furthermore, because the resulting deceleration of the head is governed by the contact interaction between the bumper system and the femur/knee joint, it is equally important that this component is optimised to reduce the amount of force imparted to the lower limbs of the pedestrian.

As with the EuroNCAP regulations for frontal crash, there is a star rating test procedure that has to be complied with. The results from such tests are used by various agencies such as insurance companies to assess the levels of liability costs.

To give an objective comparison between different car designs, a selection of impact sites have to be identified by the independent test centre and the car manufacturer. These locations have to represent typical collision scenarios such as different age group pedestrians (and therefore height) and also whether the pedestrian makes contact along the centre line or to one side of the car. A grid system has to be devised

Potential problem areas have to be remedied early on the design phase. At this stage, only a virtual model of the car is available. The procedure for the virtual gridding is quite complex and the work presented here will initially describe the software that has been developed by the author and which has now been adopted by Nissan as part of their design suite of programs.

The paper will then describe the process for creation of the representation of the internal components of the car and the results from carrying out the explicit dynamic analysis of the head/lower limb impact with the car.

## Explosion Effect of Metallized Explosive

T.Mihara (1), M.Otsuka (2), E.Hida (2), M.Moatamedi (3), S.Itoh (1)  
*(1) Kumamoto University, Japan, (2) Asahi Kasei Chemicals Co., Japan, (3) Cranfield University, UK*

In the use of high energy material like explosives, the characteristics of explosives are clarified from various aspects, and the usage development that I make use of the characteristics is expected. In order to use the explosive energy is more effectively, in this research, the explosion effect of metallized explosive is investigated. The combustion of a metallic powder is controlled by the change of material and particle size of a metallic powder for control of the explosive energy. RDX/HMX was used as explosive, and it contained the aluminum powder or the tungsten powder. Aluminum powder is well known as a material to gasify. And it is contained in order to raise burning temperature also with propellant. It is thought that tungsten is opposite to aluminum in the meaning of gasification and increasing in density of the explosive. This time, the action of underwater shock wave, the detonation gas, and detonation wave was observed optically and the respective velocities were found with the framing photographs. In addition, the results of optical observation and numerical analysis were compared.

Keywords: Shock Wave, Numerical Analysis, Metallized Explosive

## Protection of Oil-Filled Transformer against Explosion: Experiments & Numerical Simulations

Sébastien Muller, Guillaume Périgaud  
*SERGI Holding, France*

Oil-filled transformer explosions are caused by low impedance faults that result in arcing in transformer tanks. Within milliseconds, oil is then vaporized and the generated gas is pressurized because the liquid inertia prevents its expansion. The pressure difference between the gas bubbles and the surrounding liquid oil generates pressure waves, which propagate and interact with the tank. Then, the pressure peak reflections build up the static pressure, which rises and leads to the tank rupture since tanks are not designed to withstand such levels of static pressure. This results in dangerous explosions, very expensive damages and possible environmental pollution. This paper describes a transformer explosion prevention technology based on the direct mechanical response of a Depressurization Set to the tank inner dynamic pressure induced by electrical faults. Since transformers always rupture at their weakest point because of the static pressure increase, the Depressurization Set is designed to be this weakest point in term of inertia to break before the tank explodes.

To evaluate its efficiency, experiments and computer simulations have been performed. Two experimental test campaigns were carried out, first by Electricité de France in 2002 and second, by CEPEL, Brazil, in 2004 on large scale transformers equipped with that prevention technology. It consisted in creating arcing in oil filled transformer tanks. They confirmed that the arc first creates a huge volume of gas, quickly pressurized. This generates one high pressure peak that propagates in the oil and activates the transformer protection within milliseconds before static pressure increases, thus preventing the tank explosion. Beside the experiments, a compressible two-phase flow numerical simulation tool based on a finite volume method was developed. Comparisons between experiments and simulations validated the model that can thus be used to study transformer explosions as well as depressurisation induced by the explosion prevention technology.

Keywords: Power transformer, explosion, arcing in oil, experiments, pressure wave propagation, compressible, two-phase flow, finite volume method.

## Study on Shock Loading Pre-processing for Freeze-drying

Toshiaki Watanabe (1): Yusuke Yamashita (2), Daisuke Sawamura (3),  
Shigeru Itoh (2)

*(1) Natinal Fisheries University, Japan, (2) Kumamoto University, Japan, (3)  
Natinal Fisheries University, Japan*

In the food industry, it is hoping high value-aided product and the increase in efficiency of food processing. On the other hand, we get an experimental result that the load of the shock wave improves an extraction of food, and soften food. We tried to examine the effectivity of the shock wave as pre-processing for freeze-drying from the result in permeation character seen in the radish and so on. In the case of freeze-drying, the object tends to be limited to the small or thin one with size, from the sublimability in processing, the performance in case of the restoration and the viewpoint of the cost performance ratio. Therefore, we used comparatively large beheaded shrimps and squids and attempted to review the effectivity of the shock wave processing about being freeze-drying. The improvement of the sublimation speed was gotten from the result that the pressure change during freeze-drying processing and the improvement of the reconstitution was gotten from the result using hot water. It was expected that the reconstitution of the freeze-dried food is improved and that a processing time is abridged, by shock wave loading as pre-processing for freeze-drying. This phenomena will be modeled, and it will be compared with a result of an experiment.

keywords

Keywords: Freeze-drying, Shock Loading, Pre-processing



*SESSION 3.1*

**ELECTROPHYSICS**

FRIDAY 12 DECEMBER 2008

09:00 – 10:30

CHAIR

V Damic  
University of Dubrovnik  
Croatia



## Performance analysis of an intermediate temperature PEM fuel cell having a perforated gas distributor

Muhammad. S. Virk, Arne. E. Holdø  
*Coventry University, UK*

Performance analyses of an intermediate temperature PEM fuel cell with a perforated gas distributor were carried out using experimental and numerical techniques. Computational fluid dynamics (CFD) based numerical study was carried out using steady state, single phase, isothermal and non-isothermal parametric analyses. Finite element based numerical approach was used to solve the multi transport model of the PEM fuel cell coupled with the flow in porous medium, charge balance and electrochemical kinetics. Key transport and electrochemical phenomena inside the proton exchange membrane fuel cell were investigated in order to understand the local distribution of each phenomenon. This parametric study aims to investigate the performance of the new design concept of 'perforated gas distributor' by varying different operating parameters such as temperature, porosity and exchange current density of the fuel cell. Both isothermal and non-isothermal numerical analyses helped identify critical parameters and provided insight into the physical mechanisms affecting the fuel cell performance by variation of these parameters. CFD results were compared with the experimental results, which clearly indicate that variation of these operating parameters significantly affect the performance of a PEM fuel cell. Analyses show that operating cell voltage decreases with the increase in current density and there is a significant improvement in fuel cell performance with the increase of operating cell temperature and gas diffusion layer porosity, while non isothermal analyses reveals greater generation of heat at high current densities, indicating greater losses which consequently lead to lower cell voltage.

## **Coupled Mechanical Thermal Electromagnetic Simulations in LS-DYNA®**

Pierre l'Eplattenier, Nicolas Aquelet, Art Shapiro  
*Livermore Software Technology Corp., USA*

A new electromagnetism module is being developed in LS-DYNA for coupled mechanical/thermal/electromagnetic simulations. One of the main applications of this module is Electromagnetic Metal Forming. The electromagnetic fields are solved using a Finite Element Method for the conductors coupled with a Boundary Element Method for the surrounding air/insulators. Both methods use elements based on discrete differential forms for improved accuracy. The physics, numerical methods and capabilities of this new module are presented in detail as well as its coupling with the mechanical and thermal solvers of LS-DYNA. This module is then illustrated on an Electromagnetic Metal Forming case.

## Numerical Investigation of the Magnetic Flux Static Distributions in Layered Josephson Junctions

I.G. Christov, S.N. Dimova, and T.L. Boyadjiev,  
*Sofia University, Bulgaria*

The properties of multilayered (mainly two-layered) Josephson junctions (JJs) have been studied in the recent years. Such structures make it possible to state and study new physical effects that do not occur in one-layered JJs. In this work methods for modeling the stationary states of the magnetic flux in n-layered JJs are proposed and realized. The continuous analog of Newton method is used to solve the non-linear systems of ordinary differential equations. The corresponding linearized boundary value problems at each iteration are solved numerically by means of the finite element method. The transitions of the junction layers from superconductive to resistive mode are mathematically interpreted as bifurcations of some static distributions of the magnetic flux under change of parameters. In order to study this phenomena, a Sturm-Liouville problem is generated, whose minimal eigenvalue determines the stability of the solution. A minimal eigenvalue equal to zero means a bifurcation of the corresponding solution. The subspace iteration method is used to find the smallest eigenvalues and the corresponding eigenvectors. The developed technique gives a possibility for detailed investigation of these multiparametric problems. We illustrate its application to analyze the existence, stability, bifurcation curves and some physical characteristics of the magnetic flux static distributions in 3-layered JJs.

Keywords: multilayered Josephson Junctions, magnetic flux static distributions, stability, bifurcations, finite element method

## **Optimization of MicroFluidic Valve Dimensions using Finite Element Methods**

H.A. Khawaja (1,2), Imran Rauf (3), Khalid Parvez (1)

(1) NUST, Pakistan, (2) University of Cambridge, UK, (3) CALTECH, USA

This work is related to the optimization of the valve in a microfluidic chip which will be fabricated from an elastomer (PDMS). Finite element simulations have been performed with the aim of finding the shape, size, and location of pressurization that minimizes the external pressure which would be required to operate the valve. One important constraint is that the stresses should be within elastic limits, so that the component remains safe from any type of structural failure. To obtain reliable results, nonlinear stress analysis was performed using the MooneyRivlin 9 parameter approximation (Hyper Elastic Material Model). A 20 noded brick element was used for the development of the FE model. Mesh sensitivity was also performed to assess the quality of the results. The simulation were performed with the commercially available FEM software, ANSYS. The effect of varying different geometric parameters on the performance of microfluidic valve is discussed.



**SESSION 3.2**

**MODELLING ADVANCES**

FRIDAY 12 DECEMBER 2008

11:00 – 12:30

CHAIR

M Mataln

Ice Stromungsforschung GmbH

Austria

## Multi-physics Modelling with Bond Graphs

Vjekoslav Damic  
*University of Dubrovnik, Croatia*

Bond Graphs are a rather new technique for handling complex multi-physics problems. Developed by H.M. Paynter in 1959, Bond Graphs were designed specifically to deal with multi-physics problems by applying a concentrated parameter approach. As such, they are rather different from approaches based on continuous models, such as computational fluid dynamics (CFM), computational solid mechanics (CSM), and computational electro-mechanics (CEM).

The first part of this paper outlines the basic methodology, starting with the classical approach based on causal graphs. An object-oriented component model approach then is described; this simplifies model development, but at the expense of generating more general and difficult-to-solve underlying mathematical models of higher index differential-algebraic equations. The capabilities of the Bond Graph approach are illustrated by analysis of two multi-physics engineering problems. The first example models and simulates an electromagnetic actuator; the second deals with dynamical analysis of a straight pipe Coriolis mass flow meter. Both problems contain continuous models of sub-systems. In the first, use is made of external CEM, the output of which is used in a Bond Graph environment. The second uses a finite-element approach implemented within a Bond Graph modelling and simulation program.

These two problems raise questions about whether Bond Graphs provide a convenient formalism that can be used to interface different modelling approaches such as are CFM, CSM, CEM, and others. These approaches were developed to solve physically homogeneous problems and their direct communication is difficult. Without solving these communication problems, however, there is practically no real multi-physics modelling.

Keywords: Bond Graph, CFM, CSM, CEM

## The Numerical Analysis of Food Processing using Shock Wave

Y. Yamashita (1), A. Oda (1), H. Maehara (1), M. Moatamedi (2), T. Watanabe (3) and S. Itoh (1)

*(1) Kumamoto University, Japan, (2) Cranfield University, UK, (3) National Fisheries University, Japan*

In recent years, the use of the shock wave has increased not only in the fields of the material development and the metal processing, but also in the field of the medical treatment, of the environment as the science and technology upgrades. We have focused on the food processing by using an underwater shock wave. This process has various advantages such as short processing time and a very few energy consuming and no nutrient reduction due to non-thermal processing. An efficient food processing equipment is needed to evaluate the phenomenon of the shock wave loading, the numerical method for food processing by underwater shock wave is quite skillful and very important. Especially in the design for the suitable pressure vessels for food processing, the phenomenon in pressure vessel are very complex and in multi-physics manners. Therefore, in numerical calculation, a lot of parameter for the numerical analysis is need for pressure vessel material and various foods. In this study, the purpose is to clarify unknown parameters of the potatoes by measuring  $U_s$ -up. The experiments were carried out using the high-speed image converter camera, high-speed video camera and the explosive experimental facilities.

Keywords: Shock Wave, Food Processing, Numerical Analysis



## Target Reference Generator for the European Student Moon Orbiter Satellite

Rune Schlanbusch, Tor-Marius Steihaug and Per Johan Nicklasson  
*Narvik University College, Norway*

Target tracking control of spacecrafts is a field gaining more and more interest and attention due to space missions requiring higher precision in pointing of instruments. For some missions target tracking is vital in order to fulfil the mission objectives. For the European Student Moon Orbiter (ESMO) mission, two requirements for pointing modes are specified; one for nadir pointing of the camera, and a second mode for target pointing, i.e., to follow a point of interest on the Moon surface. The Student Space Exploration and Technology Initiative (SSETI) is an initiative founded by the Educational Office at the European Space Agency (ESA). The educational project ESMO is part of SSETI and aims to be the first student mission to the Moon, with students from several European universities forming the different teams. ESMO is currently scheduled for launch in 2012.

In this paper we present attitude target tracking control for the ESMO satellite based on system modelling and dynamic reference generation. The solution aims to generate a reference in real-time for the satellite thus to be used to track or follow a point on the surface of the Moon. A mathematical model of the satellite is derived, together with a passivity based sliding surface controller that globally stabilized the satellite orientation. The reference generator will have the target location on the lunar surface as input, specified as Moon latitude and longitude, in addition to satellite position and velocity, and calculate the reference attitude and angular velocity as output.

Keywords: Spacecraft System Modelling, Dynamic Reference Generator, Attitude Control

## Numerical Simulation and Experiment on Explosive Forming Using a Pressure vessel

Hirofumi Iyama (1), Shigeru Itoh (2)

*(1) Yatsushiro National College of Technology, Japan, (2) Kumamoto University, Japan*

Explosive forming is one of the unconventional techniques, in which, most commonly, the water is used as the pressure transmission medium. The explosive is set at the top of the pressure vessel filled with water, and is detonated by an electric detonator. The underwater shock wave propagates through the water medium and impinges on the metal plate, which in turn, deforms. There is another pressure pulse acting on the metal plate as the secondary by product of the expansion of the gas generated by detonation of explosive. The secondary pressure pulse duration is longer and the peak pressure is lower than the primary shock pressure. However, the intensity of these pressure pulse is based also on the conditions of a pressure vessel. In order to understand the influence of the configuration of the pressure vessel on the deformation of a metal plate, numerical analysis was performed. This paper reports those results.

Keywords: Explosive Forming, Underwater Shock Wave, Numerical Simulation, Pressure Vessel



***SESSION 3.3***

**FLUID MIXTURES**

FRIDAY 12 DECEMBER 2008  
13:30 – 15:00

CHAIR

M Souli  
University of Lille  
France

## MASS FLOW DETERMINATION IN FLASHING OPENINGS

Geanette Polanco, Arne Holdø, George Munday  
*Coventry University, UK*

The output flow characteristics of most cases of the industrial accidental releases are related to a two-phase flow and their represent a potential hazard to facilities, personnel and equipment, the environment, and the public. If these releases involve superheated liquid then a flashing process can take place, where a liquid-gas mixtures due to the breaking of the metastable state can significantly affect the hazard zone. The calculation of the conditions of the flow after a flashing opening is a very relevant in order to understand the mechanisms present after of the release opening. Numerical modeling represents an important tool to approach these types of phenomena. However, the accuracy of the obtained results will depend on the realistic values of the flow parameters taken as input information to perform the CFD work. The model proposed here is based on the definition of the thermodynamics jump formulation where the condition of the work done by the forces in the system is equal to the work done in the system in order to predict phase velocity or mass flow. The obtained results have a good agreement with the experimental data available.

Keywords: Flashing, CFD, accidental releases

## Development and Application of the Indoor Air Adsorption Design Software Model

W. Sanongraj (1), E.J. Eric Oman (2), C. Zhao (2), D. Hokanson (2), D.W. Hand (2) and J.C. Crittenden (3)

*(1) Ubonratchathani University, Thailand, (2) Michigan Technological University, Michigan, USA, (3) Arizona State University, USA*

A mathematical model that can predict the performance of an indoor air treatment system using both adsorption and reactions was developed. The model is called Indoor Air Adsorption Design Software (IndoorAirAdDesignSTM). The mechanisms incorporated in the model include advective flow, gas-to-solid mass transport, intraparticle mass transport with pore and surface diffusion, and chemical reaction of multiple components. The Freundlich isotherm equation describes adsorption equilibrium of individual compounds and Ideal Adsorbed Solution Theory (IAST) describes the competition between the compounds. The model was verified by comparing it to the analytical solutions under linear adsorption assumptions. A comparison was made for the following three cases: (1) the reaction rate controlling the overall mass transfer-reaction mechanism, (2) the gas-solid film mass transfer resistance controlling the overall process, (3) the intraparticle pore diffusion resistance controlling the overall process. The adsorption and reaction of formaldehyde adsorbed on granular activated carbon impregnated with 7% KI solution were used for the model validation. Good agreements between the IndoorAirAdDesignSTM model outputs and the analytical solutions were obtained. The validated model was applied to evaluate the efficiency of typically commercial adsorbents at removing toluene in an indoor air. One adsorbent is a granular activated carbon, namely Calgon BPL, and the other two adsorbents are activated carbon fibers, namely ACF-15 and ACF-20. The room volume, the initial toluene concentration in the room, and the air exchange rate used in the design were 31.15 m<sup>3</sup>, 0.1 fÝg/L, and 0.39 hr<sup>-1</sup>, respectively. The temperature and pressure in the room were 18 oC and 1 atm. For the treatment objective of 0.01 fÝg/L, the service times of 197 and 123 days were obtained using the fixed-bed flow rate of 2,920 m<sup>3</sup>/d and 95 g of the ACF-15 and the ACF-20. For the same treatment objective, the service time of 180 days was obtained using the fixed-bed flow rate of 8,760 m<sup>3</sup>/d and 95 g of the Calgon BPL.

Keywords: Mathematical Model, Indoor Air, Adsorption,

## On study of emulsification by the shock wave processing

A. Takemoto (1), H. Maehara (1), T. Watanabe (2), S. Itoh (1)  
(1) Kumamoto University, Japan, (2) National Fisheries University, Japan

The shock wave transmitted at the speed that exceeds speed of sound generates the expansion wave by the density difference. Moreover, the sound wave velocity of the shock wave changes depending on the density difference. The shock wave is transmitted fast by the high density.

Oil floats on water when water and oil are mixed, and the layer is formed. This is because the density of oil is lower than that of water. This density difference influences the sound wave velocity of the shock wave.

Authors experimented on the shock wave load to the mixture of water and oil that formed the layer. The load of the shock wave has emulsified water and oil. This emulsification action is thought to be an influence into which the sound wave velocity of the shock wave changes. In this research, the experiment result and the consideration are described.

Keywords: Shock Wave, Emulsification technique, Emulsifying

## Requirement of ventilation in rail tunnel: How to take a correct decision

Bent A. Borresen and Sisir Chakraborty

*C. Doctor and Thorgeir Trond Harsem, Norconsult, Norway*

Provision of ventilation in rail tunnel is a subject requires lots of study in terms of its design, application, operation, installation cost, statutory requirement, etc. Most of the railway lines are now electrified & hence the conventional requirement of diesel exhaust ventilation during normal operation has often become irrelevant. However it has been found that ventilation, if operated judiciously, plays very important role in smoke management during fire helping effective evacuation of passengers saving precious human lives. For fire and rescue teams a functioning smoke ventilation is often a requirement before they enter. This is even more important in single bore tunnels.

In most of the countries prevention of fire & its propagation are getting more attention. Starting from construction of tunnel to selection of rolling stocks increasing cares are being taken to reduce probabilities of tunnel fire.

Since the possible size of fire & its heat release rate depends on so many variables it is very difficult to optimise the capacity of ventilation system.

The cost of provision of ventilation system in long tunnels is substantial. Moreover since ventilation may propagate fire, the ventilation system should be operated with care when passengers are dispersed on either side of the fire or the fire is ventilation controlled. It is also not always possible to ensure that all the passengers will remain on one side of the developed fire. Neither it is possible for system operator to understand whether the fire is fuel or ventilation controlled. Thus even after spending a significant amount of money for installation of ventilation system different operation scenarios have to be looked into to ensure best possible safety.





*SESSION 3.4*

**FLUID STRUCTURE**  
**INTERACTION**

FRIDAY 12 DECEMBER 2008  
15:30 – 17:00

CHAIR

T Watanabe  
National Fisheries University  
Japan

## ALE and FLUID-STRUCTURE INTERACTION

M'hamed Souli  
Universite des Sciences de Lille, LML, France

Numerical problems due to element distortions limit the applicability of a Lagrangian description of motion when modeling large deformation processes.

An alternative technique is the multi-material Eulerian formulation. It is a method where the material flows through a mesh that is completely fixed in space and where each element is allowed to contain a mixture of different materials. The method completely avoids element distortions and it can, through an Eulerian-Lagrangian coupling algorithm, be combined with a Lagrangian description of motion for parts of the model.

The Eulerian formulation is not free from numerical problems. There are dissipation and dispersion problems associated with the flux of mass between elements. In addition, many elements might be needed for the Eulerian mesh to enclose the whole space where the material will be located during the simulated event.

This is where the multi-material arbitrary Lagrangian-Eulerian (ALE) formulation has its advantages. By translating, rotating and deforming the multi-material mesh in a controlled way, the mass flux between elements can be minimized and the mesh size can be kept smaller than in an Eulerian model.

## Fluid-Structure Interaction in LS-DYNA®

Nicolas Aquelet (1), Facundo Del Pin (1), Lars Olovsson (2)  
(1) Livermore Software Technology Corp., USA, (2) Impetus AFEA AB,  
Sweden

Several modules were developed in LS-DYNA® to treat complex fluid-structure interaction simulations. The basic one is the Lagrangian solver, which is an explicit Finite Element code solving fast dynamic structural problems. Then other codes were added to the Lagrangian solver to compute the fluid loading. This paper will present three of them:

The MMALE module (Multi-Material Arbitrary Lagrange Euler). This code is a complement of the Lagrangian module to solve large deformation problems involving several fluids. The Lagrangian solver could solve the fluid part if large material deformations didn't involve severe mesh distortions. The multi-material ALE module was developed to remap the mesh independently from the material boundaries (aquelet@lstc.com).

The P-FEM module (Particle – FEM). This module will be introduced in future versions of LS-DYNA® to solve incompressible flows. One of the main features of the solver is the Lagrangian representation of all FSI interfaces providing an exact imposition of boundary conditions. In this way the fluid and solid meshes are tightly coupled such that the fluid domain deforms following the Lagrangian structure displacements. Contrary to the previous module the computational fluid domain is based on a Single Arbitrary Lagrangian Eulerian (SALE) formulation and for large deformations a robust and fast re-meshing tool avoids the mesh distortions. (fdelpin@lstc.com)

The CPM code (Corpuscular Particle Method). The corpuscular particle method is a CPU efficient alternative to the MMALE approach to solve airbag problems. The code is based on the kinetic molecular theory, where molecules are viewed as rigid particles moving according the Newton's laws. The fluid-structure interaction results from the sum of the elastic collisions between the particles and structure. This new module can solve the deployment of an airbag much faster than the MMALE solver by keeping the same accuracy level (lars@impetus-afea.se).

## **Systematic evaluation of control volume method suitability for stress-analysis in conjunction with fluid-structure interaction**

D. Cokljat (1), A. Ivankovic (2) and A.E. Holdø (3)

*(1) ANSYS Fluent Europe Ltd., UK, (2) University College Dublin, Ireland, (3) University of Coventry, UK*

Fluid structure interaction would, in general, require simultaneous solution of both fluid flow and stress analysis equations. Unfortunately, over the past decades fluid and stress analysis communities have followed mostly a different path in the ways how to solve required equations. This resulted in the nowadays commonly adopted practice in which the fluid flow equations are primarily solved using control volume (CV hereafter) methods while at the same time stress analysis was primarily conducted with the help of finite element technique. Consequently, when the engineers need to solve fluid-structure interaction type of problems we end up in the situation whereby two different techniques are used for what is essentially single engineering problem. That approach does in principle work whenever the interaction/coupling between fluid and solid domains is very weak and communication between the two is fairly limited. Unfortunately, in real engineering life that is often not the case and the usage of two techniques for the same problem becomes an obstacle for effective solution of such problems. The logical solution would be to extend a single numerical technique to both domains (solid and fluid) and such approach has been adopted in the present study. This resulted in the usage of CV method for the solution of stress-analysis equations within solid domain.

Unfortunately, there are still a limited number of studies in which CV technique was used for above purpose and in particular there is a shortage of the studies in which CV approach is assessed in a systematic manner for the solution of stress analysis equations. The main intention here is to fill in that gap that exists in the literature and it will be achieved by starting from the simplest theoretical cases and then move up through the chain of complexity. Only such approach may identify potential benefits or weaknesses of control volume technique for the usage within stress analysis field. In order to achieve that, we constructed several layers of complexity whereby each stage is represented by another test case for which theoretical or experimental solution is available. Test cases calculated in this study include: uni-axial tension, bar stretched by its own weight, plate with a circular hole, bending, waves in a bar and finally pressurized pipe.

## Free vibration analysis of Dragonfly wings with Finite Element Method

M. Darvizeh, A. Darvizeh, H. Rajabi, A. Rezaei  
*Guilan University, Iran*

In the present work, investigations on the microstructure and mechanical properties of the dragonfly wing are carried out and numerical modeling based on Finite Element Method (FEM) is developed to predict Flight characteristics of dragonfly wings. Vibration behavior of wings type structures is immensely important in analysis, design and manufacturing of similar engineering structures. For this purpose natural frequency and mode shapes are calculated. In addition, the kind of deformation in each mode shape evaluated and the ratio between numerical natural frequency and experimental natural frequency presented as damping ratio. The results obtain from present method are in good agreement with same experimental methods.

Keywords: Mechanical properties; SEM; Dragonfly wing; FEM; Natural frequencies; Damping ratio











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