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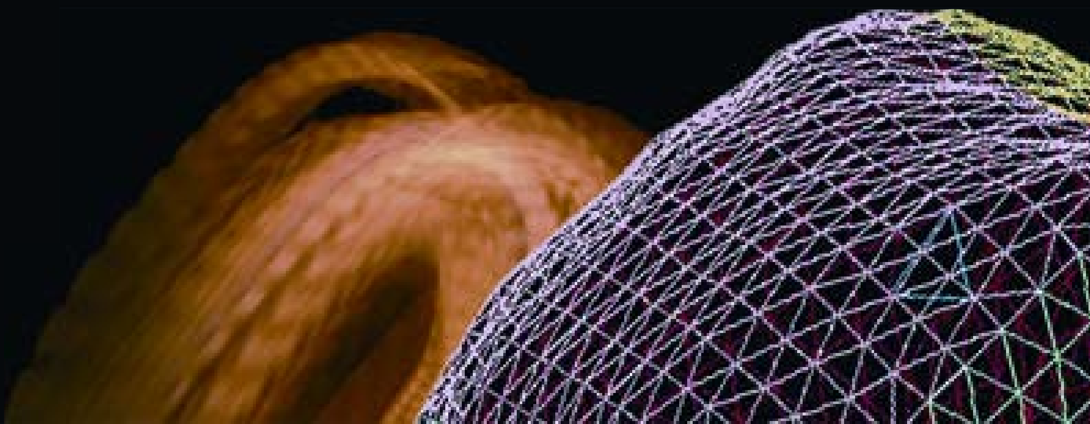
MULTIPHYSICS 2020

10 - 11 December 2020
Virtual



MULTIPHYSICS 2020
10-11 December 2020
Virtual

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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, Nuclear, Soil, Structures, and Thermodynamics.

Timing of Presentations

Each paper will be allocated 18 minutes. A good guide is 14 minutes for presentation with 4 minutes left for questions at the end.

Good timekeeping is essential, speakers are asked to keep strictly to 18 minutes per presentation.

Language

The official language of the conference is English.

Paper Publication

Authors are invited to submit full-length papers for publication in ‘The International Journal of Multiphysics’ by 31st January 2021.

There is 50% Article Processing Charge (APC) discount for one article per registration.

Sponsorship

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

Keynote Speaker

Dr. A. J. Svobodnik
President & CEO
Mvoid Group

BIOGRAPHY

Dr. Alfred J. Svobodnik is President & CEO of the Mvoid Group, specializing in providing consulting services and innovative technologies for Automotive, Consumer and Professional Audio as well as the developer of Mvoid® (Multidisciplinary virtually optimized industrial Design) methodology. Alfred is entrepreneur, thought leader, engineer and scientist. He has been researching for 30 years in the areas of Multiphysics and virtual as well as computational acoustics. Previously, Alfred spent five years with Harman International Inc. where he held several senior managerial and executive advisor positions in the areas of simulation and virtual acoustics for audio systems. Alfred started his career as founding member, Executive Partner and CTO in 1990 with Numerical Analysis and Design, a company specialized in engineering analysis with finite and boundary elements for stress analysis, structural dynamics and computational acoustics. In 1990 Alfred completed his doctorate at Vienna University of Technology with the degree “Doktor der Techn. Wissenschaften” (equivalent to PhD). The title of his dissertation is: “Numerical Treatment of Elastic Plastic Macro mechanical Behavior of Long fiber Reinforced Metal Matrix Composites”. He also hold a university degree: “Diplom-Ingenieur” (equivalent to MSc) from Vienna University of Technology. He is honorary member of NAFEMS, member of the NAFEMS German Steering Committee and Chairman of the NAFEMS Multiphysics Working Group as well as founding member of the NAFEMS Professional Simulation Engineering Scheme. Furthermore, he is a member of the Advisory Executive Board of ALMA International and a full member of the Audio Engineering Society (AES).

MULTIPHYSICS 2020

PROGRAMME

TIME (GMT)	Thursday 10 December 2020	Friday 11 December 2020
09:00 - 09:30	**Virtual Platform Access**	
09:30 - 11:00	**Keynote Address & Synopsis**	**Session 2.1** *Structures and Materials*
11:00 - 11:30	**Break / Posters**	
11:30 - 13:00	**Session 1.2** *Aerospace and Transport*	**Session 2.2** *Computational Fluid Dynamics*
13:00 - 14:00	**Break / Posters**	
14:00 - 15:30	**Session 1.3** *Multiphysics Applications*	**Session 2.3** *Vibration and Impact*
15:30 - 16:00	**Break / Posters**	
16:00 - 17:30	**Session 1.4** *Bioengineering*	**Session 2.4** *Modelling Techniques*
17:30 - 18:30	**Virtual Networking**	**Closing Remarks**

Full Programme

Thursday 10 December 2020

09:00 - 09:30 Virtual Platform Access

09:30 - 09:45 Conference Opening

Opening of The 15th International Conference of Multiphysics 2020

T Rahulan, Conference Director, The International Society of Multiphysics

09:45 - 11:00 Session 1.1
Keynote Address & Synopsis

Chair: M Moatamedi, The International Society of Multiphysics

Keynote Address: 25 Years of Industrial Multiphysical Applications – The Journey

A Svobodnik, President & CEO, Mvoid Group

Synopsis Part 1: The International Journal of Multiphysics
Synopsis Part 2: The International Conference of Multiphysics 2021

H Khawaja, The International Society of Multiphysics

11:00 - 11:30 Break / Posters

Thursday 10 December 2020

11:30 - 13:00 Session 1.2
Structures and Materials

Chair: B Alzahabi, Al Ghurair University, UAE

Multi-Resonator Metamaterials are Multi-Band Meta-Structures
A Fallah[1], N Gorshkov[2], N Navadeh[3], P Sareh[4], V Tereshchuk[5]
1. Oslo Metropolitan University, Oslo, Norway
2. Los Alamos National Lab, New Mexico, United States
3. Imperial College London, United Kingdom
4. University of Liverpool, United Kingdom
5. National Technical University of Ukraine, Kiev, Ukraine

Experimental Research of Cylindrical Power Lithium-ion Battery under Axial Compression
L Meng[1,2], X Liu[1,2], S Zhang[1,2], H Song[1,2], G Wang[1,2], B Wang[1,3]
1. Taiyuan University of Technology, Taiyuan, China
2. Key Laboratory of Material Strength and Structure Impact, Taiyuan, China
3. London Brunel University, London, United Kingdom

Study on Interactions between High Velocity Long-Rods and Steel-Elastomer Bulging Armor
T Fras
French-German Research Institute of Saint-Louis, Saint-Louis, France

Modelling a Viscosity-Density Sensor based on Small Amplitude Torsional Vibrations
D Brunner[1,3], J Goodbread[2], K Häusler[2], S Kumar[2], H Khawaja[3,4], G Boiger[1]*
1. Zurich University of Applied Sciences, Winterthur, Switzerland
2. Rheonics GmbH, Winterthur, Switzerland
3. The Arctic University of Norway, Tromsø, Norway
4. Al Ghurair University, Dubai, United Arab Emirates

13:00-14:00 Break / Posters

Thursday 10 December 2020

14:00-15:30 Session 1.3 Aerospace and Transport

Chair: A Fallah, Oslo Metropolitan University, Norway

A Concept to Estimate the Life Cycle of the Railway Track Using Finite Element Modelling
E Albahkali[1], N Alsanabani[1], M Souli[2]
King Saud University, Riyadh, Saudi Arabia
University of Lille, France

Smooth Particle Hydrodynamics Birdstrike Analysis on Aircraft Wing Leading Edge
P Hampson, I Talhah
University of Salford, Salford, United Kingdom

Estimation of Sea Spray Flux for Improving the Prediction of Marine Icing in Cold Conditions using LiDAR
S Dhar[1], K Edvardsen[1], H Khawaja[1,2]
1. The Arctic University of Norway, Tromsø, Norway
2. Al Ghurair University, Dubai, UAE

Aerodynamic Drag and Gravity Gradient Coupled Satellite Stabilization Envelopes
M Azeem, R Varatharajoo, S Ahmad
Universiti Putra Malaysia, Serdang, Malaysia
COMSATS University, Lahore, Pakistan

15:30-16:00 Break / Posters

Thursday 10 December 2020

16:00 - 17:30 **Session 1.4**
Computational Fluid Dynamics

Chair: G Boiger, Zurich University of Applied Sciences, Switzerland

2D Multiphysics Modelling of Tungsten Inert Gas Arc-Pool Interactions with Free Surface Dynamics
C Nahed, S Gounand, O Asserin, M Medale
CEA Saclay, France
Université Aix-Marseille, Marseille, France

Numerical Investigation of Effect of Aspect Ratio in Sudden Expansion Flow using Nanofluid
R Kanna[1], H Khawaja[1,2], R Rani[1], D Christopher[3]
1. Al Ghurair University, Dubai, United Arab Emirates
2. The Arctic University of Norway, Tromsø, Norway
3. Wolaita Soda University, Wolaita Sodo, Ethiopia

System Cleanliness Prediction by CFD
D Shestakov
VDL Enabling Technologies Group, Eindhoven, The Netherlands

Modelling of Pressure and Temperature Profiles for the Flow of CO2 through a Restriction
S Jackson[1], A Leyli[1], A Nordli[1], H Khawaja[1,2]
1. The Arctic University of Norway, Tromsø, Norway
2. Al Ghurair University, Dubai, United Arab Emirates

17:30 - 18:00 **Virtual Networking**

Friday 11 December 2020

09:30 - 11:00 Session 2.1 Multiphysics Applications

Chair: E Albahkali, King Saud University, KSA

Advancing the Validation and Application of a Eulerian-Lagrangian Multiphysics Solver for Coating Processes in Terms of Massive Simultaneous Cloud Computing
G Boiger, S Bercan, L Viktor
Zurich University of Applied Sciences, Winterthur, Switzerland

Specialized Methods for Multiphysics Simulations on Battery and Fuel Cell Microstructures
M Fingerle, S Linden, L Cheng, F Biebl, A Wiegmann
Math2Market GmbH, Kaiserslautern, Germany

A Dynamic Eulerian-Lagrangian Solver for the Optimization of Powder Coating Processes
B Siyahhan, G Boiger
Zurich University of Applied Sciences, Winterthur, Switzerland

Fluid Structure Interaction (FSI) Simulation of Flow through a Squeeze Bottle
V Turaga, S Bhavi, V Srinivasa,
HCL Technologies Ltd., Bangalore, India

Customized Sensors for Temperature Field Measurements in Gas Foil Bearings – Experimental Investigation
J Roemer[1,2], P Zdziebko[1], A Martowicz[1]
1. AGH University of Science and Technology, Kraków, Poland
2. Oslo Metropolitan University, Oslo, Norway

11:00 - 11:30 Break / Posters

Friday 11 December 2020

11:30 – 13:00 Session 2.2 Vibration and Impact

Chair: M Souli, University of Lille, France

Effect of Shock Loading Pre-processing for Freeze-drying
T Watanabe[1], M Nakamura[1], K Shimojima[2], S Tanaka[3], K Hokamoto[3], S Itoh[3]
1. National Fisheries University, Shimonoseki, Japan
2. Okinawa National College of Technology, Okinawa, Japan
3. Kumamoto University, Kumamoto, Japan

Thermoelastic and Thermoplastic Modelling of Point Impact on Carbon Fiber Reinforced Polymers
Z Andleeb[1], S Malik[1], G Hussain[1], A Nordli[2], H Khawaja[2,3], M Moatamedi[3,4]
1. Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, Pakistan
2. The Arctic University of Norway, Tromsø, Norway
3. Al Ghurair University, Dubai, United Arab Emirates
4. Oslo Metropolitan University, Oslo, Norway

Multiphysics of Nonlinear Vibration in Blast Loaded FVK Thin Plates
A Fallah[1], N Mehreganian[2], M Toolabi[2], Y Zhuk[3], F Moghadam[3], L Louca[2]
1. Oslo Metropolitan University, Oslo, Norway
2. Imperial College London, London, United Kingdom
3. Taras Shevchenko University, Kyiv, Ukraine

An Influence of Breathing Crack Parameters on the Flexural Forced Vibration Behaviour of Compressor Blades
K Savchenko, Y Onyshchenko, V Kruts, S Kabannyk
Institute for Nuclear Research, Kyiv, Ukraine

Forced Vibration Analysis of the Cantilever Beam with Breathing Cracks of Different Configurations
Y Onyshchenko, V Kruts
Institute for Nuclear Research, Kyiv, Ukraine

13:00-14:00 Break / Posters

Friday 11 December 2020

14:00-15:30 Session 2.3 Bioengineering

Chair: T Watanabe, National Fisheries University, Japan

Analysis of Falling Droplets into Resting Liquid and Resulting Shear Stresses
M Hostettler[1], D Brunner[1], F Rosenthal[2], M Clemens[2], E Koepf[2], G Boiger[1]
1. Zurich University of Applied Sciences, Winterthur, Switzerland
2. F. Hoffmann-La Roche Ltd., Basel,Switzerland

Multiphysics Simulation of Dental Implant Cement Squeezing, Towards Improving the Adhesion Quality
E Mohamed[1], E Hesham[2]
1. Pharos University in Alexandria, Alexandria, Egypt
2. King Saud University, Riyadh, Saudi Arabia

Impact of the Flow on Mass Transfer from Particles: Biomedical Applications
C Bielinski, B Kaoui
Université de technologie de Compiègne, Compiègne, France

In Silico Modeling of Targeted Drug Delivery using Liposomes Flowing in the Bloodstream
B Kaoui
Universite de Technologie de Compiegne,Compiegne, France

Progressive Failure Analysis of Leptadenia Pyrotechnica Composite Laminates
M Aruna
Al Ghurair University, Dubai, United Arab Emirates

15:30-16:00 Break / Posters

Friday 11 December 2020

16:00 - 17:30 Session 2.4 Modelling Techniques

Chair: A Tehrani, Office for Nuclear Regulation, UK

Multiphysics Modeling of Shoreline Evolution
E Holzbecher
German University of Technology in Oman, Halban, Oman

Conjugate Heat Transfer Model Based on SIMPLE and Coupled Energy and Heat Equations
A Leyli[1], Z Andleeb[2], H Khawaja[1,3], M Ramzi[3], R Kanna[3], M Moatamedi[3,4]
1. The Arctic University of Norway, Tromsø, Norway
2. Gulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, Pakistan
3. Al Ghurair University, Dubai, United Arab Emirates
4. Oslo Metropolitan University, Oslo, Norway

Thermomechanical Model of Gas Foil Bearing
P Zdziebko[1], S Kantor[1], J Roemer[1,2], A Martowicz[1]
1. AGH University of Science and Technology, Krakow, Poland
2. Oslo Metropolitan University, Oslo, Norway

Massive Simultaneous Cloud Computing (MSCC) for Multiphysics-Simulation Applications
G Boiger[1], M Everitt[2], D Sharman[1], M Boldrini[1]
1. Zurich University of Applied Sciences, Winterthur, Switzerland
2. Kaleidosim Technologies AG, Zurich, Switzerland

17:30 - 18:00 Closing Remarks

Posters

A Two-Phase Constitutive Model with Damage with Damage for Tungsten Heavy Alloy

J Tang[1], Z Liang[1], Y Zhang[2]
1. Xi'an Modern Chemistry Research Institute, Xi'an, China
2. National University of Defense Technology, Changsha, China

Cold Heat Shock Loading by Liquid Nitrogen to Parasite

T Watanabe[1], M Nakamura[1], H Ohta[1], K Shimojima[2]
1. National Fisheries University, Shimonoseki, Japan
2. Okinawa National College of Technology, Okinawa, Japan

Modeling by Finite Element Method of the Area Ratio effect on the Galvanic Corrosion of Steel/Al-Mg Couple

D Boukhlef[1], D Boughrara[2], H Mohellebi[2]
1. Renewable Energy Development Center, Adrar, Algeria
2. Mouloud Mammeri University of Tizi-Ouzou,Tizi-Ouzou, Algeria

Multiscale Accident Analysis for Reliable Safety Evaluation of Nuclear Reactors

T Watanabe
University of Fukui Kanawa-cho, Tsuruga City, Japan

Phase Change Phenomena of Water under Depressurization State

T Watanabe[1], M Nakamura[1], H Ohta[1], K Shimojima[2]
1. National Fisheries University, Shimonoseki, Japan
2. Okinawa National College of Technology, Okinawa, Japan

Towards Numerical Simulation Tool of Motion Solid Particles in Fluid Flow

S Zouaoui[1], H Djebouri[1], B Ferhat[2], K Mohammedi[2]
1. Mouloud Mammeri University of Tizi-Ouzou,Tizi-Ouzou, Algeria
2. M'hamed Bougara University of Boumerdes, Algeria

SESSION 1.1

KEYNOTE ADDRESS & SYNOPSIS

THURSDAY, 10 DECEMBER 2020
09:30 – 11:00

CHAIR

M Moatamedi
The International Society of Multiphysics

Thursday, 10 December 2020
09:30 – 11:00

Keynote Address

25 Years of Industrial Multiphysical Applications – The Journey of Evolution

Dr. A. J. Svobodnik
President & CEO
Mvoid Group

This address to the MULTIPHYSICS 2020 conference will give an overview of the evolution of multiphysics simulations over the last 25 years with some typical industrial application examples for each decade. Also, it is some kind of a biography of my professional career which is strongly connected to multiphysics and advanced engineering analysis. Back in the early 90's of the last century my life as a simulation engineer started with the adventure of founding a start-up right off the university with the target of developing and marketing an FEA software solution for desktop workstations. Thinking we are the only ones that had such a brilliant idea of bringing FEA from the mainframe to the desktop, we figured out after releasing the first version of our FEA structural mechanics code, we are not the only ones with this idea – actually, all major FEA vendors had the same idea. So, our business adventure was lacking innovation and hence success on the market. Two years later we decided to specialize in acoustics with a focus on fluid-structure interaction. This happened in 1992, and later it turned out that this was truly a brilliant step, probably not an idea.

It took about three years when we first released in 1995 a commercial FEA/BEM code for acoustical simulations of strongly coupled FSI systems. Another three years later the commercial breakthrough happened by porting our code to HPC systems, specifically for (massively) parallel systems. Now we were able to run industrial applications with feasible, or at least tolerable wall times for computation. The first prestigious projects jumped in e.g. for the German high-speed train ICE and a new generation of trucks for a world-leading manufacturer. And especially the audio industry hopped on the bus with making loudspeaker simulations on the PC.

At this time NAFEMS started their FENET project, an EU-funded thematic network which involved over 110 European organizations from many key industrial sectors. I learned from Prof. Mark Cross that what we do is called a multiphysical application. Hurray, I'm a multiphysicist now! Multiphysics was defined as one of three key technologies for the engineering analysis community. The network was developed between 2001 and 2005, and as a major milestone the NAFEMS Multiphysics Working Group was established.

In the mid 2000's the maturity of multiphysics ramped up, and in some industries it was used as a state-of-the-art simulation technology with a high degree of maturity and successful dissemination in industry. Currently multiphysics is more in an evolutionary phase, broadening its use in more and more industries. Quite recently the emerging Digital Twin paradigm might give another revolutionary touch to multiphysics, which is a technology enabler for Digital Twins. Finally, multiphysics simulations have reached a relatively high acceptance level in the industry with still lots of headroom left over for even wider acceptance.

Synopsis Part 1: The International Journal of Multiphysics

H Khawaja
The International Society of Multiphysics

The International Journal of Multiphysics publishes peer-reviewed original research articles, review papers and communications in the broadly defined field of Multiphysics. The emphasis of this journal is on the theoretical development, numerical modelling and experimental investigations that underpin Multiphysics studies.
The scope of the journal is to address the latest advances in theoretical developments, numerical modelling and industrial applications 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. This journal aims to publish high-quality findings of basic research and development as well as engineering applications.
The International Journal of Multiphysics is indexed in Elsevier® Scopus (SNIP, CiteScore, SJR), Elsevier® Engineering Village (EI Compendex), Clarivate Analytics® Emerging Sources Citation Index (ESCI), Clarivate Analytics® Web of Science, SHERPA RoMEO: Green, Directory of Open Access Journals. The International Journal of Multiphysics received Elsevier® Scopus CiteScore of 0.8 in 2019.

For more information, visit: www.multiphysics.org/journal

Synopsis Part 2: The International Conference of Multiphysics 2021

H Khawaja
The International Society of Multiphysics

The objective of The International Conference of Multiphysics 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, Nuclear, Soil, Structures and Thermodynamics.
In the past, Multiphysics Conferences have been organised Online (Virtual), in Dubia United Arab Emirates, Krakow Poland, Beijing China, Zurich Switzerland, London United Kingdom, Sofia Bulgaria, Amsterdam The Netherlands, Lisbon Portugal, Barcelona Spain, Kumamoto Japan, Lille France, Narvik Norway, Manchester United Kingdom and Maribor Slovenia. Researchers from all around the world participated in these events. The Organisers and the Management Committee are thankful to all attendees for making these events successful.

For more information, visit: www.multiphysics.org/conference

SESSION 1.2

STRUCTURES AND MATERIALS

THURSDAY 10 DECEMBER 2020
11:30 – 13:00

CHAIR

B Alzahabi
Al Ghurair University
UAE

Multi-Resonator Metamaterials are Multi-Band Meta-Structures

A Fallah[1], N Gorshkov[2], N Navadeh[3], P Sareh[4], V Tereshchuk[5]
1. Oslo Metropolitan University, Oslo, Norway
2. Los Alamos National Lab, New Mexico, United States
3. Imperial College London, United Kingdom
4. University of Liverpool, United Kingdom
5. National Technical University of Ukraine, Kiev, Ukraine

Introducing multiple resonators in the microstructure of a phononic material provides more flexibility in certain unique features of metamaterials. In this work, 3D-acoustic multi-band metamaterials are studied based on the substratum lattice of body/face centered cubic (BCC/FCC) systems. The metamaterial nodes consist of multilevel mass-in-mass units (isotropic multivibrators) connected by internal springs. These have been analyzed and methods of controlled formation of their dispersion properties are discussed. Our main result may be summarized as follows: the number of bandgaps is equal to the number, n, of internal masses because each of band gaps is a result of a classical analog of quantum level-repulsion mechanism between internal and external oscillations. We show that the upper boundary frequencies, $\omega^2_{upper;i}$,$i = 1,2,..,n$, of the gaps formed coincide with eigen-frequencies, $\omega^2_{int;i} \neq 0$, of the isolated multivibrator, $\omega^2_{upper;i} = \omega^2_{int;i}$, and the lower boundary frequencies, $\omega^2_{lower,i}$, are in good agreement with estimations as $\omega^2_{lower,i} \approx \widehat{\omega}^2_{int;i}$ ($\omega^2_{lower,i} < \widehat{\omega}^2_{int;i}$), where $\widehat{\omega}^2_{int;i}$ represent the eigen-frequencies of the multivibrator when its external shell is supposed fixed/motionless. Topologies of the set of dispersion surfaces, $\omega^2_m(k)$, $m = 1,2,\ldots,6$, in the corresponding pass bands are similar to each other and to the topology of the set of dispersion surfaces, $\omega^2_{ext;m}(k)$, obtained in the case when existence of the internal masses in the lattice nodes are neglected. Thus, the whole problem of analyzing the acoustic properties of the complicated system may be reduced to the study of two simple sets $\{\omega^2_{int;i}\}$, $\{\widehat{\omega}^2_{int;i}\}$, and $\{\omega^2_{ext;m}(k)\}$ (the topology of $\{\omega^2_{ext;m}(k)\}$ depends only on type of the metamaterial lattice symmetry). This splitting allows to operate with simple analytical relations and fit the controlled masses and elastic constants of the system under consideration to desirable acoustic parameters.

Multi-Resonator, Phononic Metamaterial, Acoustic Mode, Optical Mode, Bandgap, Dispersion Surface

Experimental Research of Cylindrical Power Lithium-ion Battery under Axial Compression

L Meng[1,2], X Liu[1,2], S Zhang[1,2], H Song[1,2], G Wang[1,2], B Wang[1,3]
1. Taiyuan University of Technology, Taiyuan, China
2. Key Laboratory of Material Strength and Structure Impact, Taiyuan, China
3. London Brunel University, London, United Kingdom

The safety of power batteries have always restricted the promotion and development of lithium electric vehicles. The axial compression of batteries is an important issue leading to damage. The safe performance of 18650 lithium-ion battery under axial compression was studied by experiments, the characters of load, voltage and temperature of batteries with SOC = 60%, 80%, and 100% was discussed, and the failure process of the battery under axial compression was analyzed. It was found that the voltage during the axial compression process showed the unique stepped drop, the maximum load and sudden increase in temperature occurred almost simultaneously; the local groove structure of the positive induced the battery to rupture near the positive. Comparing the batteries in axial compression with the batteries of the radial two-plate compression, it was found that the thermal runaway of power battery in axial compression is weaker than that in radial two-plate compression.

Cylindrical Lithium-ion Batter, Axial Compression, Safety Properties, Failure Mode

Study on Interactions between High Velocity Long-Rods and Steel-Elastomer Bulging Armor

T Fras
French-German Research Institute of Saint-Louis, Saint-Louis, France

Steel-elastomer laminate applied in protection systems, so-called bulging armors, take advantage of the elastomeric interlayer that deforms rapidly under an impact, which causes sudden movement of the side steel plates. Long and slender kinetic-energy projectiles (long-rod projectiles) made with a tungsten alloy tend to fracture disturbed by an asymmetric contact with the deforming plates. In the performed experimental study, the laminates with the natural rubber interlayer are impacted by the down-scaled kinetic-energy penetrators with the initial velocity above 1500 m/s. The numerical analysis accompanies the ballistic test complementing it by a detailed insight into the defeat mechanism. The performed investigation proves a protective efficiency of the discussed passive armor and explains its physical background.

Protection Against Kinetic-Energy Penetrators, KEP, WHA, Bulging Armor, Fracture, Numerical Simulation in High-Velocity Impacts, Modeling of Elastomers

Modelling a Viscosity-Density Sensor based on Small Amplitude Torsional Vibrations

D Brunner[1,3], J Goodbread[2], K Häusler[2], S Kumar[2], H Khawaja[3,4], G Boiger[1]*

1. Zurich University of Applied Sciences, Winterthur, Switzerland
2. Rheonics GmbH, Winterthur, Switzerland
3. The Arctic University of Norway, Tromsø, Norway
4. Al Ghurair University, Dubai, United Arab Emirates

The flow field around a cylindrical torsional resonator can be modelled analytically, but more complex shapes require more rigorous approaches. This study proposes a numerical model of a non-cylindrical torsional resonator for a viscosity–density measurement application. The proposed model couples an analytical mechanical model of the resonator with an empirical, simulation-based fluid model. The model was validated using experimental data over a wide range of fluid viscosities and densities. The predictions are in good agreement with the numerical model. The model could capture all viscosity- and density-related effects. Therefore, it will, enable computationally supported geometrical optimization of future viscosity-density sensors generations.

Computational Fluid Dynamics, Viscosity Sensor, Density Sensor, Fluid–Structure Interaction

SESSION 1.3

AEROSPACE AND TRANSPORT

THURSDAY 10 DECEMBER 2020
14:00 - 15:30

CHAIR

A Fallah
Oslo Metropolitan University
Norway

A Concept to Estimate the Life Cycle of the Railway Track Using Finite Element Modelling

E Albahkali[1], N Alsanabani[1], M Souli[2]
King Saud University, Riyadh, Saudi Arabia
University of Lille, France

A train run over the railway track exerts a load from vertical, lateral and longitudinal directions to the ground through the wheel-rail combining the static and dynamic forces. The main parts of the railroad track are classified as superstructure and substructure. The superstructure includes rail, fastening systems, and tie while the substructure includes top ballast, bottom ballast, sub ballast, fill material and subgrade. Ballasted rail tracks gradually deform in vertical and lateral directions, which cause deviations from the desired geometry under repeated traffic loading. A complex three-dimensional finite element model is constructed for the ballast to identify the life cycle for the railway. The study covers ballast material characterizations, ballast track design, train static and dynamic loads. The model has different stress-strain dependencies, which lead to complicated interactions between various components of the system. Several dynamic steps with several dynamic time intervals are applied. Wheel loading is also considered at these steps. It is represented by magnitude of loading, and operation frequency. Deformation and stresses at each points of subsection are measured and analyzed at several time increment. Finally, the average stiffness at each point is computed at several times in order to compute the services life cycle for the railway.

Railway Track, Ballast, Life Cycle, Dynamic Loads

Smooth Particle Hydrodynamics Birdstrike Analysis on Aircraft Wing Leading Edge

P Hampson, I Talhah
University of Salford, Salford, United Kingdom

The birdstrike impact behaviour of an aircraft aluminium wing leading edge and a carbon fibre composite wing leading edge are investigated using the finite element ANSYS Autodyn solver. The bird was modelled using a Smooth Particle Hydrodynamics (SPH) method and two validation studies were conducted prior to the main investigation in order to establish correct modelling methodology. The first validation simulated bird impact on aluminium panels of varying thicknesses and impact velocities with results compared to Cessna Aircraft Company test data and a numerical study conducted using LS-Dyna. A second validation study was then performed on a steel plate at various impact velocities. Subsequently, the non-dimensional results of force, impulse, impact duration and rise time plots achieved from ANSYS Autodyn solver were calculated and compared with U.S. Naval Research Laboratory test data and an LS-Dyna solution. Following the validation studies, bird impact was then simulated on aluminium and carbon fibre composite wing skin leading edges. Various skin thicknesses were tested at an impact velocity of 155m/s (300 knots). The numerical simulation results of the leading edge displacement and von-Mises stress were evaluated and showed that the carbon fibre composite material had a greater resistance than the aluminium to withstanding the high-speed impact.

Smooth Particle Hydrodynamics (SPH), Birdstrike, Impact, ANSYS Autodyn, Wing Leading Edge

Estimation of Sea Spray Flux for Improving the Prediction of Marine Icing in Cold Conditions using LiDAR

S Dhar[1], K Edvardsen[1], H Khawaja[1,2]
1. The Arctic University of Norway, Tromsø, Norway
2. Al Ghurair University, Dubai, UAE

Marine icing has always been a source of uncertainty for safe operations for ships, offshore or coastal facilities in cold marine climates. Several researchers had investigated this phenomenon for many years, with an attempt to understand and predict. Typically, most severe ice accretion is caused due to sea spray icing from the sprays generated by the impact between wave and hull and when it freezes across the vessel. As this phenomenon depends on several variables like vessel characteristics and uncertain influences like environmental parameters, developing an absolute model for its forecasting, evaluation, and estimation has proven to be challenging. The past efforts for the measurements of sea spray flux were only able to measure particular parts of the generated spray cloud, and most of the empirical spray-flux expressions presented only provide estimate in definite conditions. The high temporal and spatial resolution measurements and scanning capability of the LiDAR technique have proven to be valuable in the agricultural domain in the past years for studying pesticide spray drift, supporting its feasibility for the analysis of sea spray in the field of marine icing phenomenon. In this study, the author is assessing the potential of LiDAR technique for visualising the evolution of the spray drift with high resolution, which can enable comprehensive real-time assessment of spray flux for the entire sea spray cloud. Affirming the possibility of this technique for validating or improving present models of sea spray icing.

LiDAR, Sea Spray, Marine Icing, Cold Conditions, Ship Stability

Aerodynamic Drag and Gravity Gradient Coupled Satellite Stabilization Envelopes

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COMSATS University, Lahore, Pakistan

The satellite with nadir-pointing requirements and having low earth-orbit typically require a three-axis attitude stabilization. At altitudes below 500 km, satellites experience primarily aerodynamic drag. The drag force will induce disturbance torques to act about the satellite's center of mass. Gravity gradient is considered a common passive stabilization method to save the satellite fuel. Instead, aerodynamic torques can be exploited together to stabilize the satellite attitude. This paper attempts to combine the gravity gradient and aerodynamic torques to stabilize the satellite roll, pitch, and yaw attitudes. The idea of utilizing the aerodynamic torques requires installing the flaps on the satellite's body and keeping the flaps tilted at certain angles to generate desired control torques. This combined approach is analyzed via numerical computations corresponding to their deduced governing equations. The numerical results show the effectiveness of the proposed coupled gravity gradient and aerodynamic torques available for satellite attitude stabilization regimes.

Satellite Stabilization, Aerodynamic Drag, Gravity Gradient

SESSION 1.4

COMPUTATIONAL FLUID DYNAMICS

THURSDAY 10 DECEMBER 2020
16:00 - 17:30

CHAIR

G Boiger
Zurich University of Applied Sciences
Switzerland

2D Multiphysics Modelling of Tungsten Inert Gas Arc-Pool Interactions with Free Surface Dynamics

C Nahed, S Gounand, O Asserin, M Medale
CEA Saclay, France
Université Aix-Marseille, Marseille, France

Tungsten inert gas (TIG) welding is a common industrial metal assembly procedure. Ubiquitous as a welding technique, it generates high quality welds, making it important for industry. However, the quantification of the interaction of TIG argon arcs with steel weld pieces is quite complex, because of the sensitivity of the system to a multitude of phenomena. Regardless, the accurate prediction of the welding process is of industrial interest, thus motivating the accurate modelling of the process. TIG weld process modelling calls for a marriage of multiphysics, computational fluid dynamics (CFD), and finite element method techniques. This work presents the advancements realised in the modelling of arc-pool interactions for 2D weld line configurations, and the CFD techniques used to this end. The arc, modelled as a thermal plasma, transports heat and melts the target zone of the weld piece. It contributes to the shaping of the weld pool through the transported heat, shear and pressure forces. The weld pool is modelled as a liquid metal and it contributes to the shaping of the pool contour via thermo-capillary, Lorentz, and advective forces; and through the free surface dynamics of the pool. The two fluid interaction between the arc and pool is multi-scale, where the laminar flow of the arc interacts with vortices generated in the pool, via the pool's deformable free surface. These complex fluid interactions and vortices have steep gradients, and are sensitive to the welding process parameters. Therefore, the efficient capturing of these gradients by our algorithm is necessary, thus motivating the use of a shock capturing residual based artificial viscosity. The added shock capturing term to our conservation equations improves our algorithm's performance by automatically and locally damping the numerical instabilities generated by the steep gradients found at the arc-pool and inter-vortex interfaces. The residual based artificial viscosity term is consistent with the conservation equations, tending to zero as the residual error drops; moreover, it is only active where the residual is large, where steep gradients in the flow field are expected to be found. This reduces the need to over-relax the linear systems that are solved at every iteration, and so, can accelerate solution convergence.

Tungsten Inert Gas, Welding Process Simulations, Multi-Physics, Free Surface Dynamics, Thermo-Capillary Flows, Shock-Capturing, Finite Element Method

Numerical Investigation of Effect of Aspect Ratio in Sudden Expansion Flow using Nanofluid

R Kanna[1], H Khawaja[1,2], R Rani[1], D S Christopher[3]
1. Al Ghurair University, Dubai, United Arab Emirates
2. The Arctic University of Norway, Tromsø, Norway
3. Wolaita Soda University, Wolaita Sodo, Ethiopia

Sudden expansion flow encounters in many industrial applications and few are heat exchanger, electronics cooling, flow in combustion, nuclear reactor. It also involves fundamental fluid mechanics like flow separation, boundary layer, recirculation etc. To enhance heat transfer nanofluid are tested for the past two decades [1, 2]. The present investigation involves numerical simulation of sudden expansion flow using nanofluid for various aspect ratios. The governing equation are solved by in-house solver developed by Kanna et. al. [3]. The flow physics and heat transfer will be reported for the effect of Reynolds number and various aspect ratios.

References:

1. Numerical Study of Heat Transfer Enhancement for Laminar Nano fluids Flow Ramon Ramirez-Tijerina, Carlos I. Rivera-Solorio, Jogender Singh and K. D. P. Nigam, Appl. Sci. 2018, 8, 2661.

2. Review of nanofluids for heat transfer applications Dong sheng Wen, Guiping Lin, Saeid Vafaei, KaiZhang, Particuology, Particuology, Vol. 7, 2009, Pages 141-150.

3. Kanna. P.R., Jan Taler, V. Anbumalar, A.V.Santhosh Kumar, Allwyn Pushparaj and David Santosh Christopher, Numerical Investigation of Conjugate Heat Transfer from Sudden Expansion using nano fluid, Numerical Heat Transfer Part A. 2015, 67: 75–99.

Numerical Simulation, Nanofluids, Sudden Expansion, Heat Transfer, Aspect Ratio

System Cleanliness Prediction by CFD

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VDL Enabling Technologies Group, Eindhoven, The Netherlands

In modern semiconductor industry, the cleanliness of the manufacturing process is the most critical issue. The cleanliness requirements are so high that direct measurement of the airborne particle contamination level by itself is very big challenge. So, the system makers are striving to achieve highest cleanliness of the manufacturing environment and of the product components before assembling, while monitoring the actually achieved system performance in the field. This learning can be used for the next generation of the product only. By direct CFD modelling of particle contamination transport (particle tracking techniques), it is generally possible to make several improvements already before the first prototype is made. But this modelling is very complex, slow and sensitive to detailed knowledge of the particle material, shapes and sizes, so it is still not common. In this presentation, we are reporting on some alternative way: using classical CFD without particle tracking, while aiming on particle contamination prediction. This requires co-developing of simple and universal criteria for computer aided evaluation of the future products, for their best cleanliness limits, even before first prototype is made.

CFD, Airborne Particle, Contamination

Modelling of Pressure and Temperature Profiles for the Flow of CO2 through a Restriction

S Jackson[1], A Leyli[1], A Nordli[1], H Khawaja[1,2]
1. The Arctic University of Norway, Tromsø, Norway
2. Al Ghurair University, Dubai, United Arab Emirates

Carbon Capture and Storage (CCS) represents a key technology in present efforts to reduce anthropogenic CO2 emissions and is, therefore, an important theme for research work. All CCS projects require the transportation of CO2, often using pipelines, making the accurate modelling of the relationships between pressure, temperature, density and phase stability an important prerequisite for engineering design. Of particular interest is the flow of CO2 through restrictions, such as valves, flow-meters, blockages or leakages from a pipeline, because under these conditions, temperature and phase conditions are hard to predict. Most fluids flowing through a restriction experience an accompanying temperature drop, often referred to as Joule-Thompson—or JT—cooling. The degree of cooling depends on the pressure–profile resulting from flow through the restriction and the properties of the fluid involved, and although empirical correlations are available that can provide an estimate of these phenomena, a more detailed and useful understanding can be provided by the numerical modelling. However, key to developing confidence in the numerical approached is the validation of predictions against empirical and experimental results. The present study work is the concerned with development and validation of a numerical model describing the flow of CO2 through a restriction. The model was constructed in ANSYS® Fluent and the validation was carried out using both study data published by others and empirical correlations. Gas properties were modelled in ANSYS® using the Peng-Robinson equation of state. The results showed good agreement with the validation cases and that a strong temperature profile exists across the diameter of a pipeline downstream of an orifice when there exists a high velocity flow through an orifice.

CCS, CO2, Fluent, Equation of State, Joule-Thomson effect

SESSION 2.1

MULTIPHYSICS APPLICATIONS

THURSDAY 10 DECEMBER 2020
09:30 – 11:00

CHAIR

E Albahkali
King Saud University
KSA

Advancing the Validation and Application of a Eulerian-Lagrangian Multiphysics Solver for Coating Processes in Terms of Massive Simultaneous Cloud Computing

G Boiger, S Bercan, L Viktor
Zurich University of Applied Sciences, Winterthur, Switzerland

A previously introduced, OpenFoam based Eulerian-Lagrangian Multiphysics solver has been further validated and has been finding concrete applications within the powder coating industry. This talk will demonstrate simulation software advances focusing novel Kaleidosim based cloud computing capacities as well as extensive validation efforts. Thereby a large number of metallic substrates has been coated and evaluated in terms of measured vs predicted relative coating thicknesses. Within the presented validation series, process parameters such as pistol-substrate distance and applied voltage have been varied. Furthermore an extensive series of cloud based simulation runs has been conducted in Massive Simultaneous Cloud Computing (MSCC) mode, approximately 80 coating experiments have been performed and 240 Coatmaster 3D measurements have been done and evaluated. In a next step the simulation technology as well as the demonstrated validation procedure have been applied to U-profile parts. Again, striking correspondence between measurements and simulation based predictions can be pointed out and will be discussed in detail along with the interpretation of remaining deviations.

Simulation, Multiphysics, MSCC Massive Simultaneous Cloud Computing, OpenFoam®, Coating, Kaleidosim®, CFD

Specialized Methods for Multiphysics Simulations on Battery and Fuel Cell Microstructures

M Fingerle, S Linden, L Cheng, F Biebl, A Wiegmann
Math2Market GmbH, Kaiserslautern, Germany

3D imaging methods, such as micro Computed Tomography (µCT) or focused ion beam scanning electron microscopy (FIB-SEM), allow deep insights into the 3D structure of porous materials. The resulting 3D data sets are very large, often exceeding 2000^3 or 8 billion voxels. Researchers and engineers are interested in determining effective homogenized material properties based on these data sets to understand existing materials or to design new man-made materials. Recent advances in computer technology have made it possible to compute and visualize effective properties such as permeability, and thermal or electrical conductivity on these large images in very short times and using surprisingly little memory. Classical finite-element-methods (FEM) or finite-volume-methods (FVM) are not suited to run Multiphysics simulations on these large images. The bottleneck of these methods is the mesh generation that must be done before the actual simulation can take place and can take longer than the solving of the discretized partial differential equations. Instead, complex microstructures are best dealt with by fast and memory efficient numerical methods that are explicitly designed for them. The scientific software GeoDict® – The Digital Material Laboratory offers state-of-the-art numerical finite-volume-based methods which do not require mesh generation and are designed to run Multiphysics simulations to calculate effective material properties on very large 3D images. We present several use-cases where Multiphysics simulations are successfully applied for digital material research and development: Mechanical deformation of battery electrodes due to local changes in the Li concentration during cycling and water saturation dependent relative permeability of a PEM fuel cell GDL. In addition, a short outlook for AI assisted massive simultaneous cloud computing is provided.

µCT, FIB-SEM, GeoDict, Batteries, Fuel Cells, Cloud Computing, MSCC,

A Dynamic Eulerian-Lagrangian Solver for the Optimization of Powder Coating Processes

B Siyahhan, G Boiger
Zurich University of Applied Sciences, Winterthur, Switzerland

In powder coating, it is usually desired to coat the substrate as evenly as possible to the specified thickness, using the least amount of powder. To achieve this goal, the coating pistol is kept mobile with respect to the substrate. In this study, an existing OpenFOAM Eulerian-Lagrangian computational fluid dynamics solver, extensively validated for static configurations, has been further developed to simulate the coating process dynamically, incorporating the motion of the coating pistol with respect to the substrate. This makes the simulation of the powder coating process in real time possible. For the dynamic motion, a new library for generalized periodic translational and rotational motions has been compiled in OpenFOAM. Furthermore, the injection behavior of the particles has been updated to comply with the motion of the pistol seamlessly. These updates allow the simulation of multiple pistols with varying orientations and time dependent injection profiles, with the ultimate goal of coating process optimization based on given types of substrates. The results indicate that the vortex dynamics within the coating chamber play a significant role in the dispersion of the particle cloud, and this effect cannot be captured by a single steady state simulation. However, the validity of the final coating pattern with the dynamic solver needs to be established. Even though the ultimate validation will come from an experimental campaign, it is essential to form an understanding of the behavior of the empirical coefficients, governing certain physical interactions, within the solver. Therefore, a parametric study is performed to construct such a basis.

Powder Coating, CFD, Eulerian-Lagrangian, Particle Dynamics

Fluid Structure Interaction (FSI) Simulation of Flow through a Squeeze Bottle

V Turaga, S Bhavi, V Srinivasa,
HCL Technologies Ltd., Bangalore, India

Fluid–Structure Interaction (FSI) is the interaction between a movable or deformable solid structure with fluid flowing internally or surroundings. Consideration of interaction between Fluids and Structures is very important in many engineering systems. Examples of such systems include aircrafts, engines, bridges, moving containers, flow of blood through blood vessels and many more. The fluid flow may exert pressure and/or thermal loads on the structure. These loads may cause structural deformation significant enough to change the fluid flow itself. Computational Fluid Dynamics (CFD) and Structural Dynamics methods are used to capture the physics involving flow of fluids and behavior of structures respectively in the engineering systems. Fluid-structure interaction (FSI) simulation is a multi-physics study on how fluids and structures interact. The fluid and structural simulations are both set up and solved at the same time. While being solved, data is automatically transferred between the two solvers to achieve robust and accurate results. In the present study, an FSI simulation has been performed on a squeeze bottle. A squeeze bottle is a type of container such as a plastic bottle for dispensing a fluid. Pressure is exerted on the container with the user's hand, due to which fluid within the container is compressed and thereby expelled through a nozzle. Volume change due to wall deformation result in pressure rise in the fluid volume influencing the flow characteristics of the liquid being dispensed. The simulation presented here is an attempt made to capture wall deformation vs liquid out flow rate, force required to achieve required flow rate and outlet flow trajectory. This simulation can be further used to conduct parametric studies and optimize the flow characteristics and nozzle design.

CFD, FSI, Squeeze Bottle

Customized Sensors for Temperature Field Measurements in Gas Foil Bearings – Experimental Investigation

J Roemer[1,2], P Zdziebko[1], A Martowicz[1]
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2. Oslo Metropolitan University, Oslo, Norway

The present work reports the measurements of the Gas Foil Bearings (GFB) temperature profile. The concept of GFBs is known since 70's of the 20th century, however still some of the thermal stability issues are yet to be resolved. Temperature management of GFB strongly depends on their compliant structure which is usually individually tailored to a given application. Due to complex structure of GFB, the temperature measurements for their internal components is a challenging task. In recent years, the new measurement technique, based on customized sensors, was developed and successfully tested. This technique involves manufacturing GFB foil with integrated thermocouples. Preliminary tests conducted by the authors proved the effectiveness of the proposed method in terms of temperature monitoring with high resolution. The major disadvantage of the proposed method is relatively high cost of the equipment. Moreover, test scenarios usually assume running the bearing up to the operational limits which leads to its destruction. In such circumstances, durability of the used equipment has adverse impact on the overall cost of the entire experimentation process. The current work presents a technique for artificial temperature profile reproduction for GFBs. The approach assumes the use of modified shaft with integrated electric heaters. Heat generation is obtained motionless which eliminates friction between shaft and foil. This approach allows for reproducing the temperature profile in GFBs complex foil structure, without risk of bearing seizure and destroying expensive sensors. Presented technique was verified during laboratory tests.

The authors acknowledge the project "Mechanisms of stability loss in high-speed foil bearings – modeling and experimental validation of thermomechanical couplings", no. OPUS 2017/27/B/ST8/01822 financed by the National Science Center, Poland.

Gas Foil Bearings, Temperature Measurement, Thermodynamics, Thermoelectricity, Thermocouples

SESSION 2.2

VIBRATION AND IMPACT

FRIDAY 11 DECEMBER 2020
11:30 – 13:00

CHAIR

M Souli
University of Lille
France

Effect of Shock Loading Pre-processing for Freeze-drying

T Watanabe[1], M Nakamura[1], K Shimojima[2], S Tanaka[3], K Hokamoto[3], S Itoh[3]
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2. Okinawa National College of Technology, Okinawa, Japan
3. Kumamoto University, Kumamoto, 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.

Shock Loading, Pre-processing, Freeze-drying

Thermoelastic and Thermoplastic Modelling of Point Impact on Carbon Fiber Reinforced Polymers

Z Andleeb[1], S Malik[1], G Hussain[1], A Nordli[2], H Khawaja[2,3], M Moatamedi[3,4]
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2. The Arctic University of Norway, Tromsø, Norway
3. Al Ghurair University, Dubai, United Arab Emirates
4. Oslo Metropolitan University, Oslo, Norway

Composite materials are becoming more pronounced in technological applications due to the significant weight savings and strength these materials offer compared to metallic materials. In many of these practical situations, the structures are prone to drop impact loads. Material and structural responses vary significantly under impact loading conditions as compared to quasi-static loading. The present work is devoted to the thermal analysis process in Carbon-Fiber-Reinforced Composites (CFRPs) subjected to drop test. A novel drop weight impact test experimental method evaluates parameters specific to 3D composite materials during the study. Strain gauge rosette and Infrared thermography are employed to perform Non-Destructive Testing (NDT), which respectively provides the kinematic and thermal fields on the composites' surface in live recording during the tests. This technique is non-destructive and offers a fascinating full-field investigation of the material response. The combination of strain and infrared thermography data allows a comprehensive analysis of thermoelastic and thermoplastic effects in CFRPs when subjected to impacts. Experimental results are validated through Numerical Analysis by developing a Matlab® code to solve the coupled heat and wave equation in a 2-D polar co-ordinate system by discretizing through a Forward-Time Central-Space (FTCS) Finite Difference Method (FDM).

CFRPs, Drop test, Strain, Infrared Thermography, NDT, Thermoelastic Effects, Impacts, Numerical Analysis, FDM

Multiphysics of Nonlinear Vibration in Blast Loaded FVK Thin Plates

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2. Imperial College London, London, United Kingdom
3. Taras Shevchenko University, Kyiv, Ukraine

Matertials such as modern armour steel, benefit from appreciably high elastic energy storage capacity prior to failure. Such a capacity contributes to absorption of the impulse generated during an extreme pulse pressure loading event as localized blast. As the plate deforms within the bounds of the elastic region without plastic dissipation, the probability of catastrophic failure is mitigated while large deformations compared to conventional metallic panels are encountered. No studies have proposed, to date, closed form solutions of nonlinear elastic response for thin circular plates subject to pulse loads. The present work aims at deducing, from the minimization of the Föppl-von Kármán (FVK) energy functional, the exact explicit solutions for the response of dynamically (pulse) loaded thin clamped circular plates undergoing large deformations. A kinematically admissible displacement field together with an associated stress tensor potential was assumed as an infinite polynomial series, which was truncated into a multiplicative decomposition of temporal parts and spatial parts, representative of a Multiple Degrees-of-Freedom (MDOF's) system. In the case of static loading, using the Frobenius method, a recursive solution to each mode of defamation was obtained. In the event of dynamic loading useful expressions for stress tensor components were delineated, corresponding to a multimode multiplicative product, and a series of coupled Ordinary Differential Equations were derived, using the Galerkin-Ritz Variational method. The explicit solutions were sought using the Poincaré-Lindstedt perturbation method. The closed form solutions obtained were corroborated with FE including the Fluid Structure Interaction effects and showed convergence when the first few modes were considered. The influence of higher modes, however, on the peak deformation was negligible and the solution with 3 DOF's conveniently estimated the blast response to a satisfactory level of precision. The influence of element type on the response was also examined and discussed in the context of the problem.

FVK Plate, Localized Blast, PL Perturbation Method, Frobenius Method, FSI, Closed Form Solution

An Influence of Breathing Crack Parameters on the Flexural Forced Vibration Behaviour of Compressor Blades

K Savchenko, Y Onyshchenko, V Kruts, S Kabannyk
Institute for Nuclear Research, Kyiv, Ukraine

Rotating blades are one of the main parts and highly stressed components of turbomachinery. During the engine operation, they are often exposed to extreme operating environments including aerodynamic and centrifugal forces, and vibration transmission from other parts. Also, some of them are affected by thermal stresses. As a result, various types of damages such as dents, erosion or corrosion pits, and cracks can occur in the blades. Such damages, as well as the presence of any irregularities in the surface layer or abrupt changes in the cross-section, may cause the increasing stress level in the blade airfoil that leads to the appearance of fatigue cracks. They influence on the elastic and inertial characteristics of the blade and change its vibration parameters. In this study, the analyses of the forced vibration response of the cracked blade airfoil with a low twisted angle were carried out using the finite element method to determine the influence of the fatigue damage presence on the flexural forced vibration behaviour of the blade at the main, super-and subharmonic resonances. The fatigue crack was modeled as a mathematical cut and its two locations were investigated – on the leading edge and suction side of the blade airfoil. The nonlinearity due to the intermittent contact of the crack surfaces during each vibration cycle was taken into account by solving the contact problem. Based on the calculation results it has been found that the most efficient parameter of the presence of breathing crack is the ratio between the amplitudes of the dominant displacement harmonics at the super- and subharmonic resonances. Also, one of the specific features of the mentioned parameters is their ability to imply the crack location, which is characterized by a sharp change in the ratio of the amplitudes in its neighbourhood.

Compressor Blade Airfoil, Breathing Crack, Forced Vibration, Main-, Super-, and Subharmonic Resonances

Forced Vibration Analysis of the Cantilever Beam with Breathing Cracks of Different Configurations

Y Onyshchenko, V Kruts
Institute for Nuclear Research, Kyiv, Ukraine

The work is aimed at studying the influence pattern of the cross-sectional shape of the breathing crack on the next characteristics of forced flexural vibration of the cantilever beam: relative change of its frequency and amplitude at the fundamental, super- and subharmonic resonances. The breathing crack was modeled as a mathematical cut with a rectangular, triangular, and trapezoid cross-sectional shape. Numerical investigations of the beam vibration characteristics were performed using its finite element model. The computational analysis was based on Newmark methods and fast Fourier transform. The forced flexural vibrations of the beam in the plane of maximum stiffness were excited by the harmonic force applied to its free end. According to the results of the calculations, the dependencies of the frequency and amplitude of the vibration at the fundamental, super- and subharmonic resonances on the crack size and its location along the length of the beam were determined. Based on the results of the calculations it has been found that obtained dependencies have identical behaviour for all considered cross-sectional shapes of the crack and there is only their quantitative difference. It is established that for the cracks with the same cross-sectional area, the largest change in the vibration frequency is caused by a rectangular, and the smallest - by triangular crack shape. Also, it is shown that the spectrum of vibration amplitudes of the damaged beam at the fundamental, super- and subharmonic resonances contains two dominant harmonics, one of which is resonant, and the second one corresponds to the excitation frequency. In addition, due to the asymmetry shape of the triangular and trapezoidal cracks relative to the beam planes of symmetry, there are additional movements in the plane of minimum stiffness.

Breathing Crack, Rectangular, Triangular, Trapezoid Cross-Sectional Shape of the Crack, Beam, Forced Vibration, Main, Super-, and Subharmonic Resonances

SESSION 2.3

BIOENGINEERING

FRIDAY 11 DECEMBER 2020
14:00 – 15:30

CHAIR

T Watanabe
National Fisheries University
Japan

Analysis of Falling Droplets into Resting Liquid and Resulting Shear Stresses

M Hostettler[1], D Brunner[1], F Rosenthal[2], M Clemens[2], E Koepf[2], G Boiger[1]
1. Zurich University of Applied Sciences, Winterthur, Switzerland
2. F. Hoffmann-La Roche Ltd., Basel,Switzerland

When a vial filled with liquid is transported it is exposed to external vibrations. These vibrations cause motion, which in turn can lead to splashing. This vibration induced splashing causes shear stresses and pressure forces within the fluid. When it comes to pharmaceutical fluids, it is essential to understand these shear- and pressure conditions because they can lead to the degradation of the drug. The presented study focuses on the effects of splashing in a liquid using computational fluid dynamics. Thereby, a falling droplet, which impacts into a surface of a resting liquid, is investigated. The impact and immersion of the droplet into the surface generates a complex agitation of the fluid and leads to the occurrence of shear stresses. These shear stresses depend on parameters such as falling height, droplet diameter and viscosity of the fluid. Using computational fluid dynamics said degrees of freedom were investigated in relation to associated shear conditions. The computational results show that larger droplet diameters as well as larger falling heights tend to primarily increase the strength of the occurring shear stresses. On the other hand increasing fluid viscosity decreases the penetration depth of the influence region while increasing the shear stress level. Therefore, viscosity has a more complex influence on the splashing than the other studied parameters.

Computational Fluid Dynamics, OpenFOAM, Two-Phase Flow, Splashing

Multiphysics Simulation of Dental Implant Cement Squeezing, Towards Improving the Adhesion Quality

E Mohamed[1], E Hesham[2]
1. Pharos University in Alexandria, Alexandria, Egypt
2. King Saud University, Riyadh, Saudi Arabia

Missing teeth are replaced by implants and crowns. It is now common place for dentists to join crowns and implants using cement as opposed to using screws to improve aesthetics, reduced chair-time and cost-effective as well. Excess cement extrusion into the soft tissue has been shown to cause long term peri-implant disease. Only very limited data is available on how to achieve optimal cementation and avoid these health issues. In this simulation, the cement amount, speed of seating and initial placement in the crown are investigated for different implant shapes. Reverse engineering was conducted for different implant designs and the CAD file exported to the simulation deck. Overset mesh is used with volume of fluid (VOF) multiphase model. The air effect is considered in the fluid structure interaction (FSI) during the cement squeezing. Air entrapments are tracked inside the cement flow where the quality of the adhesive is greatly affected. Dental cements are non-Newtonian in nature where its viscosity varies with shear rate. Herschel-Bulkley model is used for simulating cement and input parameters for this model were obtained from literature and data sheets. Transient solution with laminar flow was adapted in the simulation. Comparing the simulation results with the published experimental studies draw the recommended amount and initial loaded place for the cement and how to reduce its residual excess. Also, it shows that speed of seating of crown matters.

Multiphysics, VOF, Multiphase, Overset Mesh, FSI, Non-Newtonian, Dental Implants

Impact of the Flow on Mass Transfer from Particles: Biomedical Applications

C Bielinski, B Kaoui
Université de technologie de Compiègne, Compiègne, France

Core-shell particles are increasingly used to encapsulate active agents in pharmaceutics and biotechnology. Their main advantage is their ability to moderate mass exchange across their shell in a controlled manner. Furthermore, the shell enables to protect efficiently the encapsulated material, and to enhance the mechanical robustness of the particle against external undesired chemical and mechanical deteriorations. While there is a large amount of publications dealing on how to synthetize core-shell particles, only few studies have investigated how they operate under realistic conditions. For example, how a drug is delivered from a core-shell particle in the bloodstream, or how biochemical reactions are well controlled in a suspension of core-shell particles in a bioreactor. All these biomedical applications involve strong fluid-particle two-way coupling and mass transfer. In addition, the core of the particle acts as a reservoir, where the concentration of the encapsulated molecules decays over time. This involves unsteady and continuous boundary conditions, in contrast to the constant steady boundary conditions largely used in literature. A numerical method based on domain decomposition is developed to model mass transfer from core-shell particles under flow and that considers unsteady mass transfer boundary conditions. Both the solvent fluid flow and the solute transport are computed using the lattice Boltzmann method. Numerical challenges arise when dealing with higher Reynolds and Schmidt numbers, which are overcome using advanced schemes of the lattice Boltzmann method. The proposed method has been successfully applied to study systematically mass transfer from a core-shell cylindrical fiber in crossflow in 2D, core-shell sphere capsule under shear flow in 3D, and multiple reactive spheres in a bioreactor in 3D. The mass transfer efficiency is measured by the Sherwood number (the dimensionless mass transfer coefficient of the particle) and the release or absorption rate of the solute. The Sherwood number is given as a function of the applied flow strength, and importantly as a function of the shell permeability to solute.

Transport Phenomena, Core-Shell Particles, Release and Absorption of Drug Molecules, Multiphysics Simulations, Lattice Boltzmann Method

In Silico Modeling of Targeted Drug Delivery using Liposomes Flowing in the Bloodstream

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Universite de Technologie de Compiegne,Compiegne, France

Two-dimensional simulations are proposed to model drug release from a suspension of liposomes (closed lipid membranes) transported by the bloodstream. The fluid-structure two-way coupling, between the particle deformation (the liposomes and the red blood cells) and the blood plasma flow, is performed with the immersed boundary method (IBM) [1]. Both the flow and the drug mass transport are computed with the lattice-Boltzmann method (LBM) [1,2]. The simulations allow predicting the instantaneous amount of the released drug, its spatial distribution and its accumulations in the targeted diseased tissues. In the limit of extremely large permeability of the particles, drug transport is mainly affected by the complex flow induced by the interplay between the applied flow and the collective motion of the particles. When the membrane exhibits finite permeability that leads to discontinuity in concentration, an algorithm is proposed to implement unsteady jump boundary conditions in the LBM [4]. The algorithm is simple to implement into an existing LBM-based code that computes diffusion and advection of a solute. When combined with IBM, the algorithm can handle moving deformable boundaries that adopt arbitrary geometries. Simulations of controlled drug release from moving liposomes in realistic geometry of blood vessels are given as a proof of concept.

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Multiphysics Simulations, Targeted Drug Delivery, Liposomes, Fluid-Structure Interaction, Vascular System.

Progressive Failure Analysis of Leptadenia Pyrotechnica Composite Laminates

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Fibre reinforced laminated composite structures can reveal substantial stress concentrations that marked on three dissimilar geometric scales. Fibre/matrix stress concentrations exist between the reinforcing fibers and compliant matrix material which cause damage accumulation resulting in stiffness reduction of the composite material. There are stress attentions at the interface between different composite plies in the ply level. At the structural level, the laminate regularly encompasses holes, cut-outs or other geometric incongruities that cause in-plane stress concentrations that occur throughout the thickness of the laminate stack. Laminated composite structures begin accumulating damage at loads that are far below the ultimate load of the structure and even accumulate enough damage prior to ultimate load. Consequently, the prediction of a laminated composite structure's ultimate load requires a Progressive Failure Analysis (PFA) where local damage evolution and associated local stiffness reduction are explicitly accounted for in the analysis. Leptadenia Pyrotechnica, a leafless desert shrub which is rich in fibre is used for this study. Numerical simulations are carried out to explore the progressive failure behavior of Leptadenia Pyrotechnica fiber-reinforced composite laminates. The Autodesk software permits PFA of Leptadenia Pyrotechnica fiber composite structures to be performed very efficiently using implicit FE simulation.

Fiber-Reinforced Composites, Progressive Failure Analysis (PFA), Geometric Non-Linearity. Leptadenia Pyrotechnica

SESSION 2.4

MODELLING TECHNIQUES

FRIDAY 11 DECEMBER 2020
16:00 – 17:30

CHAIR

A Tehrani
Office for Nuclear Regulation
UK

Multiphysics Modeling of Shoreline Evolution

E Holzbecher
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As interplay of fluid flow and sediment transport shoreline evolution is a real multiphysics phenomenon. The movement of sandy sediments is not only determined by coastal geometry and geological structure, but also by the direction and strength of the incoming waves and by the input of riverine material. Sediment transport changes the water depth, which alters currents and undercurrents, which vice versa influence the movement of the sediments. The topic is of high interest, as manmade structures are built and designed to direct the dislocation of the sediments and thus influence changes of the shoreline.
Modelling approaches of different complexity are used to model changes of shoreline morphology. 1D models mostly follow the approach proposed by Pelnard-Considère in 1956. The original approach has been extended considerably by different representations of the currents, some based on shallow water wave theory. Some models focus on statistics other on the physics. Other extensions introduce dependencies of the diffusion parameter. The concept of 1-line has been extended to 2- and 3-lines, even generalized to n-lines. There are simulations using 2D diffusion, but most 2D models are based on the shallow water equations. 3D models require not only much more computational resources, but also more elaborate measurements for calibration of a multitude of parameters and for validation.
At GUtech various approaches for shoreline models have been implemented using COMSOL Multiphysics software. In the contribution the output of 1D and 2D approaches is presented and compared. The focus lies on a model of delta and subsurface fan formation due to riverine point discharge of sediments. In the conclusions recommendations are given concerning the type of models used to simulate shoreline evolution

Shoreline Evolution, Mixed Dimension, Shallow Water Equations

Conjugate Heat Transfer Model Based on SIMPLE and Coupled Energy and Heat Equations

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2. Gulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, Pakistan
3. Al Ghurair University, Dubai, United Arab Emirates
4. Oslo Metropolitan University, Oslo, Norway

In this study, a numerical weak coupling strategy for the modeling of a conjugate heat transfer phenomenon is considered. Where the incompressible Navier-Stokes equations are solved using the Semi-Implicit Method for Pressure Linked Equations (SIMPLE) as a first step, and then the heat conduction equation for solid is solved in a second step considering the convective velocity field resulting from the first step. A finite-difference approach is used for both discretized time and spatial operators. In this paper, a two-dimensional simulation case study of a steady uniform streamwise flow around heated rectangular and triangle solids is presented. The simulation is forward in time until the steady-state regime is reached as the residuals converge and tend to zero. The spatial analysis of the temperature is obtained through the numerical resolution of the incompressible Navier-Stokes energy equation and the heat diffusion equation for the fluid and solid media, respectively. The results show the temperature, velocity, and pressure fields in the space domain. The code is written in MATLAB®, and the flow chart of the method is provided. It was noted that the convection was more dominant than the diffusion.

Conjugate Heat Transfer, SIMPLE CFD, Navier-Stokes, Energy Equation

Thermomechanical Model of Gas Foil Bearing

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2. Oslo Metropolitan University, Oslo, Norway

Gas Foil Bearings (GFB)s constitute a subgroup of the journal bearings. However, instead of oil lubrication, a thin air layer is developed to elevate the rotating shaft. This air film cooperates with the specialized metallic foils to assure a supporting layer which allows for required dynamic properties. Hence, lightly loaded GFBs can operate with very high radiational speeds at almost maintenance free conditions. As mentioned, GFBs exhibit unique construction, and, therefore, modeling of the physical phenomena present in this type of bearing is a real challenge. On one hand, the specific shapes of the structural components as well as the variety of physical domains involved result in high complexity of the mathematical description of the GFB's behavior. On the other hand, even though the numerical results are achievable, it is extremely difficult to conduct reliable experimental validation required for identification of the model parameters. The present work reports the outcomes of the investigation on thermomechanical modeling conducted for the selected components of a GFB. The raised issue is important since proper operation of this type of bearing strongly depends on its thermal management that, in turn, significantly influences the bearing's mechanical response. In fact, the developing air film is very sensitive to both thermal and mechanical responses of a GFB. The authors report the results of the conducted numerical study and conclude about thermomechanical coupling present in the elaborated GFB's model.

The authors acknowledge the project "Mechanisms of stability loss in high-speed foil bearings – modeling and experimental validation of thermomechanical couplings", no. OPUS 2017/27/B/ST8/01822 financed by the National Science Center, Poland.

Gas Foil Bearing, Thermomechanical Coupling, Coupled problem, Numerical Simulation, Virtual Prototyping

Massive Simultaneous Cloud Computing (MSCC) for Multiphysics-Simulation Applications

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The Massive Simultaneous Cloud Computing concept allows appliers and developers of Multiphysics simulation software to utilize any number of cloud-based computers simultaneously. Thus novel workflows in simulation based research and development can be introduced, focusing on simultaneous rather than on sequential computation of individual cases. On the basis of this capability the simulation-researcher/-engineer can (i) dramatically increase the parameter space of any computational parameter study, (ii) devise novel concepts of conducting optimization procedures and (iii) can ultimately even proceed to produce sufficient simulation data in order to train e.g. artificial neuronal networks. The cloud-based software platform Kaleidosim has been devised to effectively enable the handling of MSCC simulation run series of up to 500 simultaneous cloud runs. Case studies will be presented where a speed up factor of 100 has been achieved in terms of comparing MSCC based parameter studies to the standard workflow on in-house hardware.

MSCC, Simulation, Cloud Computing, Simultaneous Computing, Parameter Studies, Multiphysics, CFD

POSTERS

A Two-Phase Constitutive Model with Damage with Damage for Tungsten Heavy Alloy

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Tungsten heavy alloy is a kind of two-phase alloy composed of high-strength tungsten phase and binder phase with good-plasticity. Its mechanical properties and damage evolution are affected by both phases. The static and dynamic mechanical tests of 92.5W-4.9Ni-2.1Fe-0.5Co are carried out. According to the characteristics of stress-strain curves, KHL model is selected as the constitutive model of the material. Then, combined with Eshelby equivalent inclusion theory and Mori-Tanaka mean field theory, the stress-strain relationship of each phase in tungsten heavy alloy is studied by introducing representative volume element (RVE). The damage evolution model considering the strain rate effect is proposed, and according to the different loading states, a two-phase constitutive model with damage is established. By compiling the UMAT subroutine, the test conditions of different strain rates are calculated in ABAQUS software. The simulation results are in good agreement with the test results, and the validity of the proposed model is verified.

Tungsten Heavy Alloy, Two-Phase, Micromechanics Theory, Dynamic Mechanical Properties

Cold Heat Shock Loading by Liquid Nitrogen to Parasite

T Watanabe[1], M Nakamura[1], H Ohta[1], K Shimojima[2]
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2. Okinawa National College of Technology, Okinawa, Japan

In Japan where people like raw food of the marine products, a problem of the parasite often occurs. A similar problem occurs for feed of the dolphin that is very popular in aquarium. A parasite is contained in marine disposal of waste and feed, the method of the management is a subject. There is a guideline of the Ministry of health, labour and welfale, The information that is detailed to the parasite isn't known well. We carried out the research on the actual condition of the parasite. We tried to check about the low temperature tolerance of the parasite for usual freezing and low heat shock by liquid nitrogen experimentally

Cold Heat Shock, Liquid Nitrogen, Parasite

Modeling by Finite Element Method of the Area Ratio effect on the Galvanic Corrosion of Steel/Al-Mg Couple

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2. Mouloud Mammeri University of Tizi-Ouzou,Tizi-Ouzou, Algeria

The main objective of this work is to study the effect of cathode/anode area ratio on galvanic corrosion of steel/Al-Mg in seawater by a numerical model. Two coplanar electrodes (anode and cathode) are represented by a one-dimensional analytical solution, which is introduced as Neumann boundary conditions at the metal/ electrolyte interface. Laplace equation resolution has allowed following the evolution of some parameters such as the electric potential and the current density distributions as well as the anode border deformation for different area ratios of the galvanic coupling between steel and Al-Mg alloy. This model is based on experimental data obtained from non-linear polarization measurements and it has been reported in our previous work. The results show that the coupling of the high potential difference between the materials, allows galvanic corrosion to occur with a higher electrochemical activity of the aluminum alloy with respect to the steel.

Modeling, Finite Element Method, Galvanic Corrosion, Area Ratio, Boundary Deformation

Multiscale Accident Analysis for Reliable Safety Evaluation of Nuclear Reactors

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The safety evaluations of nuclear power plants are performed using the system analysis codes. Calculated plant behaviors under various conditions are used not only for licensing but also as the data bases for machine learning since the accident data are limited. The results of system analyses are also needed as the boundary conditions for the computational fluid dynamics approach and the structural analyses, and the reliability of system analyses is of importance for the nuclear reactor safety. Loss of coolant accidents (LOCAs) are the most significant accidents, and several experiments have been performed using integral effect test (IET) facilities. In this study, multiscale LOCA analyses for the IET and the power plant are performed using the same analytical model. The analytical model for the IET is developed first, where appropriate models and parameters are selected to obtain the agreement between the IET result and IET analysis, and the characteristics of thermal-hydraulic phenomena during the accident are checked. The analytical model for the power plant is developed next with the same modeling procedure and parameters, and the plant analysis is performed. The thermal-hydraulic behavior of the plant during the accident is checked as well as the scaling effects by comparing the plant analysis with the IET analysis. This plant model is used finally for sensitivity analyses for licensing and machine learning. By using the same modeling procedure and parameters, the user effects are eliminated and the scaling effects between the plant and the IET are made clear, and the reliability of nuclear safety evaluations and plant data bases is improved.

Nuclear Power Plant, Safety Evaluation, Loss-of-Coolant Accident, Integral Effect Test

Phase Change Phenomena of Water under Depressurization State

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1. National Fisheries University, Shimonoseki, Japan
2. Okinawa National College of Technology, Okinawa, Japan

The latent heat of the evaporation for water is very big compared with other fluid. Therefore, when evaporation is promoted by depressurization, water lowers the temperature and freezes finally. We made them freeze without applying heat by decompressing water using a vacuum pump. Even if water caused boiling, the pressure kept falling, but when freezing finally, pressure build-up was measured. It was expected that pressure build-up is caused by increase of the evaporation amount by the latent heat release when freezing. An experiment was made in detail. This is the transition phenomenon when switching over from evaporation to sublimation. This seems to bring useful information when considering a phase change model.

Water, Depressurization, Freezing, Phase change

Towards Numerical Simulation Tool of Motion Solid Particles in Fluid Flow

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2. M'hamed Bougara University of Boumerdes, Algeria

Several strategies have been proposed in the last two decades to simulate the motion of rigid bodies in a viscous fluid. In this paper we implemented a contact handling procedure. The collisions between the particles are considered as inelastic. The method consists of imposing a constraint on the velocity field of the particles. This imposition guarantees that at each time step the calculated particle velocity field belongs to an eligible velocity field of the fluid. In order to avoid overlapping, we solve the variation problem without taking into account the possible overlapping of the particles and we compute the projection of this a priori velocity onto the set of admissible velocities. The constrained problem is formulated as a saddle-point problem, by using the introduction of Lagrange multipliers. In our case, an Uzawa algorithm has been used. Numerical tests have been performed satisfactorily for large numbers of spheres.

Fluid/Solid Flow, Collision, Lagrange Multipliers, Uzawa Algorithm

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