Simulation in the Automotive Industry:

Driving Convergence to Electrification, Autonomous and Connectivity

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Event Abstracts

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Presenter Name: Aziz Abdellahi

Presenter Company: Siemens Digital Industries Software

Title: Multi-Scale Design of a Battery Thermal Management System

Type: Presentation

Keywords: Battery, Cell, Pack, Thermal Management, Cooling, Vehicle, 1D, 3D

Abstract:

Designing an efficient battery pack thermal management system (BTMS) is an essential step in meeting the stringent durability and safety requirements of the electric vehicle industry. At low temperatures, battery pre-heating reduces cell impedance, improves vehicle range and reduces the risk of lithium plating. At high temperatures, an efficient pack-level cooling system is necessary to control the temperature of battery cells. This is necessary to prevent accelerated degradation and to maintain cells in a safe temperature range, away from thermal runaway conditions. Designing an efficient battery cooling system is a multi-scale problem linking the vehicle, battery pack and battery cell scales. At the vehicle scale, pack-level power demand is determined by vehicle dynamics, as well as by energy losses in the powertrain. At the pack scale, heat production depends on the impedance of battery cells and their interconnects. At the cell scale, impedance is strongly dependent on temperature, and therefore strongly affected by the cooling system. Because the different scales are coupled, sizing the pack cooling system requires a coupled, multi-scale approach. Different usage scenarios, such as drive cycles and charging profiles, must further be considered. Given its complexity, the design of a pack cooling system is generally done using a step-wise approach. A 1D pre-design stage is typically considered first, where cell impedance and cooling system topology are treated in an approximate manner. This step is generally followed by a more detailed 3D refining stage, using higher-fidelity cell impedance models and refined 3D pack geometries. The full, multi-scale workflow must be considered at each step of refinement. In this presentation, we illustrate the process of designing a battery pack cooling system for a commercially-relevant electric vehicle design, using Siemens' Simcenter software portfolio. The following steps of the simulation-based design process are illustrated: (a) Determining battery pack power demand under different scenarios, using system-levels simulations (b) Building cell impedance models based on experimental measurements (c) Building a pre-sizing pack model, using 1D electro-thermal simulations (d) Building a refined pack model, using 3D electro-thermal simulations

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Jon Aldred

Presenter Company: HBM Prenscia nCode

Title: Methods for Structural Durability Simulations and Vibration Fatigue in Electric Vehicles

Type: Presentation

Keywords: Fatigue, Durability, Battery Systems, Electric Vehicles, Lightweighting, Swept Sine on Random

Abstract:

The increasing move to electric vehicles is requiring new simulations to successfully validate the physical performance of these vehicles. The up-front assessment of the durability of electric vehicles is requiring new approaches to be adopted to address these new and specific challenges. This presentation gives an overview of three important areas: 1. Structural lightweighting Reduced weight targets are increasing the need for alternative materials and joining techniques. In particular, there is increased use of short fiber composites for structural components in the vehicle and its sub-systems and also increased use of structural adhesives. Both require on-going development of new methods to better predict fatigue life. For example, adhesives have been typically assessed using safety factor calculations but newer adhesives are amenable to finite life approach for simulation. 2. Structural durability of battery systems Battery packs incorporate a large number of mechanical, electrical and electrochemical component systems. They comprise thousands of discrete cells that are connected in series and parallel to electrical busbars in order to supply the required energy capacity. Cells are often welded together to complete the electrical path. These welds are highly susceptible to vibration and suffer from vibration-induced fatigue damage. Furthermore, a combination of lightweight support structures with relatively heavy electrochemical components can result in mechanical resonance in the battery structure with a high risk of fatigue cracking. This section of the presentation reviews the challenges, successes and opportunities for improvement. 3. Simulating swept sine on random loading Many internal combustion engine components are tested for durability using electrodynamic shakers with a random vibration profile defined from suitably derived PSDs (power spectral densities). However, the physical characteristics of the electric powertrain now requires a greater usage of sine on random, and particularly swept sine on random shaker tests. A CAE durability simulation of the shaker test can be performed in the frequency or the time domains by using either the inputs or the outputs of the shaker. This section of the presentation outlines the advantages and disadvantages of different approaches for simulating dynamic durability tests such as swept sine on random using finite element simulations.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Jaimin Bai

Presenter Company: Ford Motor Company

Title: ADAS Calibration Optimization by Deep Neural Networks

Type: Presentation

Keywords: ADAS, feature performance, calibration optimization, Machine Learning, LCA (Lane Centering Assist), DDN (Deep Neural Networks)

Abstract:

ADAS (Advanced Driver Assistance Systems) feature performance calibration is a critical part of meeting customer satisfaction with optimal tuning of the performance. Today's feature calibration in vehicle development process is time consuming and resource expensive. A novel approach is introduced by applying Machine Learning technology to identify the optimized calibration parameters with virtual and field data. The proof of concept is illustrated to gain insights of LCA (Lane Centering Assist) feature performance through tuning parameter optimization by using DNN (Deep Neural Networks). For achieving the goal of optimizing parameters in LCA task, we will firstly test the representation capabilities of neural networks, and then explore the neural network optimization method. We proved two values of neural networks for the parameter optimization in LCA: 1. The neural network model can well represent the relationship between Calibration Parameters and Evaluation Metrics. Given a random set of calibration parameters, the model should predict the value of metrics within certain acceptable error rate. i. Given a random set of calibration parameters, the model should predict the value of metrics within certain acceptable error rate. ii. Limit the constraint domain of input calibration parameters, provide several good search spaces for simulations. iii. Find the optimal parameters based on specific metrics. 2. Integrating methods of filling design space with the neural network model to form a better search algorithm, to reduce the number of trials used for simulations and to accelerate the parameters searching processes. The simulation process of LCA is introduced, including the system and vehicle model construction, use cases definition, LCA feature major tuning parameters and performance metrics. The result shows that we can use DNN (Deep Neural Networks) models to achieve 69%–96% better LCA feature performance comparing to traditional optimization approach, and to localize the searching areas efficiently. It also shows that our method can reduce the simulation runs 2x to 10x compared with current methods. Further work in progress to apply Machine Learning technology for gaining more insights into the calibration parameters related to customer satisfaction metrics to help define better objective requirements.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: John Batteh

Presenter Company: Modelon, Inc.

Title: A Scalable System Modeling Approach for Electric Powertrains

Type: Presentation

Keywords: Electric powertrain; system simulation; Modelica

Abstract:

For many years, automotive OEMs have been applying modeling and simulation tools to reduce the time to develop and put new electric vehicles on the market. In this fiercely competitive market, OEMs are still striving for ways to increase engineering efficiency and further reduce the time-to-market. The complex nature of the electric powertrain system poses some unique challenges. Electric powertrain systems have dynamics that interact between multiple physical domains and span multiple engineering disciplines. Furthermore, multiple design targets must be fulfilled simultaneously across a range of attributes. In addition, this work must be executed through the various stages of the development cycle corresponding to different levels of design maturity, controls availability, and data availability. The different model requirements for the different domains, engineering questions, and development stages often result in multiple models of the same system with different fidelity and purpose. Time and resources can be wasted in developing, maintaining, and transitioning between the different representations. The alternative of having a single detailed model that can be used for multiple simulation purposes is seldom feasible as more detail typically translates to a need for more parameter data and often degraded simulation performance. The presentation demonstrates a scalable solution for modeling electric powertrain systems. This solution is based on a common model architecture that ensures compatibility between different fidelity levels, that supports a large set of engineering use cases, and that is applicable over the full range of development stages. Leveraging multi-physics models developed in the open standard Modelica modeling language and a cloud-based simulation platform Modelon Impact, the models describe 1D dynamics (ordinary differential equations) for electrical, mechanical, magnetic, and thermal domains, as well as the control software. Scalable models of an electric powertrain system will be demonstrated for a set of use cases. The presentation will focus on the electric machine and inverter components of this system. The model fidelity of these components will be adapted to different use cases, including sizing of the powertrain performance at an early stage and analyzing a transient fault event. The model fidelity levels range from steady state power flow models to detailed equivalent circuit models. Application examples demonstrate interaction with the models in a variety of modes, including natively in the modeling GUI, via a REST API, and also via scripting environments including Python and Jupyter notebooks.

Presenter Name: Juan Betts

Presenter Company: Predictive IQ

Title: A Fast and Intelligent Physics Informed Machine Learning Model for Optimizing the Locations of Sensors to Prevent Thermal Runaway in Lithium-Ion Batteries

Type: Presentation

Keywords: Physics Informed, Machine Learning; Deep Learning; Thermal fluid; Thermal runaway; Lithium-ion batteries

Abstract:

We develop a fast and intelligent Physics-informed Machine Learning (PIML) model to optimize the sensor locations to avoid thermal runaway in lithium-ion batteries. The PIML model considers the heat transfer from the battery cells into the surrounding air. The model evaluates different location of sensors, which measure the temperature of a module/pack of battery cells, to obtain the optimum arrangement. The model can use the sensor measurements to improve the predictions by considering the real value of temperature at each location and time. The electricity in the lithium-ion battery is produced through the charge and discharge process. Lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge and back when charging. These processes generate a small amount of heat. The heat dissipates to the surrounding in the ideal conditions, in which the cells operate at an optimum temperature bound. The operation efficiency degrades when the temperature values go out of the bound. Thermal runaway, in which the cells enter a self-heating state, as one of the primary risks of using lithium-ion batteries happens with temperature rise. It can cause several important issues such as smoke or fire. The importance of sensors locations is to diagnose the temperature rise which leads to a thermal runaway. Having known the rise in the temperature, the thermal runaway can be avoided. We solve the optimization problem using the traditional computational fluid dynamics (CFD) methods to compare the accuracy and the efficiency of our PIML model. CFD methods require many simulations to be able to optimize the location of tensors. Each simulation solves conservation of mass, momentum and energy for the air surrounding the cells to compute the change in the temperature in the three-dimensional solution domain. To that end, a large amount of computation power and time are needed, while the PIML model requires only a small fraction of the data. The PIML model also allows for a real-time training. The main benefit of using the PIML model over the original CFD model was that the PIML MBD model ran faster, and therefore allows the model to be embedded in frameworks with associated control's structure.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Abhay Bhivare

Presenter Company: Ford Motor Company

Title: Simulation of Real-World Events for ADAS - PCA Feature Validation

Type: Presentation

Keywords: ADAS, Real world scenarios, AEB (Automatic Emergency Braking), SOTIF

Abstract:

SUMMARY: As we are moving forward to make our vehicles smarter and safer, the need of Simulation in delivering reliable ADAS feature has been growing exponentially. At start simulation helped detect early functional issues and reduce the number of vehicle tests, but still there was a need to driving thousands of miles to be able to detect performance issues based on the complex real-world situations. While we wanted to address this challenge via simulation, we understand it is not important to simulate thousands of miles but be able to simulate relevant events. As we are moving towards event-based simulation approach, we are now using millions of miles of naturalistic driving data collected in past, identifying these events of interest and using them for simulation. This paper focuses on simulating real-world PCA events. Recreating these real-world events on road could be highly dangerous, simulation certainly helps address this challenge and through this simulation validation process we are able to create robust ADAS features. Bringing these complex events into simulation platform has its own challenges and has a need to develop a tool chain to do so. While we overcome this challenge, there is also a need to visualize these thousands of runs coming from the simulation data and creating meaningful dashboard. Certainly, looking at each and every simulation result is not a viable option, creating meaningful metrics and ability to analyse this huge data using smart analytics tools is important. At this point we should be able to quantify robustness of a feature and identify critical events which needs to be further studied. We have used Automated Mobility Partnership (AMP) database for this study. We have used crash and near crash events to validate our features. In this paper we also demonstrate the ability to parameterize events of interest. This helps us to convert a near crash event to a crash or rather be able to smartly manage criticality of an event. 1: Increasing the Simulation Coverage using Real-world data: With the need to cater to this emerging autonomous L3 market, simulation is playing a crucial role. Increasing the coverage of simulation is going to help make the autonomous features robust, which also aligns with the SOTIF standards. Please refer to Figure 1, to start with it would be important to increase the database of known scenarios. Then classify these known scenarios to safe vs unsafe via feature validation, now focus our efforts to convert the known-unsafe scenarios to known-safe category. Sweeping through the ODD (operational design domain) via parameterization would help us cover the known scenarios. Still, we need to understand what statistical distribution we should apply to these parameterized models? Also, how to increase the coverage by identifying the unknown events? Collecting the naturalistic driving data and then effectively using it could be the answer to above questions. Using statistical real-world distribution would help generate probabilistic real-world events for simulation. These could help us generate realistic synthetic scenarios which could be used for simulation, this could not only help increase scenario coverage but also help identify realistic unknown events. In addition to statistical distribution, identifying unknown real-world events from the naturalistic data and then reconstruct these events to scenarios for simulation. This approach is believed to add a lot more to unknown scenarios. Validation and testing of these scenarios will certainly help

make the feature robust. 2: AEB feature simulation using events from naturalistic database: Extending the feature simulation from the conventional regulatory scenarios to real-world scenarios has its own challenges. With lot more dynamic traffic and complex environment, one might find a need to update their simulation methods to accommodate these complex events and define additional metrics / KPI's. Source of these events for the study here were primarily from the AMP database. While we now want to validate our features to this ever-increasing database of scenarios, smart analytics would then be the need for PCA events. Figure 3 shows one way to depict the PCA performance in real-world, the data shown in the figure does not represent production intent. For near crash scenarios we have shown the comparison of Range Forward (max distance between host and target in longitudinal direction) before and after feature in loop simulation. We can see that with feature in the loop the range forward value has increased in all cases, making the scenario safer. For the crash events we have shown here a simple metrics classifying the scenarios post feature simulation in 3 categories: crash avoided, acceptable speed reduction and crash. The acceptable speed reduction and crash avoided scenarios are classified as safe, the ones with crash need further investigation and could be classified as unsafe. The goalpost this exercise would be to convert the known-unsafe scenarios to known-safe category. One of the ways to work on the known-unsafe scenarios is to extend the ODD for a feature. While we use this approach, it is also important to understand there would always be scenarios which would remain under know-unsafe category where the feature would not be able to avoid crash or reduce speed sufficiently. These type of scenarios are seen from abrupt actor(traffic/pedestrian) behaviour not giving enough time for the vehicle to react. 3: Extending the real-world event via parameterization: Parametrizing these real-world events furthermore to extend the feature simulation coverage was explored. It was possible to convert a near crash scenario to a crash scenario or in other words increase the criticality of the event via parameterization. While conversion of these naturalistic events to simulation, building a pipeline which could accommodate parameterization is certainly a need. This gives the ability to further develop realistic synthetic events (real-world + parameterized) which could be used to improve feature robustness. 4: Conclusion: Bringing these real-world edge cases in simulation would certainly be a huge driver to make the vehicles safer and increase feature robustness. Simulation is the only way forward to accommodate validation of these unsafe scenarios and has the ability to run massive scenarios. Scenario coverage and massive simulation for ADAS is the need for the future. This process needs to be complimented by a strong IT infrastructure to run simulations on cloud and collect this data to bring it for smart analytics. AI/ML or optimization techniques needs to be developed to reduce the number of runs while still performing ODD coverage and real-world events. Furthermore, there is a need to have smart tool chains / pipelines to automate complex real-world event conversion to simulation world with minimal intervention. Creating high fidelity real-world roads and environment while capturing the actor behaviour accurately would be a need while we move towards complex L3 features.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Chin-Wei Chang

Presenter Company: Dassault Systemes SIMULIA Corp.

Title: Integrated 1D and 3D Workflow for EV Battery System Development

Type: Presentation

Keywords: Electric vehicle, EV, battery, 1D system model, thermal analysis, CFD, CHT, 1D-3D integration, integrated analysis

Abstract:

Electrified powertrain development is the current trend and the race to develop well-performing electric powertrain systems is intense. EV manufactures and battery system suppliers are ramping up the EV battery system development to meet the market demands. In a development cycle, 1D system modeling is a helpful analysis technique, which allows engineers to build the system model based on the specification and to predict the battery system behavior. It allows engineers to quickly verify the battery or EV performance against design targets, select the most suitable architecture, and properly size the components. Traditionally, to ensure the accuracy, engineers rely on correlations from prior battery projects to tune the system model. However, electrified powertrain are relatively new and engineers have limited prior correlation data to leverage. Furthermore, the discrepancy between the current design and the prior design means that the correlation only holds in a limited parameter range. The correlation could become unreliable once the design is outside of the range. As a result, the system behavior model may have higher perdition error. It causes more late-stage issue and require higher design redundancy to prevent issues. To resolve the limitation, we propose an integrated workflow combining 1D and 3D analysis techniques for battery system design. The 3D computational fluid dynamics (CFD) and conjugate heat transfer (CHT) analysis work in conjunction of the 1D system behavior analysis. They provides high fidelity performance prediction. This allows engineers to verify the battery system performance, make quick iterations without the dependency on prior EV battery projects or physical testing. High quality correlation result is acquired through design of experiment (DoE) and advanced optimization process. A case study is conducted to demonstrate the workflow. A liquid-cooled battery pack 3D model is created with parametric geometry model. DoE characterization on the battery thermal performance is performed with CFD and CHT analysis techniques. The characterization result is conveyed to the 1D system model for correlation. The 1D system model is structured in the way for better correlation with 3D model. The correlation is performed with parametric optimization methods and it provides high accuracy of the battery pack thermal performance. The correlation predictability is examined and ensure the correlation withstand in the design space. In summary, the proposed 1D and 3D correlation workflow is a full digital workflow for battery system development, eliminating the dependency on prior data or test result and enabling fast and efficient EV development. The workflow ensures high accuracy on performance prediction, and reduce issues found in late stages. The better prediction also result in reduction of design redundancy and can further improve the EV performance and reduce the cost.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Ushe Chipengo

Presenter Company: Ansys, Inc.

Title: High Fidelity Physics-Based Electromagnetics Simulation of Radar and Vehicle-to-Vehicle Connectivity Systems for Autonomous Vehicles

Type: Presentation

Keywords: Radar, MIMO, Micro-Doppler, RCS, AI/ML, V2V, V2X, Autonomous Vehicles

Abstract:

Autonomy and electrification have emerged as key drivers of innovation and growth in the automotive industry in recent years. Various advanced driver assistance systems (ADAS) have been developed as OEMs race towards a fully autonomous and zero emissions future. Automotive radar and vehicle-to-everything (V2V/V2X) technologies are two of the key technologies that enable vehicles to have situational awareness while also communicating with other vehicles and road infrastructure. Before any of these systems are deployed, they need to go through rigorous testing and validation. While measurement is valuable, simulation has emerged as the more practical, cost effective and safer approach of testing the robustness of these systems, especially in corner cases. Here, we present high fidelity physics-based electromagnetics simulations for V2V and automotive radar systems. Specifically, we will demonstrate the impact of vehicular obstructions, multipath effects, and non-line-of-sight (NLOS) conditions on 5.9 GHz designated short-range communication (DSRC) links. We will also compare simulation results to published measured results. Automotive radar simulations of a synthetic, 128-channel, 77 GHz, multiple input multiple output (MIMO) sensor for angle of arrival determination will also be presented. Using this virtual sensor, we will demonstrate how simulation can be used to predict sensor performance in low-density and high-density traffic regions. We will also present a micro-Doppler based convolutional neural network (CNN) for classification of vulnerable road users (VRUs). Here, we use simulation to obtain thousands of spectrograms spread across 4 target classes (car, pedestrian, cyclist and dog). Using these spectrograms, we train a 5-layer CNN to classify targets. Studies were also conducted to establish the impact of data size and length of observation time window on the accuracy of the CNN. Finally, we will also present a comprehensive study of guardrail-induced radar detection issues. Using simulation, we will demonstrate the root-cause of the high radar-cross-section (RCS) of guardrails. We will then go on to show how simulation can be used to test the RCS of alternative, lower-RCS guardrail structures. Range-Doppler plots of various full-scale traffic scenes with guardrails will also be presented to demonstrate the undesirable radar signatures of guardrails. Finally, we will present rich, simulation-derived animations that show electromagnetic wave propagation in regions with guardrails for future design considerations. In this presentation, we show how high-fidelity physics-based simulation can be used to accelerate the test and validation of advanced driver assistance systems that will be at the heart of fully autonomous and electric vehicles.

Presenter Name: Steven Dom

Presenter Company: Siemens Industry Software NV

Title: Electric Drive Engineering: An Exercise in Collaboration and Integration

Type: Presentation

Keywords: Electric drive engineering, simulation, testing, collaboration, integration

Abstract:

As electrified powertrains become mainstream, the main challenges on electric drive systems engineering have shifted from designing the powertrain to operational efficiency, cost reduction, and speed-to-market. Automotive OEMs and suppliers need to create highly efficient and robust electric drive solutions at scale to drive the vehicle cost down. Operational efficiencies now lie not in individual component efficiency but rather in system efficiency and operation. Chasing operational efficiency requires a well-integrated electric drive system, often referred to as e-drives or e-axles, incorporating the electric motor, transmission, power electronics and controls into one integrated package. A key enabler for this is a combined computational model of the entire e-drive system that can enable trading off attributes between individual components and developing a robust control algorithm that operates the e-drive in the highest efficiency zone at any given moment. In this presentation we will present key things to consider in developing a true multi-physics system model for this collaborative engineering effort and how the integration of test-calibrated design sub-models can be used. Developing a complete e-drive multi-physics system will span many disciplines including mechanical, electro-mechanical, thermal, vibro-acoustic, electric, electronic and controls. Additionally, the tool chain used by engineers to predict the performance of this system of systems must be flexible, open, and scalable to enable seamless connectivity between detailed component-level design and system level simulation in all phases of the development.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Vijit Dubey

Presenter Company: Ford Motor Company

Title: Virtual Validation of Intelligent Lighting Features with Help of Simulation

Type: Presentation

Keywords: Advance Driver Assistance Systems, Simulation Validation, Adaptive driving Beam, Predictive Dynamic Bending Light, Automatic High Beam Control

Abstract:

During night driving, drivers are confronted with additional challenges and risks compared to daylight driving. While only 25% of total traffic driving at night, 50% of all traffic-related fatalities happen at night. This has led to innovations leading to brighter headlamps. But these lighting innovations have created a persistent problem of headlamp glare, which is irritating and sometimes dangerous for drivers. Intelligent headlamps enable features that not only provide objectively better illumination with reduced glare but also result in an improved user experience. DAT Lighting Simulation enables virtual integration of various Electronic Control Units (ECUs) and helps to virtually assess the performance of these features. The challenges and benefits of these simulations will be discussed. With virtual validation, supplier implementation code integrated with Ford DAT software and headlamp perception files can be evaluated even before the prototype phase in vehicle development. Simulation additionally enables testing of software for difficult and dangerous to create scenarios in real life. Lighting simulation performed using the Ansys VRXperience software, light sources are described using light distributions based on the IESNA-LM-63 standard in combination with color spectra that together provide a photometric description of the light emitted by the source. An automotive headlamp module will - depending on its setup - consist of several such light sources. With the use of Simulator, development teams can run driving experience clinics to develop a better user experience. By running the simulator in a co-simulation loop with an algorithm designed in MATLAB/Simulink, each single light source can be modulated in real-time to implement control functionality and to simulate intelligent lighting features. This enables the evaluation of control signals from ECU logic to headlamp light execution. Additionally, the data on simulation correlation, and how much cost saving per program is done with these simulation methods will be investigated.

Presenter Name: Adarsh Elango

Presenter Company: ESTECO North America, Inc.

Title: Optimization of a High-Power Electric Traction Machine

Type: Presentation

Keywords: Optimization, electrification, traction motor, torque ripple, stress constraints, process integration, design automation, web apps, democratization

Abstract:

The design of a multi-layer Synchronous Reluctance Machine (SynRM) is very challenging due to the number of constraints and possible design variables. In this study, we start with introducing the SynRM, the importance of SynRM in transportation electrification strategies and associated design challenges. We dive deep into, initial sizing, design layout and design approach for these types of motors and address the design trade-offs that engineers face during application. We optimized the SynRM for traction motor application using about 26 geometry design variables and 20 constraints. Both electromagnetic performance in terms of Torque ripple and average Torque and stress constraints were included in this Multiphysics based optimization. In the process integration and optimization, a Constraint Satisfaction DOE is used to create the initial test cases that satisfy the highly constrained problem. Then a multi-strategy self-adapting optimization algorithm is set to run an optimization to improve system performance. It took 3 days to run over 8000 load cases when parallelized 4-fold. The results can be viewed, evaluated, and compared dynamically. Final designs are selected from the pareto front with the consideration of average torque, torque ripple, displacement, and Mises stress. Discussion of the optimal pareto design set as well as other possibilities of applying this type of study to other electric vehicle design situations will be presented. The automation developed for the motor design was then published on a web-based simulation process & data management framework. Goal of this exercise was to create a motor design web app designed and prepared by engineers for engineers with no prior experience in scripting or web technologies. The data management framework enables traceability and version control of not only the multi-physics models but also the automation workflows. With a no-code, easy configuration-based approach a simulation engineer can convert his automation workflow into a shareable web app. This approach enables scaling the expertise of the motor design team to other key vehicle design functional disciplines accelerating design and development of the electrification platforms.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Mario Felice

Presenter Company: virsolTech Engineering Consulting, LLC

Title: Simulation Solutions: Opportunities and Challenges for the Effective Delivery of Automotive Electrification and Autonomous Technologies

Type: Panel Discussion

Keywords:

Abstract:

The relentless push for a decarbonized society is driving a dramatic transformation of the automotive industry, with companies totally disrupting this field and already introducing various levels of innovative technology solutions with respect to electrification, autonomy, and connectivity. This panel will focus on examining the current role of simulation and its challenges specific to the needs for the efficient development of E-Motors, EV Batteries and the introduction of level 4 and 5 autonomous technologies. Representatives from Automotive OEMs and Suppliers with expertise in design and simulation will be available for in-depth technical discussion as to current industry applications, innovative solutions, technical gaps, as well as future trends and needs.

Presenter Name: Simon Gomboc

Presenter Company: AVL Slovenia d.o.o.

Title: Optimization of an Electric Machine Cooling System

Type: Presentation

Keywords: Energy management, Electric Machine Cooling, Oil jet cooling, Thermal load management, Cooling optimization

Abstract:

To continuously advance electro mobility, a holistic approach to electric machine design is needed. Optimized designs allow for efficient energy transformation, from electrical to mechanical energy, and thus increasing the vehicle range. A critical aspect in this regard is a well-designed and sized cooling system. While there are various cooling strategies applicable to e-machines in automotive applications, for now liquid-cooled concepts attract the greater interest. With the trend of compact design and high-power density electric machines, the oil spray cooling is often the preferred cooling strategy. The optimization of the oil spray cooling in terms of geometrical properties, such as hole positioning and size, as well as flow conditions can greatly benefit from the means of Computational Fluid Dynamics (CFD) analysis. This study presents a computer simulation workflow for predicting the oil and temperature distribution in an e-machine. The workflow considers a comprehensive multi-domain geometry, simulating the multi-phase air and coolant flow and heat transfer between fluid and structure components in a single CFD model. The CFD model is validated with oil jet impinging electric machine test case from the literature. The predicted heat transfer coefficient matches well with the experiments for multiple operating conditions, varying the oil and solid wall conditions. In the next step, the model setup is applied in a real-case electric machine. To reduce the overall complexity of the model setup and geometry discretization a dedicated workflow app has been utilized. This app assists the user by providing guidance and high-level automation of time- and skill-intensive tasks (e.g. geometry pre-processing, numerical model setup, result analysis and reporting). The presented simulation workflow allows for significant time-savings by reducing the amount of “man hours” and total number of simulations required, when compared to other simulation solutions . Ultimately, it allows the comparison of different machine designs and operating conditions with respect to the probability of incurring component damage due to the thermal overload.

Presenter Name: Kenny Hoang

Presenter Company: Applied Intuition

Title: V&V Best Practices and Solutions for Building Safe Autonomous Systems

Type: Presentation

Keywords: Verification and validation, V&V, safety, framework, test library creation, coverage analysis

Abstract:

Verification and validation (V&V) of autonomous systems is a challenging task. Autonomy programs must define and follow a rigorous V&V process to ensure the safety of the systems they develop. Applied Intuition has leveraged its unique position in the autonomy industry to acquire extensive industry experience, work with customers to help them progress towards their validation and safety goals, track the latest research, collaborate with regulators and standardization committees, and develop new tools and processes to support our customers. In this presentation, we will discuss a V&V framework that programs can use to define system-level validation goals and objectives. This framework can be defined with a three-pronged approach: 1) System capabilities—what the automated driving system (ADS) needs to be able to do; 2) Requirements—How to define success for the ADS; 3) Operational design domain (ODD) taxonomy—Where the ADS needs to operate. Once the program's goals are outlined, the next challenge is to build out and scale a test library. We'll also discuss how programs can create a comprehensive scenario library to test validation goals rigorously. Programs can scale their test library through four common methods: From drive data and re-simulation, synthetically via abstract and logical scenarios, from map data, and with environmental parameterization. Each method has pros and cons and is suitable for different use cases and development goals. Successful teams see the most value by combining all of the methods through the development and testing processes to reach to full testing coverage efficiently. Lastly, we'll discuss how to calculate and measure test coverage to understand the space of known and unknown information. There are various possible scenarios—for example, pedestrians walking across a crosswalk, vehicle cut-ins, and new types of events not yet imagined. Ultimately, a measurable view of coverage is critical to identify the conditions that an autonomous system can and cannot handle safely.

Presenter Name: Navvab Khajehosseini

Presenter Company: Ford Motor Company

Title: CFD Simulation of Ram Air to Protect AV Sensor During Rain

Type: Presentation

Keywords: AV Sensor cleaning, Rapid Air Movement (RAM), Computational Fluid Dynamic (CFD), Rain Simulation, Droplet Breakup, Volume of Fluids (VOF)

Abstract:

One key challenge in the development of Autonomous Vehicles (AV) and Advanced Driver Assistance Systems (ADAS) is their poor performance in adverse climatic condition such as rain. In such conditions, even human vision is degraded and the need for AV system operation is more essential. Rain droplets on AV sensors such as lidars and cameras can create beam attenuation and backscattering and therefore inaccurate sensor reading which can lead to wrong decisions by AV algorithm. Therefore, it is important to have cleaning strategy to prevent rain droplets landing and staying on AV sensors or reactively clean the AV sensor surfaces from rain landing.

An idea to prevent incoming rain droplet hitting AV sensors is to use the airflow created by the moving car (i.e., RAM air) to create an air jet in front of AV sensors. The expectation is that the RAM air would deflect incoming rain droplets preventing them hitting the AV sensors. The goal of this study is to use CFD to evaluate and drive design of RAM air for lidar cleaning.

A detailed air flow analysis is performed to understand RAM air flow and incoming headwind interaction. RAM air flow is increased to find out what airflow rate and velocity are needed to deflect incoming headwind and to prevent a high-pressure stagnation zone on the lidar front.

Additionally, a detailed rain simulation study is conducted to evaluate the performance of the RAM air design to deflect and prevent rain droplets hitting the lidar. Several parameters are included such as the vehicle speed, droplet diameters, RAM air flow rate and velocity, and RAM air nozzle geometry. CFD correlation is conducted to build confidence in utilized Lagrangian rain particle tracking method. Rain droplets break up in cross jet is also studied both theoretically and explicitly. The explicit approach uses a CFD Volume of Fluid (VOF) approach to model single droplet in a head wind crossing the RAM air jet.

This CFD study showed that the initial design of RAM air flow is not able to deflect incoming rain droplets even at very large RAM air speed. In addition, it showed that the RAM air flow and headwind interaction creates a side circulation and stagnation zone on lidar surface. Both theoretical and CFD simulation showed that droplets do not undergo breakup as droplet break up residence time is larger than the droplet residence time in cross wind. More optimized RAM air design showed better preventive performance for rain droplet deflection and promising reactive performance improvement by omitting side circulation and stagnation zone. The RAM air design can be used in AV and ADAS sensor cleaning for their operation in rainy condition.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Anthony Lowther

Presenter Company: MAYA HTT

Title: Simulation-Based Electromagnetic Design and Thermal Analysis of Electric Machines

Type: Presentation

Keywords: Electric motors, finite element, power losses, thermal analysis

Abstract:

ABSTRACT: This work uses data-driven finite element (FE) simulations to set the background for the computational discussion and exploration of the electromagnetic design and thermal analysis of electric machines. The goal is to enlighten attendees on the relevance of thermal studies in the early design cycle of the electric motor. INTRODUCTION: Why are thermal studies important in the design and optimization cycle of the electric motor? Well, all rotating electric machines run the risk of overheating. For high-speed applications where motors could be operated for several hours, if not days, this phenomenon could even be more catastrophic! In the Automotive industry, for example, some automakers are doing serious damage to their brands or losing millions of dollars via product recalls and payment of customer warranties due to thermal defects that went unnoticed in the design process. Ford recently recalled 49,000 of its Mach-Es due to overheating. Similarly, Tesla issued seven recalls this year for the 2022 Model 3 and six for the Model Y, all of which have been ascribed to thermal problems. A total of 129,960 vehicles were recalled, resulting in huge loss of revenue. Overheating could reduce the efficiency of the machine due to increased power losses, cause the winding insulation to deteriorate, and eventually result in machine breakdown [1]. For this reason, thermal analysis is considered a crucial performance metric in the design of electric motors. Although cooling strategies are built into the design of most electric motors, such thermal management schemes are not foolproof. They are bound to fail, especially when the computational tools being used—to assess how hot or cold the machine could potentially get during run-up time—are incapable of gaining full insight into the thermal behaviour of the motor to help the motor designer choose the right cooling strategy. To address this challenge, the authors will use highly competent interoperable FE software to achieve the following objectives: • Setup a fully coupled multiphysics problem to accurately evaluate the electromagnetic and thermal performances of a permanent magnet synchronous motor (PMSM). • Obtain and interpret results in the post-processing modules of the FE software. This includes performing loss calculations on the electromagnetic side, adjusting relevant thermal settings such as emissivity, convection factor etc. to achieve realistic results. Below summarizes the design and simulation process, starting with an initial PMSM, applying the physics, and performing the coupled simulations to obtain desired results. METHODOLOGY: First, a motor template is selected and parameterized to meet initial sizing and simulation requirements using Siemens's motor design software such as Simcenter SPEED or Motorsolve. The CAD model is simulated using a transient FE solver option to evaluate the electromagnetic performances of the motor, with particular emphasis on the loss calculations. Once the electromagnetic performance objectives such as copper, eddy-current and hysteresis losses are calculated, the results are exported as thermal loads into a multiphysics simulation package such as Simcenter 3D for in-depth analysis of the motor's thermal performance. Attendees will be shown a more efficient way of connecting the electromagnetic design software to the thermal analysis module in Simcenter 3D and obtaining desired simulation results with less computational effort.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Prasad Mandava

Presenter Company: Visual Collaboration Technologies, Inc.

Title: Digital Transformation of CAE Results Processing, Sharing, and Review in the Context of Automotive Electrification

Type: Presentation

Keywords: Simulations, Simulation Results Review, Simulation Data Management, Simulation Results Processing, Multi-Physics Visualization, Digital CAE Slides, Digital CAE Reports

Abstract:

The transition from fossil fuel-based to clean energy-based products presents a significant challenge for the automotive sector. Simulation becomes a crucial component of product design and is required to achieve mission-critical results as products become more complex and less dependent on real prototypes. Simulation-derived insights have a very high value. Challenges with electrification include keeping batteries from overheating and figuring out how the structure and dynamics of a vehicle are changing. The confluence between thermal, electrical, and structural analyses is more prominent than ever in an electric vehicle. It is crucial to visualize Multiphysics findings in real-time and to identify the hotspots in each physics and their interactions. Any structural imbalance or material deterioration (for example, as a result of road or thermal conditions) could cause damage to the battery packs or cells, resulting in uneven thermal distribution and thermal runaway. It becomes important to see the results of Multiphysics in real time and figure out where the hot spots are in each physics and how they interact. Any structural misalignment or wear and tear (from the road or the temperature, for example) could cause damage to the battery packs or cells, which could lead to an uneven distribution of heat and a thermal runaway. All structural and material hotspots, as well as places where the temperature is higher or more uneven, are equally important. The number of variables and orders involved in optimization increases the problem's complexity. The result of the above problem is that you have to run hundreds of simulations for both physics and "what-if" studies to find the best design. In this situation, time, skill, data explosion, and resource limitations limit the number of simulations that may be performed. It can be hard for a product development team with many different roles to work together when simulation results are shared in a static way, like in a PPT report. Not only are the teams distinct in terms of their skill and geographic location, but the information they require from simulation runs also varies. The static nature of the simulation data or simulation information provided in the 2D report restricts the scope of collaboration, hindering the quality of information flow, and, as a result, affecting design decisions. Utilizing the outcomes of the simulation studies to their fullest extent may be one approach to overcoming design, simulation, and collaboration obstacles. This can be accomplished using a system that can dynamically overlay diverse CAD designs, CAE findings, and physics simulation outcomes in real-time to provide significant overall insights to the appropriate stakeholders. The purpose here is to provide cross-functional Multiphysics insights that can assist teams in making improved design decisions with a greater degree of certainty. This is only possible when all design stakeholders have access to all design and simulation information in its totality and the ability to extract the appropriate insights in real-time. This, however, necessitates technologies and tools that can not only depict native simulation data but also completely support cross-functional or Multiphysics visualization and offer in-depth insights. In this paper, we discuss possible solutions to address many of

these electrification-related simulation issues. These solutions deliver relevant Multiphysics simulation information in the Digital Form to respective stakeholders, making it easier for them to visually examine and extract greater insights. The dynamic nature of the information enhances the quality of collaboration and integrates cross-functional teams without regard to their respective areas of expertise. This solution enables better, and more significantly, quicker design decisions to be made.

Presenter Name: Simona Ottaiano

Presenter Company: Siemens Industry Software NV

Title: Edge Case Analysis in Adverse Weather Conditions Taking Into Account Sensor Degradation

Type: Presentation

Keywords: ADAS, Reliability, Edge Case, Adverse Weather, Rain, Soiling, Sensors, CFD, Situational Traffic Simulation, Simcenter Prescan, Simcenter STAR-CCM+, Simcenter 3D High-Frequency EMAG, Siemens

Abstract:

Reliability of ADAS is an increasingly important requirement in the progression to autonomous vehicles. In that context, edge case simulation is a common practice to identify potential situations leading to a failure, early in the design process of the system. In simulation, adverse weather conditions such as rain, snow and fog impacting the ADAS sensor performance are usually treated in a simplified way or neglected completely. Therefore, simulation results of an edge case most likely tend to be biased rather towards a best-case outcome than the favourable worst-case outcome. Overestimation of the ADAS performance can be the result. To evaluate the impact of realistic sensor performance deterioration in a situational edge case simulation, a reference edge case is created with an ideally operating radar sensor and environmental parameters. The reference case is then altered to account for adverse weather conditions with different level of fidelity. For situational traffic simulation Simcenter Prescan is used. To assess the potential of the simulation, a dynamic edge case manoeuvre is chosen, strongly impacted by radar vision. Beside the reference case under ideal conditions, the situation is simulated in Simcenter Prescan with the following adjustments: 1. Scenario one treats the sensors ideally with the environment being absorbent, emulating rain. 2. In scenario two, the microscopic performance of the radar sensor is considered. First, the sensor is placed in a non-optimized spot on the car, identified by CFD simulation in Simcenter STAR-CCM+ and the expected water film thickness is derived. Then, the microscopic sensor performance is obtained from a simulation in Simcenter 3D High-Frequency EMAG. data is then used in Simcenter Prescan for sensor simulation. 3. In scenario three, the radar sensor position is improved, and the resulting water film impact on the sensor performance is again simulated. The three cases are evaluated and compared to the reference case, regarding target detection range and timing, derived braking process and overall outcome of the manoeuvre. It is concluded that simulation can be used to identify qualitative differences between the presented sensor configurations on the car in adverse weather conditions. Moreover, the impact of the microscopic sensor properties on an exemplary edge case scenario proved to be significant.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Malcolm Panthaki

Presenter Company: ARAS Corporation

Title: What's Special About EV's? Development of a Flexible Digital Thread for System Performance Simulation at Toyota Motor Europe

Type: Presentation

Keywords: Multidisciplinary electric vehicle design, MBSE, Requirements Engineering, Conceptual Product Architecture and Design, Collaborative/Concurrent Engineering in the Cloud, Model Based Development, Engineering Data Management, Simulation Automation

Abstract:

As global and many burgeoning, new automotive companies pin their futures on Electric Vehicles (EVs) and drive towards a portfolio dominated by them in this decade, doing business as usual is no longer feasible. The multidisciplinary nature of EVs, with a focus on electronics, batteries, sensors and software, clearly point the way away from the mechanical focus of the past. Throw in the modern reality of international supply chains, regulatory implications of autonomous vehicles, new business models such as Mobility Services, and you are faced with a real problem achieving the critical task of capturing, disseminating, and communicating product requirements and functionality. The miscommunication of product intent leads to many costly errors and time delays across the entire product lifecycle, including products operating in the field – in fact, errors in early design decisions are known to be the most expensive and need particular attention. Product Lifecycle Management (PLM) platforms and especially the approach required during the conceptual architecture and design phase, must transform to meet these new, more-demanding products. What's needed? Can't we simply throw electronics, software, autonomous driving algorithms and a totally different competitive landscape (where the electronics and software become the differentiators) into the old mixing bowl and make it all work? We believe that the following elements of a solution are critical to "make it all work" – we are not, however, implying that these are the only changes that are required. 1. A fully featured, highly flexible and nimble PLM platform deployed in the cloud, supporting a requirements- and systems-centric digital thread (in stark contrast to the status quo that is BOM/Part/CAD-centric). 2. Much improved "requirements engineering" that encompasses all disciplines in a coherent, consistent form. 3. A collaborative, multidisciplinary conceptual architecture and design phase that is based on neutral/generic engineering data management approaches, with the ability to automatically drive huge numbers of simulations leading to automated design space exploration across all the disciplines. Case Study: Automotive development needs to satisfy an ever-increasing number of conflicting requirements. Specialists from different engineering backgrounds have traditionally dealt with them using standardised methods developed in each domain over the years. Model Based Development (MBD) at Toyota Motor Europe envisions the holistic development of the vehicle and its subsystems by coherent application of simulation; it is well suited to front-load development processes and to manage such increasing complexity. The effective application of MBD poses at least two sets of challenges: on the one hand, the organization should entrust and correctly understand the capability of available simulation methods, which is related to maturity of technical development and application practice; on the other hand, it should have developed infrastructure and processes to apply simulation seamlessly, in terms of quality and resources. The MBD team at Toyota Motor Europe is responsible for technical development of

simulation methods and their deployment to vehicle development projects. We have recently demonstrated the potential of a flexible and scalable system-centric digital thread for non-geometric engineering specifications; a solid data model is the necessary basis to design efficient and automated digital processes, enhancing engineering collaboration across domains. After this first pilot implementation, TME is now working on the extension to simulation processes with the same flexibility and scalability. This presentation will define the overall vision of the engineering data management solution, its extension to SPDM and results that have been measured.

Presenter Name: Anup Paul

Presenter Company: Hexagon Manufacturing Intelligence, Inc.

Title: Thermal Runaway Simulation of EV Batteries with CFD and 1-D Systems Model Co-simulation

Type: Presentation

Keywords: Battery pack, thermal runaway, 1D, 3D, CFD, CHT, 1D-3D Co-simulation

Abstract:

Electric Vehicle batteries must be operated in an ideal temperature range to prevent sluggish performance and degradation. More importantly, the battery cooling system should have the capacity to contain or delay thermal runaway due to electrical or mechanical abuse. CFD simulations can be utilized to identify potential thermal problems early in the design process and develop reliable cooling solutions. The details of a co-simulation model demonstrating the coupling of 3D CFD model for the battery module and a 1-D system model for individual cells to simulate thermal runaway will be presented. A battery module with 307 cells, coolant path, metal plates, plastic tray and case is modeled in 3D CFD to simulate convective heat transfer, radiation, and propagation of thermal runaway. The electro-thermal response of the individual cell units is modeled as a 1-D system. The coupling between 3D CFD and 1-D systems model is accomplished via FMI connection. The thermal runaway is simulated by triggering a short-circuit in selected cells to mimic a failure condition. Results of the temperature propagation and vent gas flow will be discussed.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Prashanth Ramesh

Presenter Company: OSU Center for Automotive Research

Title: Electro-Thermal Modeling and Co-Simulation of Lithium Ion Cells for High Performance Applications

Type: Presentation

Keywords:

Abstract:

Battery pack sizing and design requires careful consideration of the energy and power demands as well as the potential heat generation experienced at the system level. For high performance applications, such as motorsports, the increased power demand puts a higher stress on the battery due to large current draw resulting in higher heat generation and thermal imbalance within the system. Accurate modelling and simulations tools that can capture both the electrical and thermal response of the cells are critical to ensuring safe and efficient battery pack design. In this presentation, a co-simulation model framework capable of predicting the voltage as well as the 2-D heat generation and temperature distribution across a cell is developed and validated. The model framework relies on high-fidelity electrical circuit models for fast computation with increased accuracy to capture the voltage and heat generation. In conjunction with the electrical model, a 2-D distributed charge balance model based on the Poisson equation captures the heat generation distribution across the cell. A thermal-CFD model is developed which relies on the 2-D heat generation provided by the charge balance model to predict the temperature distribution across the cell. The co-simulation tool developed ensures synchronization between the electrical and charge balance model, in MATLAB and SIMULINK, with the thermal model, in STAR-CCM+, and closes the loop between the different models. The framework includes custom-developed code to facilitate the communication of data between the different software packages using APIs.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Sylvia Rissell

Presenter Company: Dimensional Control Systems, Inc.

Title: e-PowerTrain Electric Motor Gear Analysis

Type: Presentation

Keywords: EV, Electric Motor, Electric Vehicle, e-powertrain, gear, gear analysis, digital twin, stack simulation, gap analysis, contact analysis, flank test, angle backlash, digital simulation

Abstract:

The performance of an Electric Vehicle Power Unit is directly connected to critical tolerances. Tolerances drive opportunities for performance enhancement and cost reduction. The use of Dimensional Variation Analysis determines the critical tolerances, and showcases areas that can be adjusted without risk to the assembly. Dimensional Variation Analysis simulates both part and process variation. This enables engineers to analyse their manufacturing process and determine how it affects both the assembly and final product functionality. The part tolerances, assembly process, and product measures are functionally transformed into the ability to predict and fix quality issues before the builds of concept, prototype, pre-production, and production. This provides an opportunity for a balanced issue resolution, innovation, and cost savings. The upfront method illustrated in this presentation uses digital technology to create a Digital Twin as a parametric family of designs with statistical tolerances as the parameters. This Digital Twin then performs as the real-world product, allowing for testing and checks to be performed. The traditional method of designing gears, as opposed to the Digital Twin concept, uses a different system for design other than GD&T. Gear power companies that do the synthetic analysis and sophisticated engineering of the gears such as CAE and measurements use that system to input the data, and they get outputs for machining in a gear language which is difficult to use by other groups. In order to integrate gears into your whole system, the use of GD&T, accurate CAD designs, and then the use of a dimensional system combine to create a Digital Twin that allows multiple teams to diagnose and explain issues that can be communicated as standard information throughout the company; the manufacturing, design, and management groups. This is because many other groups want to use the information to feed their own analyses. The gears need to be integrated into the noise and vibration unit, the dimensional engineering and drafting, the manufacturing inspections, there are a lot of communications that need to happen rapidly and completely in order to get the design correct. The Digital Twin can be the centre of this process, interfacing with every group, as well as having its own capabilities in those areas. Once an adjustable statistical tolerance has been established, the tolerances can be split into the individual components. For example, in the design phase, the bearing represents the combination of the gear grade, bearing specifications, and the housing specifications. Dividing the tolerance up using statistical cost analysis can balance the design tolerances with the lowest cost. Gear micro geometry in the form of gear crowning, gear backlash or tooth clearance is another example of the method. Adjusting the tolerance as a parameter provides the geometric information to ensure the gear system backlash and flank patterns meet the required specifications. This is done using the Contributors, the root causes of variation for a measurement. In the Contributors list, the measurements input dimensions and percentage of contribution are provided. Using this form of statistical morphing, this digital model can simulate the measurements of the final manufactured drive

system as well as each component for an innovative, robust concept design or physical “mule” drivable concept vehicle.

Presenter Name: Chiranth Srinivasan

Presenter Company: Simerics, Inc.

Title: Conjugate Heat Transfer Analysis of a Cold Plate Cooled Battery Pack for Electric Vehicles Using CFD

Type: Presentation

Keywords: Battery Pack, Thermal Analysis, Conjugate Heat Transfer, Electric Vehicle

Abstract:

This study demonstrates the analysis capability of CFD for the entire cold plate cooled battery pack in electric vehicles. With the rapid development of electrically powered vehicles, there is an increasing need in the automotive industry to perform virtual simulations of the battery pack to determine the viability of the designs and evaluate the performance. Among these needs, accurate thermal analysis and predictions are vital as the thermal behaviours have significant impacts on the performance and final design of the battery packs. In this paper, a complete three-dimensional Conjugate Heat Transfer (CHT) CFD model is developed for the battery pack of GM Bolt electric vehicles, with the Simerics software package, including all the important and detailed parts like the battery cells, cartridges, separators, busbars, tray, etc. The results demonstrate the abilities of the developed CFD tool in meshing complicated, intricate paths with rapid turnaround times making it a very attractive tool for virtual design and development. The thermal simulation results obtained from the battery charging study are compared well to the test data by thermocouple measurements.

Presenter Name: Joe Wimmer

Presenter Company: Gamma Technologies

Title: Combining 1D and 3D Multi-Physics Modeling Methodologies for Thermal Runaway Propagation Analysis

Type: Presentation

Keywords: Thermal Runaway, Multi-physics modelling, Battery Safety, Electrochemistry

Abstract:

Battery pack designers must ensure that all battery packs are designed to withstand a single cell entering thermal runaway without the heat from this cell causing thermal runaway to occur in neighboring cells, leading to thermal runaway propagation. Pack designers must be confident that no matter which cell enters thermal runaway, and no matter how the cell enters thermal runaway, that thermal runaway will not propagate into a pack-level fire. Studying thermal runaway events at the pack-level has historically relied heavily on expensive pack-level experimental tests using prototype batteries or computationally-expensive 3D CAE analyses. Because the cost of a single test in either scenario (real cost or computational cost) is very high, both options allow for only a handful of scenarios to be realistically studied. Additionally, when reduced-order models of pack-level thermal runaway are employed, they have historically relied on empirically-driven models for the heat generation of cells entering thermal runaway. These models often rely on knowing the heat ejected from a cell ahead of time and often ignores the history of cells leading up to their thermal runaway events. This presentation will demonstrate the benefits of a physics-driven approach to reduced-order modelling of pack-level thermal runaway propagation. By combining 1D/3D thermal structure modelling of cell temperature, 1D flow simulation of flow paths between cells, pseudo-2D electrochemical modelling of cells leading up to thermal runaway, and generalized chemical modelling for thermal runaway reactions inside the cell, this presentation demonstrates a computationally efficient approach to modeling thermal runaway propagation that also has high model fidelity and accuracy. With an accurate and fast-running model, more virtual experiments can be setup to enable more what-if scenarios to be tested. This includes robust case sweeps and even multi-factor design of experiments (DoE) tests to be done.

Presenter Name: Justyna Zander

Presenter Company: Ford Motor Company

Title: Deploying World-Class Simulation across Ford Software-Defined Vehicles

Type: Keynote

Keywords:

Abstract:

With the arrival of software-defined vehicles, the need to virtualize every step of development became a necessity. At Ford, we are transforming software production pipelines using end-to-end simulation deployment horizontally across all software products and vertically across all platforms. The goal is to iterate fast on creating a fantastic driving experience along with a strong quality and safety compliance.

Presenter Name: Jonathan Zeman

Presenter Company: Gamma Technologies

Title: Model-Based Assessment of Fuel Economy Impact of ADAS Functions on Class 8 Trucks

Type: Presentation

Keywords: ADAS, Heavy-Duty, Class 8, Fuel Economy, Energy Management, GHG Emissions

Abstract:

Among the different vehicle categories in on-road transportation, Class 8 long-haul trucks are a significant contributor to overall GHG emissions. Furthermore, with the upcoming 2027 GHG emission and low-NOx regulations, advanced powertrain technologies, including electrification, and ADAS systems, will be needed to meet these stringent standards and reduce operating costs. With advancements in vehicle connectivity technologies for onboard computing and sensing, the full potential of existing conventional heavy-duty vehicles in reducing fuel consumption can be realized through V2X (Vehicle-to-Everything) communication. Upcoming road grade, traffic lights and lead vehicle speeds can be utilized to optimize vehicle speed profile, energy management and thermal management strategies. While many studies have been conducted in the past to evaluate control strategy changes based on longer time horizon, limited studies have been conducted to evaluate shorter time horizon strategies that dynamically adjust vehicle speed (or suggest vehicle speed) for fuel efficiency. In this study, a model-based approach was applied to evaluate the fuel economy improvement potential of a connected Class 8 long-haul truck. A system-level 1-D propulsion and thermal system model of an electrified Class 8 truck was simulated in real-world conditions including traffic lights, multiple lead vehicle and varying road grades using GT-SUITE. The look-ahead information on road grade, traffic light schedule and lead vehicle speeds were assumed to be available through GPS, V2X communication and long-range radar sensors. The connectivity information was then used to optimize the vehicle target speed, energy management strategy and thermal management strategy to predict fuel economy improvement potential on multiple real-world drive cycles.

Simulation in the Automotive Industry: Driving Convergence to Electrification, Autonomous and Connectivity

Presenter Name: Yangbing Zeng

Presenter Company: General Motors Corp

Title: Electrification Thermal Development: Challenges and Opportunities

Type: Keynote

Keywords:

Abstract:

Thermal management is of paramount importance for electrification as the automotive industry aggressively transitions to electric vehicles. To meet range demands and reduce charging times, more battery energy is being packed into vehicles with increased charging current during DCFC. Consequently, heat generation from electric vehicles keeps rising. The development of an advanced thermal management system to keep pace with heat generation from the battery becomes increasingly challenging as the battery temperature must be within a narrow window to be efficient. Additional challenges come from protecting the battery system during the event of thermal runaway. Multiple physics analyses and simulations play an important role in overcoming these challenges while developing a thermal system. The insights gained from these simulations allow thermal engineers to learn faster and select the right technologies. The high-fidelity simulation also enables the full system to be optimized virtually to shorten development time.