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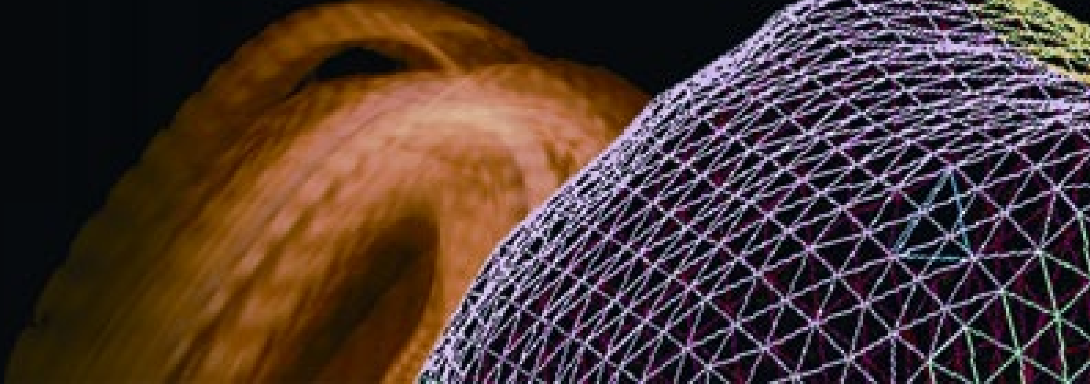
MULTIPHYSICS 2022

15 - 16 December 2022
Oslo, Norway



MULTIPHYSICS 2022
15-16 December 2022
Oslo, Norway

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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.

Registration Pack – Collection Hours

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

Thursday, 15th December	9:30-17:30
Friday, 16th December	9:30-17:30

Special Events

Thursday, 15th December Group Photograph	11:00
Thursday, 15th December Conference Banquette	19:30

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 a maximum of 18 minutes per presentation.

Group Photograph

A group photograph will be taken during the tea/coffee break on the first day of the Conference.

Language

The official language of the conference is English.

Audio-visual

The lecture room will be equipped with the following: one laptop, one LCD projector and cables, one projection screen, and one microphone.

Delegates are requested to either email their presentations to the Conference Coordinator Hassan or bring them in a memory stick.

Paper Publication

Authors are invited to submit full-length papers for publication in The International Journal of Multiphysics (ISSN: 1750-9548) by 31st January 2023.

There is no Article Processing Charge (APC) for one article per registration.

Sponsorship

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

Keynote Speaker

Prof. G. Boiger
Professor of Modeling Multiphysics Applications
ICP Institute of Computational Physics
SoE School of Engineering
ZHAW Zurich University of Applied Sciences

BIOGRAPHY

Gernot Boiger is a Professor of 'Modelling Multiphysics Applications' at the ZHAW Zurich University of Applied Sciences, Switzerland and head of the research group 'Multiphysics Modelling and Imaging' at the ICP Institute of Computational Physics. As such he pursues strong research-driven relationships with academia and industry in the field of simulation-based product- and process development. He concluded his PhD in 'Simulation Technology and Process Engineering – Eulerian-Lagrangian modelling of non-spherical particle flows in the context of automotive filtration' at the University of Leoben, Austria. He has been awarded a 'ProScientia scholarship' as well as the 'Rektor Platzer Ring of Excellence' of the University of Leoben. He holds the post of 'Vice President Europe' of the International Society of Multiphysics.

MULTIPHYSICS 2022

PROGRAMME

TIME	Thursday 15 December 2022	Friday 16 December 2022
09:00 - 09:30	Registration	
09:30 - 11:00	**Keynote Address & Synopsis**	**Session 2.1** *Multiphysics Applications*
11:00 - 11:30	Break / Posters	
11:30 - 13:00	**Session 1.2** *Cold Climate Technology*	**Session 2.2** *Modelling Techniques*
13:00 - 14:00	Lunch	
14:00 - 15:30	**Session 1.3** *Computational Fluid Dynamics*	**Session 2.3** *Optics and Acoustics*
15:30 - 16:00	Break / Posters	
16:00 - 17:30	**Session 1.4** *Materials Modelling*	**Session 2.4** *Posters*
17:30 - 18:00		Closing Remarks
19:30	Conference Banquet	

Full Programme

Thursday 15 December 2022

09:00 - 09:30 Registration

09:30 - 09:45 Conference Opening

Opening of The 17th International Conference of Multiphysics 2022

C Thodsesen, Dean, Faculty of Technology, Art and Design (TKD), Oslo Metropolitan University, Oslo, Norway

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: Multiphysics Simulation of Particle Clouds: The Long Journey from Modelling to Validated Industrial Application

G. Boiger, Professor of Modeling Multiphysics Applications, ICP Institute of Computational Physics, SoE School of Engineering, ZHAW Zurich University of Applied Sciences, Switzerland

Synopsis Part 1: The International Journal of Multiphysics
Synopsis Part 2: The International Conference of Multiphysics 2023

H Khawaja, The International Society of Multiphysics

11:00 - 11:30 Break / Posters

Thursday 15 December 2022

11:30 - 13:00 Session 1.2
Cold Climate Technology

Chair: A Fallah, Oslo Metropolitan University, Norway

Concept Validation of Windtech 'Cold' Sensation Measurement Device
H Khawaja
UiT The Arctic University of Norway

Conceptual Design of Ice Detection/Mitigation System Based on Infrared Thermography
A Yousaf, H Khawaja, MS Virk
UiT The Arctic University of Norway, Norway

Multiphase Numerical Study of Atmospheric Ice Accretion on Railway Overhead Powerline Conductors
A Lotfi, JA Pettersen, MS Virk
UiT The Arctic University of Norway, Norway

Design and Optimizing the Sea-Spray Collector using CFD
S Dhar, H Khawaja, M Naseri, K Edvardsen
UiT The Arctic University of Norway, Norway

13:00-14:00 Lunch

Thursday 15 December 2022

14:00-15:30 Session 1.3
Computational Fluid Dynamics

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

Development of a fast cloud-based simulation workflow for the complete aerodynamic evaluation of aircraft
A Schubiger, D van-Oerle, G Boiger
ZHAW Zurich University of Applied Sciences, Switzerland

Comparing RANS with LES - AMR Study in Indoor Bio-aerosol Transmission
J Owolabi, A Aganovic, H Khawaja
UiT The Arctic University of Norway, Tromsø, Norway

Study of Airflow Behavior for Duplex Circular Cylinders
P Sokolov, MS Virk
UiT The Arctic University of Norway, Narvik, Norway

Time dependent study of Laminar Separation Bubble (LSB) behavior along UAV airfoil RG-15
M Muhammed, MS Virk
UiT The Arctic University of Norway, Narvik, Norway

15:30-16:00 Break / Posters

Thursday 15 December 2022

16:00 - 17:30 Session 1.4
Materials Modelling

Chair: B Alzahabi, Kettering University, USA

An Active Controlling Mechanism for Wave Transmission in Phononic Metamaterials using Magnetorheological Elastomers

VN Gorshkov[1], P Sareh[2], G Boiger[3], AS Fallah[4]
1. National Technical University of Ukraine, Kiev, Ukraine
2. University of Liverpool, Liverpool, United Kingdom
3. Zurich University of Applied Sciences, Switzerland
4. Oslo Metropolitan University, Oslo, Norway

Modelling of Peristaltic Pumps for Viscoelastic Tube Material Properties Under Consideration of Fatigue Effects

M Hostettler[1], S Stingelin[1], F De Lorenzi[1], RM Füchslin[1,2], C Jacomet[1], S Koll[1], D Wilhelm[1], G Boiger[1]
1) ZHAW Zurich University of Applied Sciences, Switzerland
2) European Centre for Living Technology, Venice, Italy

A Thermalizing Approach to Damping: Application to Dynamic Stability of Plates with Finite Displacements

N Mehreganian[1], AS. Fallah[2,3], FJ Ulm[4], MP Tootkaboni[1], A Louhghalam[1]
1. University of Massachusetts Dartmouth, Dartmouth, United States
2. Oslo Metropolitan University, Oslo, Norway
3. Imperial College London, London, United Kingdom
4. Massachusetts Institute of Technology, Cambridge, United States

Blast Loading of Hollow Cylindrical and Truncated Conical Shells

N Mehreganian[1], Y Safa[2], G Boiger[2], AS Fallah[3]
1. University of Massachusetts Dartmouth, Dartmouth, United States
2. ZHAW Zurich University of Applied Sciences, Switzerland
3. Oslo Metropolitan University, Oslo, Norway

19:30 Banquet

Friday 16 December 2022

09:30 - 11:00 Session 2.1
Multiphysics Applications

Chair: H Khawaja, UiT The Arctic University of Norway

Experimental Characterization of the Thermomechanical Properties of a Gas Foil Bearing

A Martowicz, J Roemer, P Zdziebko, SKantor, J Bryła
AGH University of Science and Technology, Krakow, Poland

Investigation of Composite Mechanical Properties from Additive Manufacturing

Z Andleeb[1], H Khawaja[2], K Edvardsen[2], M Moatamedi[3]
1. Abyss Solutions, Islamabad, Pakistan
2. UiT The Arctic University of Norway, Tromsø, Norway
3. The International Society of Multiphysics, United Kingdom

Dimensional Spacetime Metamaterials

Y Khorrami[1], D Fathi[1], F Ghaboussi[2], RC Rupmf[3]
1. Tarbiat Modares University, Tehran, Iran
2. Universität Konstanz, Konstanz, Germany
3. University of Texas at El Paso, El Paso, Texas, USA

Laser Spot Thermography and Flash Thermography – Comparison of Performance for Nondestructive Testing of Composite Structures

J Roemer, M Sobczak, Ł Pieczonka
AGH University of Science and Technology, Krakow, Poland

11:00 - 11:30 Break / Posters

Friday 16 December 2022

11:30 – 13:00 Session 2.2
Modelling Techniques

Chair: N Mehreganian, University of Massachusetts Dartmouth, United States

A Multiphysics-Simulation-based Study of Process-Parameter-Impact on Key-Performance-Attributes of the Powder Coating of U-Profiles
G Boiger[1], B Siyahhan[1], D Sharman[1,2], A Cabrera[2]
1. ZHAW Zurich University of Applied Sciences, Switzerland
2. Kaleidosim Technologies AG, Zurich, Switzerland

Wind Farm Optimization Using Machine Learning
A Keprate[1], N Bagalkot[1], D Berawala[2]
1. Oslo Metropolitan University, Oslo, Norway
2. Equinor ASA, Norway

The Modelling of Substrate Surface Interactions in a Eulerian-Lagrangian Multiphysics Solver and its Impact on Powder Coating Pattern Prediction
B Siyahhan, G Boiger
ZHAW Zurich University of Applied Sciences, Switzerland

The explosive boiling caused by thermal contact between cryogenic fluid and room temperature fluid
A Nakano, T Watanabe, K Tokunaga, T Shiigi
National Fisheries University, Japan

13:00-14:00 Lunch

Friday 16 December 2022

14:00-15:30 Session 2.3 Optics and Acoustics

Chair: M Souli, Lille University, France

Electron Beam Collimation Study with CFD
DA Shestakov
VDL Enabling Technologies Group (VDL ETG), Eindhoven, The Netherlands

FEM Analysis of Various Multilayer Structures for CMOS Compatible Wearable Acousto-Optic Devices
M Hanif[1], V Jeoti[2], MR Ahmad[1], MZ Aslam[1], S Qureshi[2], G Stojanovic[2]
1. Universiti Teknologi PETRONAS, Malaysia
2. University of Novi Sad, Novi Sad, Serbia

Numerical Simulations on the Performance of Optical-Acoustic Sensors of Minimal Dimensions
A Kosík[1], G Stojanovic[2]
1. OST Ostschweizer Fachhochschule, Buchs, Switzerland
2. AMS International AG, Jona, Switzerland

Structure Optimization for Electrostatic MEMS Mirror in Autonomous Vehicle LiDAR Application
Z Yan[1], Z Li[2]
1. Sichuan University, Chengdu, China
2. University of Michigan, Ann Arbor, United States

15:30-16:00 Break / Posters

Friday 16 December 2022

16:00 - 17:30 Session 2.4 Posters

Chair: T Rahulan, Staffordshire University, United Kingdom

Liquid Nitrogen Flashing in the Glass Vessel under Rapid Depressurizations
T Watanabe[1], A Nakano[1], K Tokunaga[1], T Shiigi[1], K Shimojima[2]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, Japan

Effect of Shock Loading Pre-Processing for Freeze-Drying
T Watanabe[1], K Tokunaga[1], T Shiigi[1], K Shimojima[2], S Tanaka[3], K Hokamoto[3], S Itoh[4]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, Japan
3. Institute of Industrial Nanomaterials, Kumamoto University, Japan
4. Institute of Shockwave Applied Technology, Japan

Cold Heat Shock Loading to Parasite by Liquid Nitrogen
T Watanabe[1], T Shiigi[1], K Tokunaga[1], K Shimojima[2]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, Japan

Phase Change Phenomena of Water under Decompression State
T Watanabe[1], A Nakano[1], K Tokunaga[1], T Shiigi[1], K Shimojima[2]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, Japan

Developing a Fast Cloud-Based Simulation Workflow for the Full Aerodynamic Evaluation of Airborne Vehicles
A Schubiger, D van-Oerle, G Boiger
ZHAW Zurich University of Applied Sciences, Switzerland

Statistical Prediction of Rate Constants for the Pyrolysis of High-Density Plastic Waste
RA Nabi[1], MY Naz[1], S Shukrullah[1], H Khawaja[2]
1. University of Agriculture, Faisalabad, Pakistan
2. UIT The Arctic University of Norway, Tromsø, Norway

17:30 - 18:00 Close of Conference

SESSION 1.1

KEYNOTE ADDRESS & SYNOPSIS

THURSDAY, 15 DECEMBER 2022
09:30 – 11:00

CHAIR

M Moatamedi
The International Society of Multiphysics

Thursday, 15 December 2022
09:30 – 11:00

Keynote Address

Multiphysics Simulation of Particle Clouds: The Long Journey from Modelling to Validated Industrial Application

G Boiger
Professor of Modeling Multiphysics Applications
ICP Institute of Computational Physics
SoE School of Engineering
ZHAW Zurich University of Applied Sciences

Creating qualitative Multiphysics models of technical and natural processes is a demanding yet fascinating task. It requires careful observation, thorough analysis and the ability to break up complex phenomena into simpler sub-problems. However as scientists work ever more closely together with industry, one basic truth becomes clearer and clearer: Qualitative modelling is often just the very first step on a 'long, hard journey' from grasping the mere physical principles of any technological problem towards creating a fully validated, comprehensive simulation approach. One that can not just replicate, but reliably predict, one that can actually be applied in 'real-life', one that stands up to the task of seamless integration into cost- and time- driven, competitive industrial development efforts.

This Keynote-talk will focus on one representative example of such a 'long, hard journey'. It will focus on 'Modelling, simulating and predicting particle cloud behaviour in the context of complex, industrial surface treatment applications'. This concrete case shall demonstrate just how time-intensive and demanding the path from creating a Multiphysics simulation model that 'just looks about right', towards 'full validation' and 'actual industrial applicability' can really be. The talk will span a journey form first qualitative simulation models, via thorough step-by-step validation, towards the creation of a novel, cloud-powered simulation software, capable of computing 100s of simultaneous process scenarios and ready for industrial application. We will cover a span of seven years of development-effort and approximately 16'000 man-hours of work invested. Thus the talk will hopefully show that for us Multiphysics enthusiasts and experts, persistence, obsessive love for detail, accuracy and diligence are just as important as creativity and knowledge. And finally there is one essential realisation: we can never 'know' the actual truth, all we can ever do is 'to model it'.

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 1.1 in 2021 (in comparison to 1.0 in 2020). According to the 2022 Elsevier® Scopus CiteScore tracker, it is 1.2 indicating a rising trend.

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

Synopsis Part 2: The International Conference of Multiphysics 2023

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 Oslo Norway, 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

COLD CLIMATE TECHNOLOGY

THURSDAY 15 DECEMBER 2022
11:30 – 13:00

CHAIR

AS Fallah
Oslo Metropolitan University
Norway

Concept Validation of Windtech 'Cold' Sensation Measurement Device

H Khawaja
UiT The Arctic University of Norway, Tromsø, Norway

Prolonged 'cold' exposure poses numerous challenges for industrial operations, human survival, and living convenience. The impact of the cold cannot be quantified just based on temperatures; however, other factors such as wind speed, humidity, and irradiance have to be considered. Therefore, efforts have been made to develop combined indices, such as wind chill temperature (WCT), AccuWeather RealFeel® temperature, universal thermal climate index (UTCI), and others. The given presentation discusses these indices and industrial standards that emphasize the quantification and implementation of risk assessment in cold regions. The presentation introduces the concept behind the novel Windtech device and briefly discusses its operating principle involving 'heated' temperature, which is affected by environmental parameters, including ambient temperature, humidity, wind speed, and irradiance. Furthermore, the device working principle is simulated in MATLAB®, where the physical properties of air are taken from CoolProp libraries. The results validate the concept of the Windtech device and set the basis of calibration.

Cold Sensation, Heat Loss, Cold-related Risks, Real Feel Temperature, Windtech Device

Conceptual Design of Ice Detection/Mitigation System Based on Infrared Thermography

A Yousaf, H Khawaja, MS Virk
UiT The Arctic University of Norway, Narvik, Norway

Ice accretion has been a persisting issue in cold regions and poses a threat to onshore and offshore infrastructure, especially to sensitive equipment and personnel safety. Thermal infrared imaging (thermography) can be used as a non-destructive, non- invasive technique to determine the presence and thickness of ice over a surface. The paper presents early-stage experiment results with a FLIR® Lepton 2.5 radiometric thermal IR camera (resolution 80 X 60) to detect the presence of freshwater and marine ice of different types. Other environmental effects are also studied qualitatively, and corresponding results are validated against a high-speed, high-resolution FLIR® T1030sc thermal IR camera. The presented results are the first step in detecting and mitigating ice on flat surfaces. The discussed technique will lead to the development of autonomous, remote, energy-efficient ice detection and mitigation system.

Ice, Detection, Mitigation, Infrared Thermography, Automation, System Development

Multiphase Numerical Study of Atmospheric Ice Accretion on Railway Overhead Powerline Conductors.

A Lotfi, JA Pettersen, MS Virk
UiT The Arctic University of Norway, Narvik, Norway

Many countries around the globe experience harsh winters and extreme cold resulting in snow and ice conditions. Ice and snow are significant issues for railway infrastructures in cold regions. Ice accretion on railway overhead power lines can threaten the network's safety and reliability. As a result of prolonged icing, power outages and tower collapse are possible. Also, icing on railway contact wires can cause various issues such as overloading, arc formation, mass imbalance, and wire galloping, which are critical issues for engineers and researchers. The focus of this multiphase numerical study is to analyze the ice accretion physics on railway overhead line conductors at various operating conditions. In this regard, a grooved shape contact wire (similar to an actual conductor) with a diameter of 12mm is used. Wind speed, liquid water content, droplet size distribution, and temperature are the main variables considered in this study. The process of ice accretion at different operating conditions is discussed in this paper. Results show that variation in the operating weather parameters considerably affects the ice accretion both in terms of thickness and mass.

Atmospheric ice, Multiphase, Railway, Powerline, Weather

Design and Optimizing the Sea-Spray Collector using CFD

S Dhar, H Khawaja, M Naseri, K Edvardsen
UiT The Arctic University of Norway, Tromsø, Norway

Sea-spray contributes significantly to marine icing, posing a severe challenge to marine operations in cold regions. There are two parts to spray icing, i) amount of water impingement on marine structure, ii) thermodynamics/heat transfer governing the fraction of spray that freezes and adheres to the structure. Sea-spray collection provides means to investigate into marine icing phenomenon.
In this work, a sea-spray collector is designed, inspired by the principle of a cyclone separator in the process industry. In the designed spray collector, the air-laden spray droplet enters the collector; both centrifugal and cyclonic action separates the water droplets from the air, gradually coalescing and accumulating at the bottom. From the scientific literature, particle size distribution in sea-spray ranges from 1 µm up to 7700 µm. Since the smaller particles ride the fluid streamlines, hence are more difficult to capture. Considering the above, particular emphasis was given to understanding the fluid streamlines that can be simulated using the traditional CFD method, Reynolds Average Navier Stokes (RANS) using commercial software ANSYS® Fluent. Hence it was chosen for dimensionalizing and optimizing the design features such as entrance area, nozzle shape, vortex finder, orifice size, etc.

Sea-Spray, Collector, CFD, RANS, Geometric Design

SESSION 1.3

COMPUTATIONAL FLUID DYNAMICS

THURSDAY 15 DECEMBER 2022
14:00 - 15:30

CHAIR

G Boiger
ZHAW Zurich University of Applied Sciences
Switzerland

Development of a fast cloud-based simulation workflow for the complete aerodynamic evaluation of aircraft

A Schubiger, D van-Oerle, G Boiger
ZHAW Zurich University of Applied Sciences, Switzerland

The field of Computational Science is facing an increasing demand for data-intensive investigations. Engineering tasks such as parameter, sensitivity and optimisation studies need ensemble computing to an ever-increasing extent. At the same time, the field of artificial intelligence (AI) is pushing for ever more extensive, numerically derived learning, testing and validation data.
With the cloud software KaleidoSim, we can run many numerical simulations simultaneously [1] and generate large amounts of data in a short time. Although KaleidoSim supports various simulation tools, this study uses only OpenFOAM.
In this work, we developed tools and routines to speed up, simplify and automate studies containing hundreds of simultaneous simulations in the cloud. To test our toolbox, we conducted a complete 360° aerodynamic analysis of various airborne vehicles. The study included 420 OpenFOAM simulation cases. Each case was a steady-state, Reynolds Average Stress (RAS) turbulence model-based, single-phase flow simulation on a 1.5 million cell hexahedral finite volume grid. Drag and lift coefficients were calculated for each case.
We used a combination of Python and KaleidoSim Application Programming Interface (API) routines to develop the toolbox. The Python-based graphical user interface (GUI) allows switching between different CAD models so that multiple aircraft can be compared. The GUI also enables mesh sensitivity analysis to identify optimised meshes for each aerodynamic shape. Based on this, we performed a series of mesh sensitivity analyses using snappyHexMesh and CfMesh grids.
This work proved that a combination of cloud computing via KaleidoSim-based API routines and Python scripting can speed up certain parameter study workflows by a factor of 50-100. Specifically, the exemplary, representative, semi-automated workflow of the aerodynamic study with 420 cases could be performed and post-processed in under 45 minutes, whereas a comparable workflow had before taken up to a full working week on local hardware.

OpenFOAM, Massive Simultaneous Cloud Computing (MSCC), CFD, Aerodynamic Analysis

Comparing RANS with LES - AMR Study in Indoor Bio-aerosol Transmission

J Owolabi, A Aganovic, H Khawaja
UiT The Arctic University of Norway, Tromsø, Norway

The study presents the multiphysics modeling of bio-aerosols generated from human respiratory impulses such as coughing, sneezing, breathing, and talking. These droplet-packed viruses exploit the influence of airflow for effortless transmission, rendering them a potential health risk to individuals in the same indoor environment. To gain insight into the transmission of these airborne particles, their accurate prediction is critical. Computational Fluid Dynamics (CFD) is a numerical method that can be utilized for this study, however, it's computational intensity in terms of accuracy relies on mesh. Thereby, optimizing mesh generation in the transient calculation of droplet transmission is essential to obtain more accurate results. This study investigates the application of Adaptive Mesh Refinement (AMR) and its integration using Reynolds Average Navier-Stokes (RANS) and Large Eddy Simulation (LES) models in the ANSYS Fluent CFD tool to validate an experimental and numerical study of indoor aerosol transmission.
The simulation case setup takes after the experimental investigation of a simplified human body of 1.67m height, located at 1.64m in length, mid-width from the wall of a room of 5.4m (length) x 6.6m (width) x 3m (height) with four (4) air inlets on the roof and five (5) air outlets each on the lower side of both walls. The boundary conditions are set at; low, medium, and high, inlet air supply velocities of 0.16m/s, 0.28m/s, and 0.33m/s, respectively. A constant room temperature of 20ºC is adopted. The exhaled particles in the computational ventilated room domain are injected using the Discrete Phase Model (DPM). Integrating the AMR with RANS and LES models, the meshes are refined in the region of interest as it successfully follows the main flow profile during transmission and establishes stable refined mesh around the dispersed particles.
It is hypothesized that RANS with AMR methodology will be less computationally intensive; however, it will provide a reasonably accurate solution. We also intend to test LES with AMR and compare the computational intensity and accuracy of the results with the experiments.
The presented study on the mesh optimization process is part of the more extensive investigation that aims to understand better the transmission modes of bio-aerosols (e.g., virus-laden droplets) in ventilated indoor environments.

CFD, Indoor, Bio-aerosol, Transmission, Mesh, RANS, LES, AMR

Study of Airflow Behavior for Duplex Circular Cylinders

P Sokolov, MS Virk
UiT The Arctic University of Norway, Narvik, Norway

The modeling of atmospheric ice accretion on duplex cylinders have received a rather limited attention from scientific community, with the two most cited works on the topic being works of Wagner (2010) and Qing et al. (2018). This is in no small part due to the lack of experimental data on the matter – to the best of the author's knowledge, the publicly available experimental data about the ice accretion on the duplex cylinders is limited to experiments of Qing et al. and Veerakumar et al. (2022). When comparing the modeling data of Wagner and Qing et al. with the results of Veerakumar et al., the major difference between them is the airflow behavior in the wake of the windward cylinder, primarily the extent of the wake, the extent of recirculation bubble and the velocity distribution in the wake. Both Wagner and Qing et al. have used the k – ε turbulence model and their variations. Thus, there is need to ascertain the impact of the turbulence model choice on the modeling of the airflow behavior of duplex cylinders, with primary focus being the behavior of the wake of the windward cylinder. This study concerns itself with reporting the results of the complex airflow behavior of duplex circular cylinder bundle obtained using several turbulence models employed by current Computational Fluid Dynamics (CFD) code. The focus is made on the behavior of the wake past the windward cylinder of the bundle. The comparison among current results and the available simulation and experimental data is presented.

CFD; turbulence; wake behavior; bundle; duplex; cylinder

Time dependent study of Laminar Separation Bubble (LSB) behavior along UAV airfoil RG-15

M Muhammed, MS Virk
UiT The Arctic University of Norway, Narvik, Norway

The operating environment of the manned aircraft flying at a high Reynolds number (O(10^6)) is typically dominated by turbulent flow. The flow separation is delayed under such conditions due to the action of viscous force, whereas the flow around an Unmanned Arial Vehicle (UAV) operating at a low Reynolds number regime of the O(10^5) is predominantly laminar and is sensitive to even mild flow pressure gradients. The previously attached laminar boundary layer surface starts separating from the surface due to the adverse pressure gradients and reattaches at some distance downstream while transitioning into turbulent flow. The resulting separation bubble is termed a Laminar Separation Bubble (LSB) [1]. Such separations are more prone to appear along the suction side surface of the airfoil and can alter the aerodynamic airfoil shape and the behavior of the flow field. Low Reynolds number airfoils are so sensitive that even mild changes in the geometry and operating conditions can deteriorate their performance. The pressure, shear stress, and heat flux distribution are considerably affected by LSB, which in turn affects lift, drag, and pitching moment values [2].
Most existing RANS (Reynolds-Averaged Navier-Stokes) turbulence models are built on the assumption of fully turbulent flow. Therefore, these models require additional transport equations or reformulations or specific transition information to predict the LSB observed in low Reynolds number transition flows. Transition turbulence models uses empirical correlations to predict the onset of separation, its reattachment and the transition location. Such models are capable of predicting the LSB with considerable accuracy for airfoil geometries. In this study transient computational fluid dynamics simulations were done to study the transient behavior of LSB on RG-15 airfoil at low Reynolds number of the O(10^5). The time averaged results are then compared with the steady state results to understand the differences in the predictions.

Laminar separation bubble, Transition models, Intermittency, low Reynolds number, UAV.

SESSION 1.4

MATERIALS MODELLING

THURSDAY 15 DECEMBER 2022
16:00 - 17:30

CHAIR

B Alzahabi
Kettering University
USA

An Active Controlling Mechanism for Wave Transmission in Phononic Metamaterials using Magnetorheological Elastomers

VN Gorshkov[1], P Sareh2, G Boiger[3], AS Fallah[4]
1. National Technical University of Ukraine, Kiev, Ukraine
2. University of Liverpool, Liverpool, United Kingdom
3. Zurich University of Applied Sciences, Switzerland
4. Oslo Metropolitan University, Oslo, Norway

Phononic metamaterials allow for smart transmissibility of phonons based on their frequencies when faced with pass- and stop-bands of the spectrum. We investigate the possibility of designing 2D acoustic metamaterials as embedded core-shell systems of an extremely simple morphology, the frequency spectrum of which contains many real-time tunable bandgaps. The connected shells of such metamaterials form a grid with square cells entailing nuclei which may be partitioned into two subsystems. Both subsystems are characterized by their frequency spectra, and it is the coupling between them that generates the bandgaps. Once the structural elements of the metamaterial are made of magnetoelastomers, the bandgaps can be easily controlled by an external magnetic field that changes the elastic moduli of shells and/or cores. Through this investigation, we have demonstrated the possibility of manipulating single bandgaps at different locations on the spectrum, as well as simultaneous control of all bandgaps up to their complete closure. The possibility of spectral manipulation is achieved, specifically, with no change in the maximum achievable frequency in the metamaterial, a matter of significance. The results obtained can be used for selective filtering of damaging wave components, dynamic bandgap creation, active control of seismic or blast waves, frequency-specific sonar systems, ultrasound imaging, impact-resistant metastructures, and noise cancellation protocols. The physical concepts developed may be extended to lower and higher dimensions i.e. to 1D or to 3D-structures in a similar fashion so can benefit a wider community.

acoustic metamaterials, active filtering, core-shell structures, controllable gaps, frequency band structure, magnetoelastomers

Modelling of Peristaltic Pumps for Viscoelastic Tube Material Properties Under Consideration of Fatigue Effects

M Hostettler[1], S Stingelin[1], F De Lorenzi[1], RM Füchslin[1,2], C Jacomet[1], S Koll[1], D Wilhelm[1], G Boiger[1]
1. ZHAW Zurich University of Applied Sciences, Switzerland
2. European Centre for Living Technology, Venice, Italy

Peristaltic pump technology is widely used wherever relatively low, highly-accurately dosed volumetric flow rates are required and where fluid contamination must be excluded. Thus, typical fields of application include food, pharmaceutical, medical technology and analytics. In certain cases, when applied in conjunction with polymer-based tubing material, supplied peristaltic flow rates are reported to deviate from expected set flow rates relevantly. Said deviations are related to i) chosen tube material, ii) total over all time of the pump cycles exerted on applied polymer tubes and iii) applied frequency of pump revolutions.
This work presents a fast, dynamic, 2D Multiphysics simulation method, which significantly reduces the considered deviations by serving as the basis for elaborating an a priori operational setpoint correction. The numerical solver encompasses laminar fluid dynamics, geometric restrictions provided by peristaltic pump operation, as well as viscoelastic tube material properties and tube material fatigue effects. Within this work, a considerable variety of validation experiments and application examples of the novel methodology will be presented.

peristaltic pump, multiphysics simulation, viscoelastic, validation, fatigue

A Thermalizing Approach to Damping: Application to Dynamic Stability of Plates with Finite Displacements

N Mehreganian[1], AS. Fallah[2,3], FJ Ulm[4], MP Tootkaboni[1], A Louhghalam[1]
1. University of Massachusetts Dartmouth, Dartmouth, United States
2. Oslo Metropolitan University, Oslo, Norway
3. Imperial College London, London, United Kingdom
4. Massachusetts Institute of Technology, Cambridge, United States

Accurate estimation of damping is crucial in various fields of engineering where the evaluation of the dynamic response is at stake. However, the simplified numerical and analytical methods adopted to capture the viscous damping coefficients as a constant parameter often exaggerate the influence of the viscous force over other dissipative mechanisms. In this work, we employ a thermalization process for the microcanonical system between the plate element and the heat bath, i.e., the Nosé-Hoover thermostat, to dynamically capture the damping of the plate. In this microcanonical ensemble, the thermodynamic equilibrium between the bath and the plate is achieved by prescribing a kinetic temperature to the plate whereby the extended Lagrangian characterising both the plate and heat bath is formalized for the entire closed system.
By way of application, we investigate the Eigen-vibrations of a damped simply-supported rectangular plate as well as its dynamic stability due to an axial buckling load, where the influence of finite displacements, or geometry changes, is retained in the study. The dynamic response of the structure is obtained by accounting for the coupling between the heat exchange rate and the velocity fields. The use of such microcanonical ensembles provides new insight into the instability and stability analysis of the structural elements and demonstrates the capability of the kinetic temperature as a fundamental state variable to identify the plate failure and assess the visco-elastic response of the model with a higher degree of precision.

Microcanonical ensemble, Nosé-Hoover thermostat, kinetic temperature, heat exchange rate, dynamic buckling

Blast Loading of Hollow Cylindrical and Truncated Conical Shells

N Mehreganian[1], Y Safa[2], G Boiger[2], AS Fallah[3]
1. University of Massachusetts Dartmouth, United States
2. ZHAW Zurich University of Applied Sciences, Switzerland
3. Oslo Metropolitan University, Oslo, Norway

Hollow cylindrical and truncated conical shells provide torsional, flexural, and shear resistance hence are ubiquitously found in various engineering applications in fields such as aeronautics, submarine hull design, and offshore and onshore wind turbine designs. Upon extensive localised blast loads these elements undergo both local and global deformations. The degree of damage to the shell is contingent upon the stand-off and charge mass and is proportional to the emerged local dynamic stresses, as well as the large inelastic deformations. Working in tandem, the large localised translational displacements relocate the structure's original pivot point, thereby inducing global rotational displacements about the new one, raising the probability of structural collapse. Therefore, understanding the structural integrity of these shells is of prime significance.
We present an analytical and several numerical Finite Element (FE) models to investigate the large plastic deformation of the hollow cylindrical and truncated conical shells subject to lateral pulse pressures, such as blast pressures from high explosives. We prescribed a pressure function as a multiplicative decomposition of a temporal and a spatial part, each characterised by a piecewise continuous function. The analytical solution was sought for the cylindrical shells in two distinguishable phases. Subsequently, dynamic pulse shape effects were examined to render the solution pertinent for both high explosive detonations and gas explosions. The analytical model validation with the FE models demonstrates the capability of the former to capture the dynamic plastic collapse of the cylindrical shells with a high degree of accuracy.
FE methods which incorporated Fluid-Structure Interactions (FSI) were developed to address free air blasts, whose results were employed to determine a set of dimensionless functions in terms of the characteristic charge length to stand-off ratio. These functions linked the dimensional load parameters to those characterising the structural material and geometric properties as well as the response.

Local and global failures, Localised blast pressure, Dynamic Plastic Collapse, FSI, Hollow Cylindrical shells, Truncated Conical shells

SESSION 2.1

MULTIPHYSICS APPLICATIONS

FRIDAY 16 DECEMBER 2022
09:30 – 11:00

CHAIR

H Khawaja
UiT The Arctic University of Norway
Norway

Experimental Characterization of the Thermomechanical Properties of a Gas Foil Bearing

A Martowicz, J Roemer, P Zdziebko, SKantor, J Bryła
AGH University of Science and Technology, Krakow, Poland

High-speed rotating machineries require unique technical solutions to be implemented to address their specific operational conditions. One of the adequate choice regarding the type of the suspension nodes are Gas Foil Bearings (GFB)s. These bearings can be used at very high rotational speed, i.e., up to several hundreds of thousands rpm, also for a wide temperature range. The structural part of the GFBs' suspension layer is composed of a set of thin metallic top and bump foils made of an superalloy Inconel 625. After an air film is developed in a GFB, the shaft's journal elevates over the bearing's foils and then the system continues contactless high-speed operation. GFBs, however, require thermal control to maintain proper mechanical properties, including the desired capability of load carrying. Excessive temperature gradients observed within the surface of the bearing's foils may cause significant thermal expansions and finally a damage of the bearing. In the presented research the measurement techniques used to investigate the bearings' thermal and mechanical properties have been developed and successfully applied to experimentally characterize the GFB's operational properties. Specifically, the specialized sensing top foil has been equipped with the built-in thermocouples and bonded strain gauges to respectively measure the temperature and strain fields. There are presented and discussed measurement results obtained for the examples of the bearing's complete operation cycles consisting of the following stages: run-up, stable operation, run-out and cooling down. Both the temperature and strain experimental readings are provided to characterize the temporal courses of the GFB's characteristics and to study the bearing's behavior during development and losing the air film. This research was funded by the National Science Center, Poland, within the project grant number 2017/27/B/ST8/01822 entitled "Mechanisms of stability loss in high-speed foil bearings - modeling and experimental validation of thermomechanical couplings".

gas foil bearing; strain field; temperature field; thermomechanical properties; rotor dynamics; turbomachinery

Investigation of Composite Mechanical Properties from Additive Manufacturing

Z Andleeb[1], H Khawaja[2], K Andersen[2], K Edvardsen[2], M Moatamedi[3]
1. Abyss Solutions, Islamabad, Pakistan
2. UiT The Arctic University of Norway, Tromsø, Norway
3. The International Society of Multiphysics, United Kingdom

Manufacturers consider carbon fiber as a wonder material for the world's economy. Its distinctive combination of high strength and low weight has helped drive the wind power revolution and make aircraft and ships more fuel-efficient. In addition, the carbon fiber structures can function longer and are more rigid than the traditional metallic models, making them more resilient in cold and more efficient in corrosive environments. Automobile makers also realize the material's potential to make lighter and more efficient vehicles. But, despite all the benefits of carbon fiber, there is a key problem associated with it; the high-technology material is wasteful to produce and very difficult to recycle. As carbon fiber (prepreg) is combined with a plastic polymer resin in a fixed ratio to manufacture the strong, light composite material, often the manufacturing process, in which sheets of composite material are laid up, produces tons of waste. By the time they have been trimmed to the required size, almost a third of these carbon fiber sheets end up as waste on factory floors. This research proposal explores 3D printing as an alternative to conventional manufacturing processes. 3D printing is an additive manufacturing process in which layers of material are built-up to yield accurate parts with a nearly flawless surface finish, saving almost one-third of the material waste from conventional manufacturing methods. However, the industrial benefits of composite 3D printing technology are still limited owing to the lack of knowledge regarding the performance of 3D printed parts during their intended applications.This presentation intends to discuss the mechanical properties of CFRP by performing standard mechanical tests i.e., tensile, Charpy, penetration resistance, drop-weight, and fatigue, and also validates them through numerical analysis. Furthermore, this presentation will take Numerical Modeling and Simulation to a new level by aiming to solve the problem of interfacial gaps between 3D printed layers and infill patterns that do not conform with conventional continuum-based Finite Element Method (FEM) material models. New findings in FEA will help the scientific community to handle similar problems. The success of 3D printing composite parts with the required mechanical properties will revolutionize the composite manufacturing industry and help in reducing carbon footprint and achieving environmental sustainability.

Carbon Fiber; Composite; 3D Printer; Additive Manufacturing; Mechanical Testing; Material Model; Finite Element Analysis (FEA), Life Cycle Analysis

Dimensional Spacetime Metamaterials

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1. Tarbiat Modares University, Tehran, Iran
2. Universität Konstanz, Konstanz, Germany
3. University of Texas at El Paso, El Paso, Texas, USA

In this brief opinionated article, we present a critical look at metamaterial dimensionality which is published in many articles and literatures these days. We try to discuss space and time as dimensions and the future of the degrees of freedom regarding dimensional spacetime metamaterials. In the following, we propose a practical common procedure that is used but has not been recognized, and that is the need for lower degrees of freedom to solve space-time problems instead of going to greater degrees of freedom or dimension

Spacetime, dimension, metamaterial, metasurface

Laser Spot Thermography and Flash Thermography – Comparison of Performance for Nondestructive Testing of Composite Structures

J Roemer, M Sobczak, Ł Pieczonka
AGH University of Science and Technology, Krakow, Poland

It is expected that composite market benefits of 6.6% annual growth and reach up to 133.5 billion by 2028. The requirement of high technology makes a high entry barrier which makes the composite market especially fitted for EU countries. Due to their specific nature (hidden defects), composite structures required advanced testing methods which are constantly developed. Most common techniques are based on X-rays and ultrasound techniques, however, due to the rapid development of IR cameras, active thermography becomes more and more popular in recent years. The following paper presents NDT for composite samples using two active thermography techniques: laser spot thermography and flash thermography. A technology demonstrator of both techniques was designed and constructed at AGH UST. In the first chapter, an introduction to principles of active thermography with a focus on flash and laser spot techniques was presented. The next chapter covers a detailed description of both technology demonstrators. Then, the experimental procedure of laboratory testing along with data processing algorithms was presented. Finally, the results of laser spot thermography and flash thermography testing were compared and discussed. The research has been financed within the scope of project no. 0001/L-11/2019 "Laser thermography testing for damage detection in composite structures" financed by the National Centre for Research and Development, Poland. Part of the work was also financed by the AGH University of Science and Technology, Poland, WIMiR, research grant no. 16.16.130.942/GD/2022.

Thermography, NDT, Composites

SESSION 2.2

MODELLING TECHNIQUES

FRIDAY 16 DECEMBER 2022
11:30 – 13:00

CHAIR

N Mehreganian
University of Massachusetts Dartmouth
United States

A Multiphysics-Simulation-based Study of Process-Parameter-Impact on Key-Performance-Attributes of the Powder Coating of U-Profiles

G Boiger[1], B Siyahhan[1], D Sharman[1,2], A Cabrera[2]
1. ZHAW Zurich University of Applied Sciences, Switzerland
2. Kaleidosim Technologies AG, Zurich, Switzerland

The abilities of Kaleidosim, a Massive Simultaneous Cloud Computing (MSCC) platform and of a Eulerian-Lagrangian finite-volume OpenFOAM-based solver were combined within the powder coating simulation software CoatSim. While the OpenFOAM solver can model Multiphysics corona-formation effects as well as Lagrangian particle-based spray-cloud evolution between coating pistols and electrically grounded metallic substrates, the MSCC capability allows for the simultaneous cloud-based computation of hundreds of process-parameter-scenarios. CoatSim simulates the fluid dynamics of process airflow, coating-particle-dynamics, fluid-particle, particle-particle and highly detailed particle-substrate interaction including blow-off effects, corona formation around the high voltage electrode as well as particle charging mechanisms within the corona.
Previous works have demonstrated the practical relevance of the software in terms of qualitative and quantitative validation against hundreds of coating experiments. In addition a comprehensive graphical user-interface was recently added, further increasing its practical applicability.
In the current study, CoatSim is applied to compare actually thousands of process-parameter scenarios for the powder coating of U-profiles, which, due to Faraday-cage effects, have always posed a certain challenge for powder coating. More specifically the focus of this study lies on investigating the impact of varying process parameters on key-performance-attributes of the process. The process parameters to-be-varied are: i) applied voltage, ii) primary- and secondary- process airflow rate and iii) particle-charging-function-factors. The key-performance-attributes to be evaluated are: i) visualised coating-patterns, ii) coating-efficiencies, and iii) the relative standard batch-based coating deviation. Limiting investigations to static setups (= pistol not moving), single-pistol-, single-burst- scenarios and simplifying certain parameter-cross-dependencies, optimal U-profile coating-process-settings can be proposed.

CoatSim, U-Profiles, Powder Coating, Kaleidosim, Massive Simultaneous Cloud Computing, Parameter Study, OpenFOAM

Wind Farm Optimization Using Machine Learning

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1. Oslo Metropolitan University, Oslo, Norway
2. Equinor ASA, Norway

Over the past decade offshore wind farms have gained significant interest from different stake holders. However, one of the main problems which still need considerable attention from researchers is regarding the wind turbines relative location in the wind farms. In the present work different wake models coupled with machine learning are used to address the problem of wind farm optimization. One of the expected objectives of a wind farm is to guarantee high Annual Energy Production (AEP) at a low operational cost. One way to achieve this is to understand the multi-physics involved in he operation of a wind turbine. In the current paper Shell hackathon dataset consisting of three different types of data namely wind data, turbine power curve data (based on Jensen Wake model) and the turbine locations data (for testing) is used. With the objective of maximising AEP, different ML algorithms, are utilised on the Shell dataset to arrive at an optimised wind farm layout. Various python packages such as PyWake shall be used to perform the optimization.

windfarm, optimization, machine learning

The Modelling of Substrate Surface Interactions in a Eulerian-Lagrangian Multiphysics Solver and its Impact on Powder Coating Pattern Prediction

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

In industrial processes, powder coating is widely utilized to attain functional or aesthetic surface properties on manufactured parts. In our previous contributions, we have introduced the software coatSim developed specifically for the simulation of surface coating processes and an underlying Eulerian-Lagrangian Multiphysics solver, developed within OpenFOAM.
In the scope of the current study, a closer investigation is conducted into the interactions that occur on the surface of a substrate during the coating process. As a first approximation, it can be assumed that a particle sticks to the substrate at the location of first contact. However, in reality it is observed that particles glide over the substrate, based on the forces acting on them. Of those forces, the pressure force, exerted by the on-setting airflow and the electro-static particle-substrate attraction force act perpendicular and pointing towards the surface of the substrate, while the fluid-particle shear force and an electrostatic particle-particle repulsion force, act parallel to the surface. The gravitational body force, which may have components in both directions, depending on the orientation of the substrate, will complete the force balance on individual particles at a certain location on the substrate. The ratio of magnitude of the sum of perpendicular force components to parallel force components will determine whether a particle will stick or not. In the latter case the particle will drift along the substrate surface until blown-off. It will be demonstrated that the interactions on the surface of the substrate have a big impact on the coating outcome and that experimentally observed patterns can only be predicted accurately if those interactions are taken into account. Experiments conducted previously will form the basis for the validation of the surface interaction model and a dimensional analysis will illustrate the weight of the individual forces on the overall force balance.

Powder coating; coatSim; Multiphysics simulation solver; Particle surface interaction; Eulerian Lagrangian method

The Explosive Boiling Caused by Thermal Contact between Cryogenic Fluid and Room Temperature Fluid

A Nakano, T Watanabe, K Tokunaga, T Shiigi
National Fisheries University, Japan

Thermal contact between cryogenic and room temperature fluids causes explosive boiling and freezing phenomena. This is because the superheated state of the cryogenic fluid and the supercooled state of the room temperature fluid coexist. In this study, in order to investigate their use as energy, the explosive phase change phenomena caused by thermal contact between cryogenic and room temperature fluids were treated as part of an experiment on the boiling of cryogenic fluids. Liquid nitrogen was used as a representative cryogenic fluid and tap water as a typical room temperature fluid. When these were brought into thermal contact, their boiling and freezing aspect, the evaporating mass of liquid nitrogen and the temperature change of the liquid were observed. Based on these results, the effectiveness of energy utilization of the explosive phase change phenomena caused by this thermal contact was considered. In the future, we are planning to develop that numerical models based on the results obtained.

Liquid Nitrogen, Explosive boiling, Cryogenic fluid, Room temperature fluid, Thermal contact

SESSION 2.3

OPTICS AND ACOUSTICS

FRIDAY 16 DECEMBER 2022
14:00 – 15:30

CHAIR

M Souli
Lille University
France

Electron Beam Collimation Study with CFD

DA Shestakov
VDL Enabling Technologies Group (VDL ETG), Eindhoven, The Netherlands

Electron beam collimation by classical asymmetric triple-element electrostatic lens was studied with help of ANSYS CFX. The primary objective was to understand if a CFD tool can be used for reliable analysis of the electron optics system. The standard particle tracking and electric field modelling features of the CFX were used together with customized routine for classical Lorentz force acting on the particle with proper charge-to-mass ratio. The results were compared to publicly available experimental data and numeric simulations by specialized software SIMION. CFX and SIMION models have similar accuracy when compared to the experiment.
It was concluded that ANSYS CFX can be already used for electron optics simulations for 0-5 keV electrons.

CFD, electron optics

FEM Analysis of Various Multilayer Structures for CMOS Compatible Wearable Acousto-Optic Devices

M Hanif[1], V Jeoti[2], MR Ahmad[1], MZ Aslam[1], S Qureshi[2], G Stojanovic[2]
1. Universiti Teknologi PETRONAS, Malaysia
2. University of Novi Sad, Novi Sad, Serbia

Lately, wearable applications featuring photonic on-chip sensors are on the rise. Among many ways of controlling and/or modulating, the acousto-optic technique is seen to be a popular technique. This paper undertakes the study of different multilayer structures that can be fabricated for realizing an acousto-optic device, the objective being to obtain a high acousto-optic figure of merit (AOFM). By varying the thicknesses of the layers of these materials, several properties are discussed. The study shows that the multilayer thin film structure-based devices can give a high value of electromechanical coupling coefficient (k2) and a high AOFM as compared to the bulk piezoelectric/optical materials. The study is conducted to find the optimal normalized thickness of the multilayer structures with a material possessing the best optical and piezoelectric properties for fabricating acousto-optic devices. Based on simulations and studies of SAW propagation characteristics such as the electromechanical coupling coefficient (k2) and phase velocity (v), the acousto-optic figure of merit is calculated. The maximum value of the acousto-optic figure of merit achieved is higher than the AOFM of all the individual materials used in these layer structures. The suggested SAW device has potential application in wearable and small footprint acousto-optic devices and gives better results than those made with bulk piezoelectric materials.

Figure of merit, acousto-optic, SAW, LiNbO3, ZnO, AlN, SiO2, multilayer structures, piezoelectric, optics, COMSOL, FEM

Numerical Simulations on the Performance of Optical-Acoustic Sensors of Minimal Dimensions

A Kosík[1], G Stojanovic[2]
1. OST Ostschweizer Fachhochschule, Buchs, Switzerland
2. AMS International AG, Jona, Switzerland

This paper presents analytical and numerical methods for developing optical-acoustic sensors of minimal dimensions. One can find acoustic sensors used as microphones in various electronic devices such as smartphones or smartwatches. Therefore, it is highly desirable to minimize them while ensuring high-quality sound reception.
The optical-acoustic sensor relies on laser detection of membrane vibrations. It consists of a membrane that vibrates in the presence of an acoustic field and reflects the radiation emitted by the laser back to the laser. We are concerned with methods to optimize the design of the membrane itself and also the cavity (back volume) that separates the laser from the membrane. The back volume compliance significantly affects the sensitivity of the membrane. In addition, it is a noise source due to acoustic and viscous damping. Using calculations and simulations, we show the possibilities of reducing the membrane size and the air-filled back volume size while achieving the desired acoustic properties. We employ analytical calculations for the mechanical vibration of the diaphragm, back-volume compliance and resistance, and precise FEM simulations of the interaction between membrane vibration and the acoustic field. We build on similar techniques used for micromachined capacitive microphones, but we apply these methods newly to a specific setup of backplate-less optical-acoustic sensors. Based on the theoretical results, we can conclude that optical-acoustic devices achieve the same maximum noise level with smaller dimensions than the current industry standard.

optical-acoustic sensors, membrane dynamics, acoustic and viscous damping, FEM simulations

Structure Optimization for Electrostatic MEMS Mirror in Autonomous Vehicle LiDAR Application

Z Yan[1], Z Li[2]
1. Sichuan University, Chengdu, China
2. University of Michigan, Ann Arbor, United States

This paper presents an electrostatic-based scanning MEMS mirror with high scanning angle and stability. The mirror is designed for Light detection and ranging (LiDAR) system on self-driving cars. Multiple facts are revealed in this paper using simulation tool COMSOL Multiphysics on structure optimization. The mirror is actuated by comb drive rotators, and able to cover a maximum of ± 10.31 degrees in both axes and scan at maximum 1.8 kHz, while its size can be reduced to within 2 × 2 mm2.This design is tested in -50 ℃ to 100 ℃ temperature range and 20 g acceleration in both lateral and vertical directions to prove its robustness. The design in this paper is expected to further lower the cost of LiDAR system, increase scanning efficiency, and promote the popularization of LiDAR devices in autonomous vehicles.

MEMS mirror, LiDAR, electrostatic actuator

SESSION 2.4

<u>POSTERS</u>

FRIDAY 16 DECEMBER 2022
16:00 – 17:30

CHAIR

T Rahulan
Staffordshire University
United Kingdom

Liquid Nitrogen Flashing in the Glass Vessel under Rapid Depressurizations

T Watanabe[1], A Nakano[1], K Tokunaga[1], T Shiigi[1], K Shimojima[2]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, Japan

Recently, a demand for cryogenic fluids as a coolant has been increasing because of the industrial development of low temperature technology. The purpose of this study is to clarify some fundamental features of the phase changes associated with the flashing of cryogenic fluid. Liquid nitrogen at low temperatures was used as the test liquid. Experiments on the decompression boiling of liquid nitrogen in a pressure vessel made of glass were conducted. In these experiments, many types of boiling behavior were observed. These were classified into several typical patterns by visual observation. The degree of superheat of liquid nitrogen at the start of boiling was found to depend strongly on the rate of depressurization.

Liquid Nitrogen, Flashing, Depressurization, Glass vessel

Effect of Shock Loading Pre-Processing for Freeze-Drying

T Watanabe[1], K Tokunaga[1], T Shiigi[1], K Shimojima[2], S Tanaka[3], K Hokamoto[3], S Itoh[4]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, Japan
3. Institute of Industrial Nanomaterials, Kumamoto University, Japan
4. Institute of Shockwave Applied Technology, 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.

Shock Loading, Pre-processing, Freeze-drying

Cold Heat Shock Loading to Parasite by Liquid Nitrogen

T Watanabe[1], T Shiigi[1], K Tokunaga[1], K Shimojima[2]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, 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

Phase Change Phenomena of Water under Decompression State

T Watanabe[1], A Nakano[1], K Tokunaga[1], T Shiigi[1], K Shimojima[2]
1. National Fisheries University, Japan
2. Okinawa National College of Technology, 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, Phase Change, Decompression State

Developing a Fast Cloud-Based Simulation Workflow for the Full Aerodynamic Evaluation of Airborne Vehicles

A Schubiger, D van-Oerle, G Boiger
ZHAW Zurich University of Applied Sciences, Switzerland

The field of Computational Science is facing an increasing demand for data-intensive research. Engineering tasks such as parameter-, sensitivity- and optimisation studies require ensemble computing to an ever-increasing extent. At the same time, the field of artificial intelligence (AI) is pushing for ever more extensive, numerically derived learning-, testing- and validation data.
With the cloud software KaleidoSim, we can run hundreds of numerical simulations simultaneously [1] and generate large amounts of data in a short time. Whilst KaleidoSim supports various simulation tools, only OpenFOAM is used in this study.
In this work, we have developed tools and routines to accelerate, simplify and automate studies with hundreds of simultaneous simulations in the cloud. We performed a full 360° aerodynamics analysis of different aircraft to test our toolbox. The study included 420 OpenFOAM simulation cases. Each case was a steady-state, Reynolds Average Stress (RAS) turbulence model-based, single-phase flow simulation on a 1.5 million cell hexahedral finite volume grid. Drag and lift coefficients were calculated for each case.
For the toolbox development, we used a combination of Python and KaleidoSim Application Programming Interface (API) routines. The Python-based graphical user interface (GUI) allows switching between different CAD models to compare multiple aircraft. The GUI also allows mesh sensitivity analysis to determine optimised meshes for each aerodynamic shape. Based on this, we performed a series of mesh sensitivity analyses using snappyHexMesh and CfMesh meshes.
This work has shown that a combination of cloud computing via KaleidoSim-based API routines and Python scripting can speed up certain parameter study workflows by a factor of 50-100. Specifically, the exemplary representative semi-automated workflow of the 420-case aerodynamic study could be performed and post-processed in less than 45 minutes, whereas a comparable workflow had previously taken up to an entire work week on local hardware.

OpenFOAM, Massive Simultaneous Cloud Computing (MSCC), CFD, Aerodynamic Analysis

Statistical Prediction of Rate Constants for the Pyrolysis of High-Density Plastic Waste

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The 400 million tons of waste plastic are disposed of around the world. A study reported by SINTEF estimates that the Norwegian fishing fleet dumps around 380 tons of plastic material in the ocean each year. This waste is increasing at an alarming rate, threatening aquatic life, polluting the environment, and causing serious diseases. Since this waste includes hydrocarbons and is a massive source for economically producing pyrolytic oil that can replace traditional fuels. To obtain Liquid fuels and gases from the thermal destruction of high-density plastic (HDP) pyrolysis using empirical rate constants is costly and time-consuming. A commercially sustainable quantity of liquid fuel is not achieved. As a result, predicting statistical rate constants (k) which are based on a suitable combination of activation energy (Ea) and frequency factor (Ao), and investigating their sensitivity is a need of time that has not been documented. This study can provide a better insight into the reaction mechanism of HDP and assess the suitable combination of Ea, Ao, and k that can play a significant role in the effectiveness of liquid fuels and gases at a commercial scale.
In this study, H-abstraction, chain fission, polymerization, and β-scission reactions have been chosen from literature due to the majority of free radicals. The Arrhenius equation is implemented in R software to predict temperature-dependent rate constants at a fixed temperature (340°C to 370°C). In MATLAB (R2020a) the second-order differential equation solver has been employed to assess how changes in temperature, Ea, and Ao affected the efficiency of species such as oil, gas, and waxes.

Pyrolysis, Waste, Plastic, Reaction Constant, Product Yield

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