NAFEMS EASTERN EUROPE CONFERENCE

24-25 April 2024 | Kraków, Poland

Gold Sponsor	Silver Sponsors	Exhibitors	Media Sponsor

Agenda | 15th of April 2024

NAFEMS Eastern Europe Conference 2024
24-25 April 2024, Kraków Poland

Plenary presentations

Bayesian Uncertainty Quantification and Machine Learning in Engineering Analysis

Dr. Frank Günther

Director of Analysis & Simulations at Knorr-Bremse Rail Systems

Virtual development of technical rubber products and tires

Dr. Boris Kuselj

Head of Virtual Engineering EMEA at Trelleborg Seals & Profiles

Industrial implementation of the external approximations

Dr. Victor Apanovitch

Senior Vice President at Altair | Author of the book "The Method of External Finite Element Approximations"

Electromagnetic simulations in technical, industrial, and medical applications

Dr. Rafal M. Wojciechowski

Director for Science of Institute of Electrical Engineering and Electronics at Poznan University of Technology

FEA processes organization for the purpose of concurrent design

Marcin Debniak

Validation manager for Global FEA Operation | Faurecia R&D Center Poland

Special sessions

Nonlinear FEA the Smart Way: Designing Beyond the Obvious

Practical guide of harnessing the Nonlinear FEA Power in Real-World designs

Dr. Łukasz Skotny

CEO / Lead Designer / FEA Course Creator at Enterfea

enterfea

Probabilistic Foundations of Uncertainty Quantification and Machine Learning: How to Model What We Don't Know

Dr. Frank Günther

Director of Analysis & Simulations at Knorr-Bremse Rail Systems

KNORR-BREMSE

First day of the conference - 24th of April 2024

All aspects of engineering simulation

09.00 – 09.30	Registration	
09.30 – 10.00	Conference opening ceremony – NAFEMS (Ian Symington, Marton Groza)	
10.00 – 10.40	Bayesian Uncertainty Quantification and Machine Learning in Engineering Analysis Dr. Frank Günther, Director of Analysis & Simulations at Knorr-Bremse Rail Systems	
10:40 – 11.20	Virtual development of technical rubber products and tires Dr. Boris Kuselj, Head of Virtual Engineering EMEA at Trelleborg Seals & Profiles	
11.20 – 11.50	Morning break	
11.50 – 12.30	Electromagnetic simulations in technical, industrial, and medical applications Dr. Rafal M. Wojciechowski, Director for Science of Institute of Electrical Engineering and Electronics at Poznan University of Technology	
12.30 – 13.00	Aiolas – NAFEMS AI Ian Symington, Chief Technical Officer at NAFEMS	
13.00 – 14.00	Lunch	
14.00 – 15.00	Structural Mechanics 1 Chair: Dr. Witold Kąkol Shake Table Test of Instrument Transformer Compared to Transient and Response Spectrum Analysis Ivan Čehil, Koncar Instrument Transformers Automated data-driven method for nonlinear material model fitting for composites Kristóf Szalai, Senior Structural Analyst at eCon Engineering Dental implant structural and durability performance study Dr. Jakub Michalski, Simulation engineer at Technia	System Simulation Chair: Karol Wesołowski Electric truck cabin and HVAC digital twin with novel type of thermal measures in a multi-level simulation environment Imre Gellai, Austrian Institute of Technology Utilising an FMU protocol to perform 1D-3D coupling studies Slawomir Polanski, Technia UK Simulation-Based Digital Twins in a Multiphysics World Dr. Árpád Forberger, Gamax Laboratory Solutions
15.00 – 15.20	Afternoon break 1	
15.20 – 16.20	Computational Fluid Dynamics 1 Chair: - Prediction of thermal shock phenomenon in car radiators using CFD and FEA techniques Tomasz Płusa, Łukasz Widzyk, Valeo How To Reduce Costs & Increase ROI Of Your CAE Simulations in the Cloud Wolfgang Gentzsch, UberCloud Accelerating Vehicle Aerodynamics Simulation with Cloud-Based CFD and Optimization Tools Sophie Petraman, Noesis Solutions	Special Session 1 Probabilistic Foundations of Uncertainty Quantification and Machine Learning: How to Model What We Don't Know Dr. Frank Günther Director of Analysis & Simulations at Knorr-Bremse Rail Systems
16.20 – 16.40	Afternoon break 2	

16.40 – 17.40	Structural Mechanics 2 Chair: Marcin Lisiecki Design of tube-to-tube joining tool by FEA – simulations and V&V Dr. Szabolcs Jónás, Dr. Péter Zoltán Kovács, Knorr-Bremse Rail Systems, Budapest University of Technology and Economics, University of Miskolc Metal–polymer self-piercing riveting with various FEM codes analysis Dr. Robert Cacko, Assistant Professor at Warsaw University of Technology NVH methods standardization for massive application in Forvia Automotive Seats Simulations Maciej Malinowski, Senior FEA Engineer, Faurecia Grójec R&D Center	Special Session 1 Probabilistic Foundations of Uncertainty Quantification and Machine Learning: How to Model What We Don't Know Dr. Frank Günther Director of Analysis & Simulations at Knorr-Bremse Rail Systems
17.40 – 19.00	Exhibition	
19.00 – 21.00	Conference dinner	

While we aim to maintain this schedule to facilitate your planning, please note that there may be adjustments. We appreciate your understanding and flexibility.

Second day of the conference - 25th of April 2024

Simulation supporting engineering design

09.00 – 09.20	Opening of the second day	
09.20 – 10.00	Industrial implementation of the external approximations Dr. Victor Apanovitch, Senior Vice President at Altair, Author of the book "The Method of External Finite Element Approximations"	
10.00 – 10.40	FEA processes organisation for the purpose of concurrent design Marcin Debniak, Validation manager for Global FEA Operation, Faurecia R&D Center Poland	
10.40 – 11.10	Morning break	
11.10 – 11.20	Plenary presentation from the Gold Sponsor, Altair Driving value for your business with Digital Twins Kimon Afsaradis, Vice President EMEA Indirect Business	
11.20 – 11.40	Multiphysics simulations for short-time current (STC) tests of electrical power equipment Paweł Bajerski, R&D, Team Leader and Jakub Rozwód, Scientist at ABB Sp. z o.o.	
11.40 – 12.00	Numerical analyses as engineering support in the diagnostic process, illustrated by the identification of causes of damage to railway suspension Adam Przewoźnik, EC Engineering	
12.00 – 13.00	Lunch	
13.00 – 14.00	Structural Mechanics 3 Chair: - On design guidelines for non-standard components Anže Čelik, Poclain Hydraulics Offshore Pipeline Installation Bartosz Dywan, Analysis Engineer at TechnipFMC	Special Session 2 Nonlinear FEA the Smart Way: Designing Beyond the Obvious Practical guide of harnessing the Nonlinear FEA Power in Real-World designs Dr. Łukasz Skotny CEO, Lead Designer, FEA Course Creator at Enterfea

	Quick and reliable simulation process automation reducing product development time and cost Karlheinz Peters, Business Development Lead at Novus Nexus	
14.00 – 14.20	Afternoon break 1	
14.20 – 15.40	Structural Mechanics 4 Chair: - Machine Learning Optimization and Quick Verification of an Electric Vehicle Rocker Design Athanasios Papadopoulos, Customer Service Specialist at BETA CAE Systems The numerical calculations of the bolted connection Dr. Marcin Nowak, Advanced Engineering Solutions, ALTEN Polska Combination of Finite Element Analysis with Checks According to Standards Oleg Ishchuk, Chief Operating Officer at SDC Verifier Enhancing Turbomachinery Design: Integrating Machine Learning with Computational Fluid Dynamics for Efficient and Accessible Aerodynamic Analysis Semih Şimşek, Numesys	Special Session 2 Nonlinear FEA the Smart Way: Designing Beyond the Obvious Practical guide of harnessing the Nonlinear FEA Power in Real-World designs Dr. Łukasz Skotny CEO, Lead Designer, FEA Course Creator at Enterfea
15.40– 16.00	Afternoon break 2	
16.00 – 16.20	Conference closing ceremony (NAFEMS Eastern Europe Steering Committee)	

While we aim to maintain this schedule to facilitate your planning, please note that there may be adjustments. We appreciate your understanding and flexibility.

Plenary presentations

Bayesian Uncertainty Quantification and Machine Learning in Engineering Analysis

Dr. Frank Günther

Director of Analysis & Simulations at Knorr-Bremse Rail Systems

The role of engineering analysis in product development is in the middle of a dramatic paradigm shift.

The first phase of engineering analysis was characterized by hand calculations and pioneering finite element calculations, suitable for little more than preliminary dimensioning and gaining engineering understanding of a product.

In the second phase, computer aided engineering, engineering analysis was used to predict hardware test results as accurately as possible. This has made product development more efficient and accelerated product development cycles.

The third phase is the complete digital transformation of the whole product life cycle:

- Virtual verification, validation, and certification eliminates the need to use hardware testing as the final confirmation of an OK result. Instead, we test to gather information in the most efficient way.
- Digital twins create interaction between the physical and virtual worlds, fusioning data from many sources.
- Creation of new, digital and digital-enhanced products.
- Convergence of different modelling domains: physical, statistical, ML / data driven.

This shifting role of engineering analysis makes simulation governance more and more important: We need to establish processes and quality management systems such as NAFEMS ESQMS to ensure the predictive power of simulation results, and we need to quantify the uncertainty of our predictions.

Bayesian machine learning methods are an ideal extension of engineering analysis to quantify uncertainty. They are the product of a similar transformation in the field of statistics, from frequentist hand calculations to solving general statistical models through numerical solution procedures such as Markov Chain Monte Carlo.

This presentation will illustrate these general trends with specific application examples that show the convergence of physical and statistical modelling.

Virtual development of technical rubber products and tires

Dr. Boris Kuselj

Head of Virtual Engineering EMEA at Trelleborg Seals & Profiles

Virtual Product Development (VPD) is an interdisciplinary, finite element method based, alternative to the traditional, mostly empirical approach produce-try-correct a prototype. VPD or CAE (Computer Aided Engineering) is widely used in many industries for product development. Knowledge of mechanics, modelling of material properties, product design principles and use of dedicated software packages are needed for this interdisciplinary approach. To utilize its advantages entirely, it is smart to employ VPD early in the product development process for what-if parametric and sensitivity studies of design variants and material choices.

Virtual prototypes of a product are virtually tested in obtain insight into performance of a product in conditions close to those in service. Less physical prototyping and testing, and less guesswork are needed. Increased design quality and reliability of products is achieved at reduced development costs.

Geometry and elastomeric materials of rubber products exhibit mostly nonlinear behaviour. Elastomeric materials are nearly incompressible. Their progressive-degressive hyperelastic stress-strain relationship may be almost reversible upon unloading leaving a certain hysteresis. Such mechanical properties can be handled by finite elements of the Herrmann formulation. Mechanical and thermo-mechanical material properties are described by a material model, where parameters and exponents may be computed from experimental data.

VPD of some technical rubber products and motorcycle tires are presented and explained along with experimental verification.

Electromagnetic simulations in technical, industrial, and medical applications

Dr. Rafal M. Wojciechowski

Director for Science of Institute of Electrical Engineering and Electronics at Poznan University of Technology

The presentation will discuss the latest research results related to the implementation of the finite element method (FEM) - especially in its new, multi-stage approach - for the design, modelling, and analysis of systems with an electromagnetic field.

The history of the development of numerical methods used in modelling electromagnetic phenomena will be presented. Next, field methods for describing electromagnetic phenomena and equations describing the electromagnetic field distribution in systems with conduction currents and dielectric shift currents will be discussed. The definition of the generalized element used in the multi-stage approach will be provided, along with mesh models of systems with electromagnetic fields used in modelling systems through the multi-stage FEM approach.

However, special emphasis will be placed on the modelling and analysis of systems widely used in technology and industry, including electric drives (e.g., electric motors with permanent magnets), elevator systems (e.g., special converters, executive actuators, etc.), and systems used in power systems (e.g., variable inductance inductor); as well as in medicine, particularly in modelling the phenomena of magnetic hyperthermia, which finds applications in the destruction of cancer cells.

Industrial implementation of the external approximations

Dr. Victor Apanovitch

Senior Vice President at Altair | Author of the book "The Method of External Finite Element Approximations"

Fundamental mathematical features of external finite element approximations (EFEA) are discussed. It is shown that the features make EFEA well suitable for industrial software implementations. Robustness, speed, and accuracy of the simulations come from alternative definitions of degrees of freedom (DOF), use of always complete spaces of approximation functions, exact integration in a physical space, and decoupling of the function definitions from geometry. It is also shown that alternative DOF can be associated with arbitrary geometrical entities including ragged surfaces, point clouds, and sub-volumes. This makes software implementations extremely robust in handling assemblies with such classic geometry imperfections like misalignments, excessive gaps/penetrations, corrupt and untrimmed geometries, etc. Therefore, EFEA technology can be a perfect foundation for development of FEA software oriented towards users from almost none to a very modest experience in simulations. The alternative definition of DOF also allows to construct highly adaptive schemes of the computations which results in significant reduction in equation system size, speedup of the computations, and small memory footprint. Another benefit of geometry-functions decoupling is the possibility to construct approximation functions which are traditionally problematic for conventional Finite Element Analysis like divergence-free functions, or function which meet governing differential equations of a Boundary Value Problem. This results in further reduction of the equation system size, improved accuracy, and unconditionally stable numerical solutions.

Special Sessions

Probabilistic Foundations of Uncertainty Quantification and Machine Learning: How to Model What We Don’t Know

Dr. Frank Günther

Director of Analysis & Simulations at Knorr-Bremse Rail Systems

Tutor biography

Dr. Frank Günther is the Director of Virtual Testing and Simulations at Knorr-Bremse SfS, the world market leader for railway brake systems, as well as many other railway technologies. In this role he leads several diverse, international teams responsible for all aspects of CAE and numerical simulation.

Dr. Günther has many years of experience both as a leader and an expert in numerical analysis and simulation technology. His experience has led him to become a proponent of Virtual Testing, Simulation Governance, Physics-Informed Machine Learning / AI, and Uncertainty Quantification.

Before joining Knorr-Bremse, Dr. Günther worked as a senior crash simulation expert and project leader at Daimler AG in Stuttgart, Germany.

He started his career by obtaining a PhD in the Theoretical and Applied Mechanics Group of Northwestern University in Evanston, IL (USA).

Seminar details

1) Introduction to uncertainty, statistical modeling, and learning from data (50 min)
    a) Bayesian and Frequentist concepts of probability,
    b) Aleatory and epistemic uncertainty,
    c) Tools for statistical machine learning,
    d) Statistical modeling: data generating model and prior predictive simulation,
    e) Bayes’s rule as the foundation for statistical simulation,
    f) (Machine) Learning from data and posterior predictive simulation.
2) Industrial applications (50 min)
    a) Uncertainty quantification as an important element of Simulation Governance,
    b) Numerical solution of statistical models: Kalman filters, particle filters, Markov Chain Monte Carlo,
    c) Example: Using statistical machine learning to predict fatigue test outcomes,
    d) Example: Using statistical machine learning to enhance faulty and incomplete measurement data through sensor fusion.

A full set of notes in PDF format as well as simulation case files in ZIP format will be available for download for the seminar attendees. All the above will be explained in a purely practical manner without much theory. Most explanations will be done on simple examples attendants will be welcomed to try for themselves.

What will you learn?

- You will learn about the basics of Uncertainty Quantification and Statistical Machine Learning starting from first principles such as concepts of probability and the application of Bayes’s Rule.
- You will see how statistical simulations can be run and evaluated using freely available software such as R, Stan, and RStudio.
- You will learn about application use cases of Statistical Machine Learning in industry.

What questions will this course answer?

- What is probability and how can I use it to assess and enhance the predictive power of simulations?

- How can I use statistical modeling to learn from data?
- How can statistical simulation bridge the gap between traditional simulation and "physics-agnostic" machine learning?
- How can I make predictions and decisions in the face of uncertainty?

Who should attend?

Everyone is welcome to attend. The seminar will be most interesting for

- Simulation engineers that would like to understand the predictive power of their models by quantifying uncertainty.
- Engineers that would like to broaden their understanding of potential applications of statistical machine learning in their field.
- Anyone interested in the practical application of physical modeling, machine learning, and data science.

Nonlinear FEA the Smart Way: Designing Beyond the Obvious

Dipl.-Ing. Dr.techn. Łukasz Skotny

CEO / Lead Designer / FEA Course Creator at Enterfea

Tutor biography

Hey, my name is Łukasz Skotny.

I studied civil engineering in the Wrocław University of Technology, where I've made a Ph.D. in the field of shell stability. I've been an academic teacher for a decade in the field of designing structural steel structures.

Parallel to my Ph.D. I started my first design company (structural field). Right now, Enterfea is a leading company in the region providing high-end Nonlinear FEA designs to our Customers. At the same time, I'm running a blog, and I offer online and offline training in Finite Element Analysis and Structural Design.

Privately I have a wonderful wife, and 4 awesome kids. I like miniature wargaming (mostly Warhammer), reading good fantasy books and snowboarding (in winter) and rollerblading (in summer).

Seminar details

The seminar will cover following topics:

1. Introduction To Nonlinear FEA
    a. Difference between Linear and Nonlinear Analysis
    b. Problems with establishing realistic outcomes in Linear FEA
    c. What can be nonlinear in your models
2. Understanding how things work
    a. What Nonlinear Material does
    b. What Nonlinear Geometry does
    c. What are the practical implications
3. Running your Nonlinear Analysis
    a. How Nonlinear Solver works, and what it means to you
    b. How to properly set Nonlinear Analysis
    c. Dealing with non-convergence
    d. Different Steering options in Nonlinear Solvers
4. Understanding Outcomes of Nonlinear Analysis
    a. How to establish capacity based on nonlinear analysis

All the above will be explained in a purely practical manner without much theory.

Most explanations will be done on simple examples attendants will be welcomed to try for themselves.

What will you learn?

You will gain knowledge and understanding about Nonlinear FEA analysis. What things can be nonlinear, why that is the case, and what this implies to practical design.

You will also learn how to properly set up nonlinear solver, how to deal with common non-convergence problems and what to expect.

But what is perhaps most important is, that you will learn how to interpret outcomes of nonlinear FEA analysis in design scenarios.

What questions will this course answer?

- What is Nonlinear FEA?
- What can be Nonlinear, and what this means in practical setting?
- How to properly setup and run Nonlinear FEA analysis?
- How to post-process outcomes to establish capacity of your model.

Who should attend?

Everyone is welcome to attend. The seminar will be most interesting for

- Civil, Structural, Mechanical, Aerospace and Naval engineers required to perform capacity design of various (mostly metal) systems with the use of Finite Element Analysis.
- Project managers dealing with FEA done by others, and willing to deepen their understanding of the field (and what to pay attention to when assessing if the analysis is what was needed).
- Academic researcher trying to build their own FEA models.

Presentations | Structural mechanics

Metal–polymer self-piercing riveting with various FEM codes analysis

Dr. Robert Cacko

Assistant professor at Warsaw University of Technology

Self-piercing riveting – SPR – is a mechanical joining technique that involves local plastic deformation of the connected sheets and the connecting element – rivet. In recent years, it has become an attractive alternative method of assembling various sheet-made components made of metals, especially lightweight.

Modelling the SPR process at the beginning was not a trivial task due to the occurrence of two phenomena: a significant local strains gradient, translating into local solid deformations of the finite elements mesh and fracture (separation) of the upper layer material, which must be taken into account to lead to the appropriate foundation of rivet in coupled sheets. Modelling and simulations of the SPR, after many years of different tests and approaches, have been well recognized for materials that are most often assembled with this method: steel and aluminium. However, attempting to use other materials, especially with significantly different properties, is not trivial. So far, the authors presented such problems when joining copper sheets.

This work presents trials to use various codes based on FEM for modelling the joining polymer–metal stack-up and the resulting problems. It is a part of the initial stage of the project, which aims to refine the methodology of joining steel and aluminium sheets with polymer materials used in the car industry. Some of the initial results indicated such applications' promising capabilities, while others showed the misalliance of selected parameters. The tests demonstrate the potential for connection using standard steel rivets and a field for research on modifying rivets (printed rivets, rivets with variable properties zones, etc.). Three different approaches based on three commercial codes and comparing the results are finally presented.

On design guidelines for non-standard components

Anže Čelik

Valve simulation expert at Poclain Hydraulics

Poclain Hydraulics is a world market leader for hydrostatic transmissions and strives to offer a complete solution for most-demanding applications. An increase of market needs and demands require hydraulic components and systems to be more efficient, more reliable, and last but not least, adopted to customer environment.

The paper shows and explains activities performed to evaluate mechanical response of non-standard plug because of different loading type. In-depth understanding of plug behaviour helps to setup design guidelines for such components.

In the first step, different non-standard plugs have been selected to consider size effect. Then, different materials have been selected in order to evaluate effect of plug material. For the purposes of experimental evaluation, plugs have been modified to allow installation of strain gauges.

Thanks to detailed simulation model, mechanical response has been closely observed. Stress field helps to identify areas where design modifications are needed as well as to identify "hot-spots" on plug that affects structural integrity.

Experimental activities have been performed with the aim to evaluate induced stresses and preload forces due to tightening torque, contact forces and piloting pressure due to spool shifting, etc. Tests have unrevealed several details regarding mechanical response on plug that have not been known previously.

Shake Table Test of Instrument Transformer Compared to Transient and Response Spectrum Analysis

Ivan Čehil

R&D engineer at Koncar Instrument Transformers

Instrument transformers play an important role in substations. Although their primary role is to accurately transfer electrical variables such as voltage and current to measurable values, their mechanical withstand is also a very important aspect of their performance. With this in mind, it is essential to design the instrument transformers in such a way that they can withstand substantial mechanical loads, regardless of which natural phenomena they originate from.

One of the most unpredictable and destructive natural phenomena that affects the power grids and instrument transformers is an earthquake. Due to their specific slender design, instrument transformers, if not adequately designed, can be a critical component of the substation when facing the earthquake loads. The main aim of this paper is to present strains, stresses and deflections recorded during the shake table test of 145 kV voltage instrument transformer mounted on the support structure and compare them to the values calculated by two different numerical methods, non-linear transient earthquake analysis and linear response spectrum analysis.

Furthermore, this paper will try to evaluate how relevant are these two fundamentally different numerical methods when compared to an actual shake table test and potentially highlight the need for nonlinear analysis to be more strongly considered in future versions of seismic standards.

All calculations and shake table test itself will be made in accordance with the IEEE 693-2018 standard which is widely recognized as the most stringent and broad seismic standard for substation equipment. The data and conclusions of this paper may be of interest to substation designers, equipment manufacturers, seismic specialists as well as equipment users as they provide broad insight into the seismic behaviour of one of the substation's critical equipment.

NVH methods standardization for massive application in Forvia Automotive Seats Simulations

Maciej Malinowski

Senior FEA Engineer, R&D Test & Simulation, Faurecia Grójec R&D Center

FORVIA is an automotive technology group at the heart of smarter and more sustainable mobility: We bring together expertise in electronics, clean mobility, lighting, interiors, seating, and lifecycle solutions to drive change in the automotive industry. "Forvia Faurecia automotive seating" is developing and manufacturing complete seats, frames and mechanisms for all car manufacturers.

Seat parts development and validation is currently mainly based on Safety & Regulation specifications and simulation methods mainly aiming to get predictive models for crash simulation. NVH models are created through conversion of our crash models. The aim of this study is to standardize the implementation of the modelling methodology for modal simulation of seats and mechanisms at Forvia. The most important task was the development of a standardized method for modelling kinematic connections and contact interactions in complex structures of entire seats. Method should be easy to use and allow to convert models to other computational programs.

In the process of creating and validating the method, simulations from many designs of seats and mechanisms were used including correlation process with real tests were used. In the last stage, efficiency tools were introduced to standardize modelling choices and significantly speed up the model creation process.

As a result of the team's work and activities, it was possible to find and standardize a method for modelling connections in modal analysis and most importantly, to introduce a clear process validated in many projects around the world. To sum up, the standardization of the connection modelling method has been verified and correlated with real tests on many projects, giving FEA engineers the opportunity to examine design changes as well as conversion to other programs with a minimal investment of their working time.

Offshore Pipeline Installation

Bartosz Dywan

Analysis Engineer at TechnipFMC

Installation by reel-lay is the fastest and most efficient method of installing offshore pipelines. The TechnipFMC vessels Deep Energy, Deep Blue have been purpose built for this method. The installation involves fabrication of the pipeline at an onshore spool base, spooling and transportation on the lay vessel, and installation at the desired offshore location. Standardized of approximately 1 kilometer in length. Fabrication practices are followed at all TechnipFMC spoolbases ensuring high quality production. Pipe joints, typically delivered in 12-meter lengths, are inspected, end-bevelled and pre-heated. The pipe joints are aligned, and girth welded together on a production line. Each weld is then inspected using non-destructive examination techniques; usually automatic ultrasonic testing or radiography. Finally, field joint coating is applied after grit blasting and heating the weld region. This process continues until the pipe joints are assembled into a pipe stalk. The reeling process begins with spooling of the pipeline onto the vessel. A stalk is pulled from the spoolbase onto the vessel and then plastically bent in a controlled manner around the reel. The process continues until the second end of the stalk reaches the end of spoolbase causeway. Once the required length of pipeline is reeled onto the vessel, the vessel departs from the spoolbase and sails to the offshore field location where installation process begin. TechnipFMC has the capability to assess the entire reeling process using in-house developed finite element analysis models, which accurately replicate the full reeling process. We additionally perform reeling assessments of complex pipeline arrangements involving mechanically lined pipe (MLP), electrically trace heated (ETH) PiP systems, PiP bulkheads, transitions and pawnheads. We perform engineering criticality assessments of pipeline welds, including complex, dissimilar CRA materials, such as welds between clad and lined pipes.

Numerical analyses as engineering support in the diagnostic process, illustrated by the identification of causes of damage to railway suspension

Adam Przewoznik

Senior Analysis Engineer at EC Engineering

In-depth identification of the causes of failures in engineering structures is a crucial element in the process of acquiring necessary technical knowledge, enabling the prevention of such incidents. The acquired knowledge often also helps prevent catastrophic accidents resulting from such failures. Broadly understood numerical analyses combined with physical experiments often become a significant support in the work of engineers searching for the causes of equipment and system failures. The presentation illustrates the application of multibody dynamic simulation and calculations using the finite element method in diagnosing the causes of failures in the suspension system of a railway vehicle, focusing on the example of cracking in the primary suspension helical coil spring. The mentioned analyses and simulations were part of a comprehensive diagnostic process, which also included measurement campaign and macroscopic as well as microscopic examinations of the spring material. The presentation focuses on the research component involving simulations and numerical analyses.

Automated data-driven method for nonlinear material model fitting for composites

Kristóf Szalai, András Jasics

eCon Engineering

The reliable estimate of material properties for Finite Element (FE) simulations is a must to provide high accuracy estimate of the behaviour of the product being developed. With high-fidelity simulations the level of virtualization can be substantially increased which leads to shorter development time, reduced prices and carbon footprint. The issue summarized above is especially persists in terms of the reliable simulation of the behaviour of Continuous Fiber Reinforced Plastics (CFRP). The standard linear constitutive models available in commercial FE codes are seldom applicable to predict the mechanical response around failure due to the non-negligible nonlinearity. In addition, there are no guidelines available nowadays how to convert the failure information from mechanical experiments into abstract parameters of multiaxial failure models available in the portfolio of commercial FE codes. Current presentation introduces data-driven optimization and parameter fitting techniques to find nonlinear constitutive model constants and multiaxial failure model parameters of a unidirectional (UD) composite material via the automated and holistic processing of a set of raw data from mechanical experiments. The system is able to find the pre-selected nonlinear constitutive model parameters on a probabilistic basis using Bayesian optimization and is also capable of analysing the available raw experimental information from parameter sensitivity and identifiability aspect with regards to the potential multiaxial failure model constants to fit. As a result of that is can provide suggestions about the most reliable and robust model to fit in an automated way. The capabilities of the parameter evaluation technique are demonstrated via the example of a set of virtually generated standard and non-standard mechanical experiments on UD coupons.

Dental implant structural and durability performance study

Dr. Jakub Michalski

Simulation engineer at Technia

Dental implants are very common replacements for missing teeth. Their popularity is still increasing even though it is an invasive form of treatment and can be very costly. However, their appearance, functionality and durability make them the best choice for many patients. To ensure sufficient strength, stiffness, and durability of those tiny, precisely manufactured mechanical components, one may utilize modern numerical simulation software. The design of dental implants may involve many iterations and prototypes and require a lot of extensive testing to ensure proper performance under difficult operating conditions. Because of that, the connection between CAD and CAE becomes crucial.

This paper discusses the use of the 3DEXPERIENCE platform in a structural and durability performance study of a two-component dental implant system consisting of an abutment with a screw and a fixture. They are made of medical titanium alloy Grade V and designed from the scratch on the platform. The structural simulation study consisted of two steps – tightening the screw and loading the whole system with axial and bending forces. Apart from the stresses and displacements, changes in the axial force in the screw were analysed. The subsequent durability study was carried out to evaluate the fatigue life of the dental implant system. Each component could be investigated in terms of the expected number of cycles to failure.

The presented workflow is an example of a comprehensive performance study of a dental implant system with the use of modern finite element analysis software with a direct connection to CAD. It can be easily automated and extended to other cases. The proposed methodology is based on years of experience and research in the area of simulations of dental implant systems.

Machine Learning Optimization and Quick Verification of an Electric Vehicle Rocker Design

Athanasios Papadopoulos

Customer Service Specialist at BETA CAE Systems

Prior to their market debut, all prototypes of vehicles undergo validation for their crashworthiness. Achieving compliance with safety standards, while simultaneously avoiding compromises in other crucial design aspects, demands a highly detailed engineering simulation approach during the product design phase. These processes become even more complicated, and time-consuming, with electric vehicles, such as Lithium-ion battery-powered cars. In many cases to accomplish the safety aims during product design, while also meeting time limitations and deadlines, sophisticated simulation tools need to be employed. Such tools are those that enable optimization studies and that take advantage of Machine Learning capabilities.

In this study, an optimization and a quick verification of an electric vehicle rocker design were performed with the aid of an Optimization tool and Machine Learning methods.

This Optimization tool employs Design Experiments and a Machine Learning predictive model (referred to as a "Predictor") to approach optimal design parameters for a given objective and constraints. This extends to quick verification of new designs, enabling rapid testing of modifications without re-solving the model. To enhance efficiency, a macroscopic battery model is used, allowing the ML Predictor to consider electromagnetic phenomena in damaged batteries without increasing solution time in side-crash simulations.

All in all, using the Machine Learning based Optimization tool, and the Transfer Learning related functionality, an already trained predictive model was able to estimate the optimal design of the vehicle with updated components and verify the updated designs without having to re-run the complete optimization and solution processes.

Combination of Finite Element Analysis with Checks According to Standards

Oleg Ishchuk

Chief Operating Officer at SDC Verifier

Explore the practical applications of SDC Verifier software through a presentation based on use cases. This session will showcase the engineering company's success story where the combined approach of general Finite Element Analysis and industry standards checks elevated structural engineering workflow. The presentation will show how adaptable engineering solution helps to meet industry standards' requirements within the context of structural engineering projects. Furthermore, the presentation will explore the pragmatic features, designed to improve the workflow efficiency of structural engineers: From tailored standards and checks to practical functionalities, the focus is on how simulation serves as a valuable tool in real-world scenarios, addressing the challenges faced by engineers in their day-to-day projects. Join us for an engaging session on the practical combination of verification according to standards and design in structural engineering. Discover how software, through authentic project applications, empowers engineers to navigate challenges, achieve efficiency, and elevate the overall quality of structural analyses.

Quick and reliable simulation process automation reducing product development time and cost

Karlheinz Peters

Business Development Lead at Novus Nexus

Wide-range use of simulations through all phases of the product development is becoming increasingly important to meet the growing challenges of global competition. Simulation not only helps to develop competitive products faster, but also helps to reduce the number of necessary prototypes and related physical testing.

However, to realize all the achievable benefits of simulation, it needs to be performed systematically, consistently, and efficiently. In an optimal scenario, simulation is directly available to a broader group of users, not only simulation specialists, with designers and analysts closely collaborating. Automated simulation processes for analysts as well as designers and product developers, are essential for realizing such systematic and efficient use of simulation. Historically, a broader use of automated processes often fails due to the difficulty of the automation task. Automation via common approaches like scripting (Python, etc.) quickly results in a prohibitive effort for implementation and upkeep, especially when complex or vastly differing geometries are involved. Not only is the initial setup complex here, but extensions or modifications down the line can become exceedingly complicated, and too often result in a complete rebuild of the processes.

Therefore, new approaches are needed to overcome the current challenges and secure a fuller range of benefits from simulation; methods that enable fast, easy, and robust process automation. This presentation explores how a combination of simulation-specific “no-code” tools (based on abstract modelling), together with universal "low-code" tools, can drastically simplify automation, even and especially when complex products are involved. The impact of systematically automated simulation processes on the overall development cycle is also analysed.

Advantages of this approach to automation include the ability for non-CAE specialists to initiate reliable simulations, the relief for analysts from unproductive routine work, the preservation of simulation knowledge, and the continuous use of best practices for future simulations.

Design of tube-to-tube joining tool by FEA – simulations and V&V

Dr. Szabolcs Jónás, Dr. Péter Zoltán Kovács

Knorr-Bremse Rail Systems, Budapest University of Technology and Economics, University of Miskolc

Numerous methods are available for joining tube endings, but the utilization of forming methods remains relatively uncommon. This presentation delves into an innovative yet underexplored tube joining technique. Given its relative novelty, comprehensive calculations are imperative prior to tool manufacturing.

The design phase involved meticulous consideration of various geometrical parameters for both the tools and tubes. The primary objective is to ascertain the optimal geometrical parameters for the joining tools. Multiple simulations, encompassing aspects such as determining tool distance and tapering angles on tube edges, were conducted using efficient 2D axisymmetric models, facilitating swift and accurate results.

The subsequent phase involved the translation of simulation outcomes into practical applications. The joining tools were precisely manufactured, and a series of tests were systematically executed to generate force-displacement curves. These tests included subjecting joints to diverse conditions such as tensile and bending tests. The comprehensive examination revealed a remarkable agreement between simulated and tested curves.

Considering the limited information available on this particular joining procedure, a range of joints were meticulously prepared to delve deeper into the nuanced physical behaviour, enabling a thorough comparison with simulated data. The obtained results are not only promising but also underscore the potential for utilizing simulation models in a pre-design capacity, significantly mitigating trial-and-error costs and expediting the development process.

The numerical calculations of the bolted connection

Dr. Marcin Nowak

Advanced Engineering Solutions, ALTEN Polska

The bolted connections are one of the most popular and widely used detachable connections in various industries. The appropriate selection of screws is therefore extremely important for the correct and reliable operation of the structure. Rapid technical progress and increasing requirements for screw connections entail necessity of improvement of its designing process. The proper analysis of screw connections at the design stage is crucial for stabilization of future constructions. Incorrect selection of a screw connection may result in a significant increase in the weight of the structure and its costs. On the other hand, incorrect selection of screws for a threaded connection may contribute to the malfunction of the structure or, in the worst case, its destruction. The presentation will show the most popular methods of modelling screw connections for numerical calculations. Next, the authors will present some of the above-mentioned examples of modelling and calculations for a connection that has been verified in finished constructions. In the summary authors present the advantages and disadvantages of particular types of numerical models and the ways of utilization acquired.

Presentations | Fluid dynamics and heat transfer

Prediction of thermal shock phenomenon in car radiators using CFD and FEA techniques

Tomasz Płusa

Simulation leader and simulation expert at Valeo

The phenomenon of thermal shock is common in cars with internal combustion engines. Its occurrence is mainly influenced by the acceleration and braking of the car. A car radiator consists of a very large number of repetitive components such as tubes or fins, and it is difficult to predict the temperature distribution over time using only empirical or analytical techniques. Laboratory testing is costly, as we need to perform several thousand to tens of thousands of cycles to see the effect on fatigue of radiator components. A financial and time-saving alternative is to use CFD methods to determine the temperature distribution during thermal cycling and FEA methods to estimate fatigue strength.

Accelerating Vehicle Aerodynamics Simulation with Cloud-Based CFD and Optimization Tools

Sophie Petraman

Noesis Solutions

External vehicle aerodynamics is a crucial factor for improving fuel efficiency, performance, and safety of automotive products. However, traditional engineering software tools are often limited by computational resources, model complexity, and data accessibility. In this paper, we present a novel approach for accelerating aerodynamics performance analysis using cloud-based Computational Fluid Dynamics (CFD) and optimization tools. We use id8, a cloud-based collaborative engineering platform by Noesis Solutions, and SimScale, a cloud-based Computer-Aided Engineering (CAE) simulation tool, to perform CFD analysis and optimization of various vehicle models. We demonstrate how our approach can speed up the design process by 12 times, reduce the operational cost and computing time by 50%, and enable data-led decision making by extracting insights and knowledge from simulation data. We compare our results with existing solutions and show significant improvements in aerodynamics performance and design efficiency.

Furthermore, the platforms effectively bring together Simulation Engineers, Design Engineers, Project Managers, and Research teams, breaking down barriers within design teams.

Our work addresses the challenge of collaborative automotive design across different locations and disciplines. We demonstrate how cloud computing can enable design teams to share and integrate data, models, and simulations in real time. This approach has the potential to enhance the efficiency, quality, and innovation of automotive engineering.

How To Reduce Costs & Increase ROI Of Your CAE Simulations in the Cloud

Wolfgang Gentzsch

President & Co-Founder at UberCloud

Cost savings might be one of the reasons why engineers are interested in moving their simulations to the cloud. In this presentation, we are analysing several ways of cost reduction, direct and indirect, such as: using reserved and spot instances, saving software license cost by using faster and more powerful hardware, monitoring compute usage, increasing engineer’s productivity by using more compute resources simultaneously, etc. And more compute resources mean more simulations mean better product quality. We offer two examples of cost and cost savings in the cloud. First, we present a concrete cost calculation for a complex automotive simulation with 100 million cells, on 16 compute nodes / 1920 cores, based on a detailed Bill of Materials. And second, we demonstrate that cloud resources operating at 2X performance over on premises and one additional software license per engineer can enhance an engineer's productivity by 4X, while saving the company $260K per engineer per year in additional expenses compared to the on-premise solution. The easy access to and increased availability of compute resources facilitate more simulations, fostering innovation and yielding better results, such as improved materials, geometries, physics, functionalities, etc. This ultimately leads to a more efficient and cost-effective workflow.

Enhancing Turbomachinery Design: Integrating Machine Learning with Computational Fluid Dynamics for Efficient and Accessible Aerodynamic Analysis

Semih Şimşek

Senior CFD Application Engineer at Numesys

Computational Fluid Dynamics (CFD) is a methodology employed for the modelling of fluid motion, heat transfer, and chemical reactions, including aerodynamic and aero-thermal calculations in turbomachinery. The CFD approach is capable of conducting aerodynamic and aero-thermal calculations for turbomachinery designs with high accuracy. However, the analyses can become costly as they encompass large-scale behaviours and their consequent effects. Additionally, the diversity of systems and types of machinery in the turbomachinery sector, coupled with varying blade profiles and sub-designs, necessitates the integration of contemporary and alternative computational methods to complement CFD.

Within the scope of this study, the focus has been placed on incorporating machine learning models into CFD solutions to reduce computational costs. The Reduced Order Model (ROM) structure, which is interactively functional within Ansys, reduces the outcomes of various CFD analyses into lower-order models based on machine learning algorithms, focusing on pertinent details to create a database. This enables accurate prediction of the aerodynamic and aero-thermal characteristics of new designs. In this research, results from different axial turbofan models analysed using PyFluent have been taught to the ROM. Consequently, faster CFD results have been obtained for new axial turbofan designs. The validity and predictive accuracy of the model were established after comparing and verifying the outcomes with the analyses conducted via PyFluent. All procedures, from the completion of analyses using PyFluent to the training of the ROM, were conducted in a BATCH environment.

This methodology not only accelerates the analysis processes but also facilitates a system whereby turbomachinery designers can provide their designs without needing advanced CFD knowledge and obtain practical results without observing the backend CFD and ROM operations. The aim is to enhance the accessibility of the CFD approach.

Presentations | System simulation

Electric truck cabin and HVAC digital twin with novel type of thermal measures in a multi-level simulation environment

Imre Gellai

Austrian Institute of Technology

The next generation of electric trucks must be developed with excellent efficiency in mind for every component, since this will result in greater driving range or load capacity. Cabin heating and cooling systems are among the most major energy users in these vehicles, therefore improving thermal properties is critical. An improved truck idea may be established during the early phases of planning thanks to digital twin technology.

This research, part of the NextETruck European project, shows a digital twin of a Ford truck interior with efficiency-improving features. The NextETRUCK project's main goal is to demonstrate next-generation e-mobility concepts comprised of comprehensive, inventive, affordable, competitive, and synergetic zero emission vehicles and ecosystems for tomorrow's medium freight haulage, serving as a trailblazer in the decarbonization of vehicle fleets.

The truck cabin has several efficiency-enhancing features, such as isolation, an air-air heat exchanger, and infrared panels. These modifications result in considerable energy savings while maintaining the same level of comfort. The consequences of these measures may be modelled in the digital twin so that entire-system simulations can account for them.

The thermal properties of an original Ford vehicle interior were tested to confirm the digital twin and efficiency-enhancing techniques. The created technique properly anticipates the thermal interactions between the test case's truck cabin and its environment, illustrating how exact thermal behaviour simulations may lead to efficient energy consumption reduction.

In summary, this study demonstrates that significant energy savings can be achieved by increasing the efficiency of every part of electric trucks, including the thermal characteristics of the cabin. This can lead to longer driving ranges and greater cargo capacity. An effective tool for optimizing electric truck designs at the early planning stages is the digital twin technology, which opens the door to the creation of more eco-friendly and efficient automobiles.

This project has received funding from the European Union’s Horizon 2021 research and innovation programme under grant agreement No 101056740 NextETruck.

Simulation-Based Digital Twins in a Multiphysics World

Dr. Árpád Forberger

Application Engineer at Gamax Laboratory Solutions

An important requirement in the concept of the digital twin is that it should be a dynamic, continuously updated representation of the real physical product, device, or process. It should not be a static representation of real space.

COMSOL Multiphysics® software can provide the multiphysics and multiscale models required to build high-fidelity descriptions for digital twins. In addition, the COMSOL® software has capabilities to control and validate these models using measured data in combination with different methods for parameter estimation, optimization, and control. The computational speed of an app can be greatly increased by using a surrogate model instead of a full-fledged finite element model. A surrogate model created by Deep Neural Networks is a simpler, usually computationally less expensive model that is used to approximate the behaviour of a more complex, and often more computationally expensive, model. The faster model evaluation offered by a surrogate model provides the app user with a more interactive experience and makes it easier to spread the use of simulation throughout an organization.

A COMSOL Multiphysics model may also contain several model components to model a system with components that can be strongly coupled. The tight linkage between real and virtual spaces can be achieved in COMSOL Multiphysics using COMSOL API for use with Java®. The Java® model file incorporated in such a program can communicate with the external system. Benefiting from the Java® ecosystem, it is also possible to implement the virtual space as a web service that could be presented.

COMSOL Server™ and Model Manager Server can be used to administrate models and applications that can be queried for simulation data triggered by the update of an input file or an operator. Also, it enables you to collaborate with your co-workers on version-controlled simulation models and data files.

Utilising an FMU protocol to perform 1D-3D coupling studies

Slawomir Polanski

Senior Simulation Engineer at Technia UK

In light of the recent advancements in the domains of Artificial Intelligence and the Internet of Things, it is projected that the majority of numerical simulations in the future will incorporate some form of external data as an integral part of their input. This data could potentially be derived from a multitude of sources. For instance, it could be gathered from existing devices and sensors that are already in operation. Alternatively, it could be sourced from simplified models, such as one-dimensional models or Reduced Order Models, which can offer simplified, but accurate representation of physics. The upcoming presentation is designed to provide a comprehensive guide on how to effectively combine a simplified 1D model with a fully-featured Finite Element model. This combination aims to leverage the strengths of both types of models, thereby enhancing the overall effectiveness and accuracy of the simulation process. The presentation will delve into the specifics of executing a coupled 1D-3D simulation. This involves creating an interaction between a model built in Dymola, a system modelling and simulation software, and Abaqus, a software suite for finite element analysis. The coupling of these two models will be facilitated using the existing Functional Mock-up Interface (FMU) protocol, a tool that enables the integration and interoperability of complex systems.

Multiphysics simulations for short-time current (STC) tests of electrical power equipment

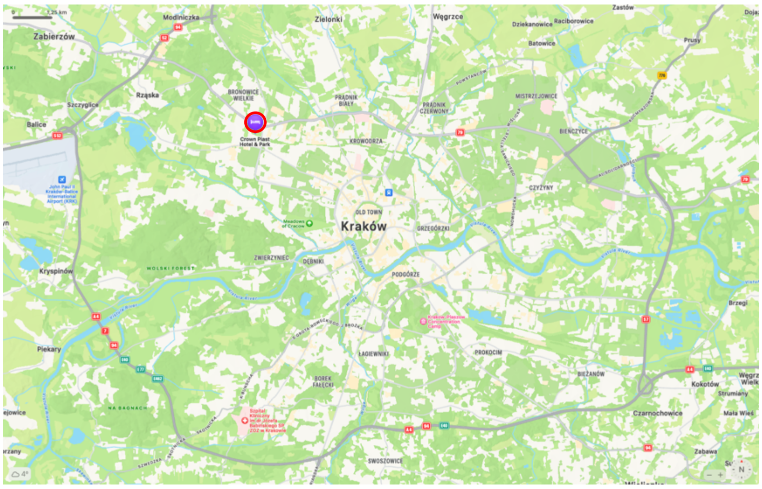
Paweł Bajerski, Jakub Rozwód

ABB Sp. z o.o.

ABB is a technology leader in electrification and automation business areas. Large part of company products portfolio are medium voltage products such as distribution and automation products, switching, limiting, measuring and sensing devices, switchgears and modular substation packages. Medium voltage switchgears are used to distribute electric power in a variety of demanding applications. The most important aspects of electrical products are technological functionality and safety. MV products is required to pass STC (short-time current) test conducted by certified unit. The short-circuit is the accidental or deliberate connection across a comparatively low resistance or impedance between two or more points of a circuit which usually have differing voltage. The use of numerical methods allows to predict weak points on structure and live paths. Thanks to that optimization and reduction of iterations may be achieved in the process of passing international standard of STC requirements for MV products. One of the greatest challenges is to predict the real behaviour of the busbars during the tests. The most popular method involves calculating Lorentz forces in pathway using magnetostatic approach and then simulating the structure's response in static mechanical solver. The main assumption of this approach is to use direct current based on peak current values occurring during the test. Neglecting the AC phenomena and other simplifications made due to the use of magnetostatic solver are significant disadvantages of this approach. Furthermore, inertia effects cannot be observed because of the static method applied. The presented topic covers alternative method for electromechanical calculations in fully dynamic manner. Proposed approach uses CST Studio Suite to extract Lorentz forces in low frequency time domain solver and Abaqus/Explicit to which the loads are imported to assess the final behaviour of the live pathways and support structure. Predicting more accurate and realistic behaviour MV products during the short-circuit event in dynamic manner is the main advantage of this approach. Proposed method is presented on the 3-phases system example utilizing one-way coupling between magnetic and mechanical solvers.

Venue - Hotel Crown Piast & Spa

The conference will be held at the Hotel Crown Piast & Spa, located at a calm and green location. The city center is 20 min. away by a local tram line. Access the Hotel's website to book your accommodation.



Contact

If you have any questions, don't hesitate to reach out to Marton Groza (Regional Representative for Eastern Europe) at marton.groza@nafems.org.