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2	1	Marion Andritz	Chemical Engineering, Montanuni Leoben	**Investigation of an innovative perovskite-based catalyst for process optimization in the reverse water gas shift reaction: Unlocking the potential for e-fuel production**
3	1	Barbara Buxbaum	Physical Chemistry, Montanuni Leoben	**Optimization of Composite Air Electrodes for Solid Oxide Cells**
4	1	Mehmet Aksoy	Physical Chemistry, Montanuni Leoben	**Development of sustainable air electrode materials for solid oxide cells**
5	1	Larissa Jeindl	HyCentA	**Green Hydrogen On-Board Storage Systems**
6	2	Alejandro Robles Martin	Urban Gold	**Circularity of e-traction machines**
7	2	Miljana Vuksanovic	AIT	**Shellac - Application of a Sustainable Biopolymer as a Binder for Si/Gr-Anodes in Li-Ion Batteries**
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10	2	Kamalesh Bharadwaj	LKR	**Wire-arc directed energy deposition of copper for e-mobility components**
11	3	Dominik Schlüter	Virtual Vehicle	**Design and optimization of filters in the cathode path of a fuel cell vehicle**
12	3	Dominik Köppel	TU Wien IMM	**Highly Dynamic & Decoupling Fuel Cell Testbed Control**
13	3	Emina Hadzialic	AIT	**Airworthy battery energy storage for decarbonizing aviation**

14	3	Joel Edjokola	CEET, TU Graz	**Investigation of the Degradation Mechanisms of PtCo Oxygen Reduction Catalysts in Polymer Electrolyte Fuel Cells Under Humidity Gradients**
15	3	Johanna Bartlechner	TU Wien IMM	**PEM Fuel Cells – Assessing degradation during dynamic operation**
16	3	Matthias Hofer	TU Wien ESEA	**HeAD – High performance electrical Austrian Drivetrain, a highly integrated and high-speed electric axle**
17	3	Maximilian Käfer	CEET, TU Graz	**Optimizing Water Management for Sustainable Fuel Cell Electric Vehicles**
18	3	Samuele Cappelli	HyCentA	**Simulation toolchain for the development of metallic bipolar plates for PEMFC**
19	3	Florian Tritscher	CEET, TU Graz	**Investigation of Advanced Membrane Electrode Assemblies in High Temperature Proton Exchange Membrane Fuel Cells for Heavy Duty Vehicle Applications**
20	4	Lucas Winder	Virtual Vehicle	**Next Generation Emission-Reduced Charging System Technology**

1 The development of novel materials to improve CO_2 converting reactions

F. Schrenk, T. Berger, T. Cotter, H. Drexler, L. Lindenthal, J. Michalke, J. Rollenitz, R. Rameshan, T. Ruh, C. Rameshan

The fight against climate change is one of the most pressing issues in our time. One focus point is the mitigation and conversion of greenhouse gases such as CO_2 and methane. In the project TUCAS we research catalysts for CO_2 converting reactions. Thereby we focus on a material class known as perovskite-oxides as they are emerging as promising candidates for these reactions. Perovskite-oxides can undergo a special process known as exsolution in which they form metallic nanoparticles on their surface. In contrast to conventional surface decorations these nanoparticles have limited mobility and therefore great stability at reaction temperatures, which usually exceed 600 °C depending on the reaction.

One goal of our research is to help close the carbon cycle and therefore reduce the emittance of CO_2 in the atmosphere. We developed a catalyst that can be used directly on-site of the emission to convert CO_2, ether with methane or hydrogen, into CO. This gas can then be transported and stored easily and used as energy carrier or further transformed into synthetic fuel. Another reaction we are developing materials for is called methanol steam reforming. This would allow the conversion of methanol, in the presence of water, into hydrogen and CO_2. This reaction is part of a greater concept in which renewable energy is used on-site to produce hydrogen and in turn methanol. The methanol can then be transported easily and safely and turned into hydrogen again using methanol steam reforming. The CO_2 can then be used for methanol production again.

2 Investigation of an innovative perovskite-based catalyst for process optimization in the reverse water gas shift reaction: Unlocking the potential for e-fuel production

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The transport sector, a significant contributor to global CO_2 emissions, plays a critical role in addressing climate change, but hard-to-abate sectors like aviation or marine transport still heavily rely on carbon-based products. Utilizing CO_2 offers a sustainable alternative to decarbonized fuel production, where the reverse water gas shift (rWGS) reaction represents a key technology for the conversion of CO_2 and green H_2 to syngas, which is a feed gas for the Fischer Tropsch synthesis for e-fuel production.[1] The rWGS is thermodynamically favored at high temperatures (800 – 950 °C), low pressures (1 – 8 bara), and an H_2:CO_2 feed ratio of 3:1, whereas undesired side reactions like methanation (CH_4) are suppressed. On the other hand, large-scale CO_2 conversion in high-temperature reactions, such as the rWGS, remains challenging due to the high energy demand. Operating the reactor at lower temperatures decreases the heat input and thus reduces operating and investment costs due to simpler reactor design.

Here, a comparison of commercially available nickel catalysts and novel perovskite-based catalysts described by Lindenthal et al. [2] is demonstrated on a laboratory plant scale. The impact of various operating conditions (temperatures between 550 and 950°C and pressures up to 8 bara) on the product gas composition was investigated.

Results show that at 550°C, 8 bara, and 8,000 h^{-1}, the perovskite catalysts exhibit relatively low methane formation, peaking at 2.7 vol.-%, in contrast to the nickel catalyst, which produces 28 vol.-%. This finding indicates, that the perovskite catalyst can be operated at moderate temperatures and therefore exhibits great potential for rWGS reactions related to power-to-liquid processes.

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3 Optimization of Composite Air Electrodes for Solid Oxide Cells

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Solid oxide electrolysis cells (SOEC) are a key technology to produce sustainable energy carriers. Co-electrolysis of CO_2 and H_2O not only enables highly efficient storage of volatile renewable energies but also the reduction of CO_2 emissions. Another advantage is that a mixture of CO_2 and H_2O can be converted into synthesis gas (CO and H_2), which can be used in the Fischer-Tropsch-process to synthesize e-fuels (methane, methanol, ethanol etc.) which can be used in innovative propulsion systems.

The material development of state-of-the-art air electrodes such as $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ is currently pushing the limits of cell efficiency and lifetime. A promising way to further improve the electrochemical performance and long-term stability of the air electrode is the utilization of composites like $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) with $Ce_{0.9}Gd_{0.1}O_{1.95}$ (GDC). This work aims to correlate electrochemical investigations with microstructural characterization to design guidelines for optimized composite air electrodes for H_2O- and co-electrolysis at high current densities. A set of composite air electrodes was prepared with LSCF-GDC weight fractions of 30:70, 40:60, 50:50, 60:40 and 70:30 and analyzed by electrochemical impedance spectroscopy (EIS) and 2D/3D-SEM imaging. Analyses of anode-supported full cells were performed at 800°C with different ratios of CO_2 and H_2O. Advanced image analysis was performed to extract microstructural features such as the porosity, the tortuosity, etc.

4 Development of sustainable air electrode materials for solid oxide cells

Session 1: Sustainable Energy Carriers

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Solid oxide electrolysis cells (SOECs) are a highly efficient technology to produce hydrogen (H_2), which can be used as a sustainable fuel and as an environmentally friendly energy carrier for various applications. In particular, H_2 produced via SOECs can serve as energy for fuel cell vehicles, promoting cleaner transportation. However, in modern energy conversion and storage technologies, many of the materials used contain "critical" elements such as cobalt or rare earth metals. These elements are highly important for technological applications but are sourced from only a few countries. In this work, functional ceramics made from abundant and cost-effective elements like calcium and iron are being studied to develop sustainable air electrodes for solid oxide fuel cells (SOFCs) and solid oxide electrolysis cells. When examining the Ca-Fe-O system, it was found that $Ca_2Fe_2O_5$ (CFO) with a brownmillerite structure is stable in ambient air. However, CFO showed a relatively low electronic conductivity of 0.4 S/cm at 800°C for CFO. In order to improve the electrical properties, $Ca_2Fe_{1.3}Mn_{0.7}O_5$ (CFMO) was synthesized, as previous research indicates that substituting Fe with Mn in CFO can enhance electronic conductivity. In addition, a two-phase composite was created by mixing CFO with $LaNi_{0.6}Fe_{0.4}O_3$ (LNF), known for its excellent conductivity, in a 50:50 weight ratio. The electrical conductivity of this CFO-LNF composite and CFMO at 800°C was approximately 48 S/cm and 6 S/cm, respectively. Further studies on the electrode performance of these materials in electrochemical cells are ongoing.

5 Green Hydrogen On-Board Storage Systems

Larissa Jeindl

Liquid hydrogen offers a significantly higher volumetric energy density compared to gaseous hydrogen due to its compact nature in the liquid state, enabling more efficient storage in limited spaces. This property is especially advantageous for space limited applications such as spacecrafts. However, ensuring safety in the handling and storage of liquid hydrogen necessitates a thorough investigation of potential failure scenarios, particularly in the event of leaks from filling lines or storage tanks. Various failure conditions and operational states result in multiple scenarios that require detailed analysis.

This research focuses on the leakage of the inner insulation layer, modeled through 2D Computational Fluid Dynamics (CFD) simulations using Ansys Fluent. A suitable multiphase model is employed to simulate the evaporation process that occurs due to insufficient insulation. Additionally, the liquid hydrogen filling process is examined, where warm pipes in the initial phase cause evaporation and pressure buildup in the tank. Once the pipes are sufficiently cooled, the liquid hydrogen filling process begins. The 0D filling model used in this study is validated against experimental data from HyCentA's previous infrastructure and serves as a foundation for validating more detailed 3D CFD tank-filling models. Furthermore, the research investigates the venting of hydrogen vapor through the boil-off valve as a result of pressure increases due to evaporation.

6 Circularity of e-traction machines

UrbanGold
recycling for a green future

EM-TECH

Session 2: Circular Economy

Abstract: Circularity of e-traction machines

EM-TECH is an on-going research project within the Horizon Europe activities, which brings 10 participants from industry and academia together to develop novel electric in-wheel and on-board motors for vehicle traction. These include, among others, innovative direct and active cooling designs, enhanced machine control, reduction of 60 % of rare earth in permanent magnets, and the adoption of circular solutions.

Two baselines are defined for the in-wheel motor and the on-board motor respectively to verify the final project enhancements by applying LCA/LCC methodologies. Various waste legislations are reviewed to determine the end-of-life scenario of the baselines and identify eco-design strategies to improve recyclability for both e-traction machines. Special attention is drawn to the Directive on End-of-Life Vehicles 2000/53/EC, which appears to be obsolete for not considering the features of e-vehicles and focusing on internal combustion engine vehicles.

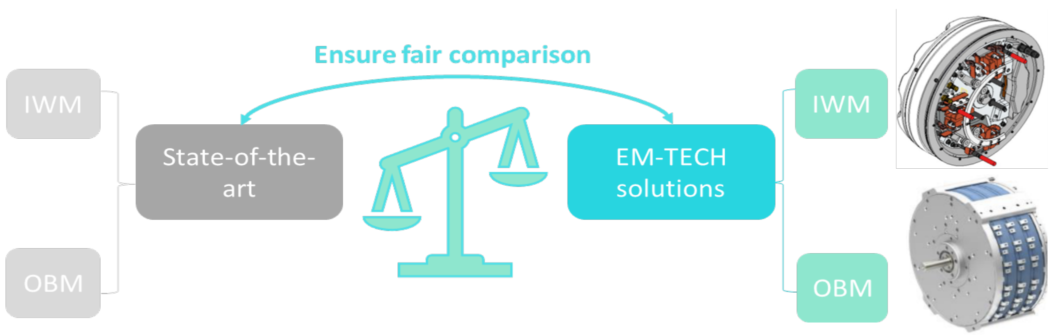

Figure 1. LCA/LCC approach

The poor recyclability of permanent magnets identified in the baseline – either the magnets remain attached on the machinery of the shredding facilities or dilute in the metal recycling industry – indicate the need of dismantling the magnets before forwarding them to shredding. Thus, the enablement of the recovery of permanent magnets involves the participation of the manufacturing industry by applying eco-design strategies, the recycling industry by developing new processes which allow the separation and recovery of critical elements, and policymakers by establishing a legal framework which promotes the recycling of permanent magnets.

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7 Shellac - Application of a Sustainable Biopolymer as a Binder for Si/Gr-Anodes in Li-Ion Batteries

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Introduction

Silicon (Si) has a great potential to increase the lifetime and capacity of lithium-ion batteries (LiBs), since it can store more than ten times more theoretical capacity (≈4200 mAh·g-1) compared to conventional graphite (Gr) (≈370 mAh·g-1). (1) However, its application often leads to drastic volume changes (>300%) during the charge-discharge process which cause significant changes and errors on the surface of the electrode. Depending on the Si-content, lack of structural integrity, as well as particle deformation can be observed. All these lead to drastic capacity loss. These problems can be solved by choosing a more suitable binder system. (2)

Shellac as a Self-Healing Binder

To overcome the aforementioned problems, shellac as a binder was suggested in this study. Shellac is a water-insoluble resin that is secreted by a lac insect. The main advantages are renewability, abundance, and non-toxicity.

This naturally available polymer has the potential to serve as a self-healing binder in LiBs, due to its self-polymerization properties during the aging process. During this process, cross-linking or inter-esterification of polyhydroxy carboxylic acids with the free alcohols occur. (3) The effects of these reactions are tested in coin cell format against Li metal. Si/Gr anodes with the binder system Carboxymethyl cellulose (CMC) with styrene butadiene co-polymer (SBR), which were tested in parallel, serve as a reference.

Acknowledgments

This work was financially supported by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (bmk).

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8 RecAL- Recycling Technologies for Circular Aluminium

LKR Leichtmetallkompetenzzentrum Ranshofen

Gerald Prantl, Clemens Simson, Stefan Gneiger

Session 2 – Circular Economy

Poster „RecAL- Recycling Technologies for Circular Aluminium"

Recycling aluminium from End-of-Life and production scraps holds immense promise, using a mere 5% of the energy required for primary material production and causing 80% less CO2 emissions. Recognizing its pivotal role in global decarbonization, particularly in alignment with the European Green Deal, the RecAL project aims to maximize the potential of this resource, that is key to many aspects of the transition towards sustainable economy.

RecAL is a Horizon Europe Research and Innovation Action project (RIA), that started 2024 and is funded with almost 11 MEUR. A consortium of 19 European partners will advance 14 Circular Amplification Technologies (CATs) and integrate them into a digital, socio-technical ecosystem - the Aluminium Hub for Circularity.

The project provides a balanced approach towards full circularity in aluminium recycling by

1) Advancing a complementary set of up- and recycling technologies (CATs) to TRL 6 to improve capture and separation of aluminium recyclate at its source, steering it into high purity streams thus enabling re-use in high quality products.

2) Designing, developing and validating a digital HUB that combines these techniques to plan, monitor and improve circularity of aluminium throughout the value chain, spanning across sectors, linking producers, scrap suppliers and buyers within an innovative circular business model.

Ultimately, the RecAL Circularity HUB will be demonstrated via three use-cases, that resemble and quantify the impact on future closed value loops from aluminium EoL-procurement to remanufacturing.

9 Deriving Performance Casting Materials from Complex Secondary Value Streams

LKR Leichtmetallkompetenzzentrum Ranshofen

Giulia Scampone, Martin Schnall, Alexander Grossalber, Clemens Simson

Session 2 – Circular Economy

Poster „ Deriving Performance Casting Materials from Complex Secondary Value Streams"

To ensure the widespread use of sustainable and recyclable aluminum alloys, it is essential to deal with elements that typically have a detrimental impact on the mechanical properties.

Developing an alloy with a multi-phase eutectic structure can be an effective technique for overcoming this problem. In these alloys, elements typically considered detrimental in standard alloys (e.g., Fe) are incorporated into the multi-phase eutectic structure. This results in an ultra-fine eutectic structure, enabling elevated mechanical properties without compromising ductility. As they are formed independently of the cooling rate or casting process chosen, this strategy is a promising approach to allow cross sectoral aluminium circularity.

Additionally, these alloys are suitable for heat treatments and welding processes, allowing the construction of complex industrial components. As evidence of this, during the SUSTAINair project, the inner frame structure of an experimental wing was produced using a nano-eutectic AlMgZnSiFeNi-alloy. The frame was composed of sandcast and high-pressure die-cast parts with welding rods - all manufactured from the beforementioned alloy and welded together using Tungsten Inert Gas (TIG) technology.

10 Wire-arc directed energy deposition of copper for e-mobility components

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Additive manufacturing offers promising opportunities for rapid prototyping, design flexibility, lightweighting and the realisation of functional features in industrial applications. With the increasing use of copper components in electric vehicles and alternative energy solutions, sustainable manufacturing of copper parts is critical. Wire-arc directed energy deposition is an emerging process for sustainable additive manufacturing of metal components due to lower material wastage and lower emissions during wire manufacturing. The present study investigates the feasibility of the process using copper as filler material and the properties imparted in the deposited parts. The robot toolpath strategy and process parameters were developed for processing copper CuSn1, overcoming challenges such as high thermal conductivity and arc deposition instability. Afterwards, the microstructure and mechanical properties of the produced test parts were analysed. A relative density of 99.99% is achieved in the deposited material. In addition, a textured morphology with grains growing along the build-up direction is observed. In terms of mechanical properties, a Vickers hardness of 64 $HV_{0.1}$, a tensile strength of 185 MPa and an elongation of 60% is achieved. Finally, an electrical busbar component is fabricated for the demonstration of the process feasibility.

11 Design and optimization of filters in the cathode path of a fuel cell vehicle

Autors: Dominik Schlüter, Bernhard Fischbacher, Almir Cajic, Bernhard Lechner

Abstract:

Fuel cell vehicles will be used in applications where short refueling times and high energy densities are required.

However, fuel cell systems are sensitive to harmful gases such as sulfur dioxide, ammonia and nitrogen oxides, which can irreversibly damage the fuel cell.

For this reason, an air filter is installed upstream in the cathode path. As part of this work, investigations were carried out to optimize the filter regarding absorption and desorption of humid gas mixtures.

12 Highly Dynamic & Decoupling Fuel Cell Testbed Control

Authors: Dominik Köppel, Christoph Markler, Stefan Jakubek, Christoph Hametner

Session: Session 3 – Advance Propulsion Systems

Abstract:

Fuel cell system lifetime represents a crucial factor for the successful use in automotive applications. To extend the system´s lifetime, realistic tests during the developing process are vital. Fuel cell systems are typically controlled with their balance of plant (BoP) components. In order to perform highly dynamic tests (e.g., emulating automotive scenarios or stress tests), a sophisticated control strategy of the BoP components must ensure the desired gas conditioning at the fuel cell. Due to generally strong coupling in the gas conditions, conventional testbed control just allows for slow changes between operating points.

In contrast, we introduce a strategy with the goal of conditioning the fuel cell as fast as possible. The advantages of the proposed strategy are: 1) Highly dynamic testing scenarios are precisely tracked; and 2) Desired gas conditions (fuel cell inlet pressure and flow) can be independently varied. The presented testbed control is beneficial to either induce or avoid detrimental conditions or to decouple the desired gas conditions for diagnosis tools (e.g., EPIS).

To realize highly dynamic control, a model-based control approach using a nonlinear model is derived. The model is parametrized employing real testbed measurements. This strategy applies the framework of exact input-output linearization to decouple the desired gas conditions. Essentially, the proposed control strategy determines the BoP component setpoint trajectories to independently guide pressure and flow along desired dynamic trajectories.

The control framework was successfully implemented at a real testbed. Controller performance was demonstrated for highly dynamic tests with a real working fuel cell.

13 Airworthy battery energy storage for decarbonizing aviation

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Aircraft electrification is key in tackling the challenge of reducing greenhouse gas emissions from aviation enabling energy-efficient electric drive trains and distributed electric propulsion concepts. The advancement of battery technology will play a crucial role in accelerating this transition and supporting the electrification. Li-ion batteries will mature in the upcoming years reaching 500+ Wh/kg at the cell level and will stay the predominant technology for the next generation aircraft with entry into service by 2035. Ultra-efficient aircraft integration requires reliable numerical tools for performance, ageing and safety modelling taking into account aeronautic certification requirements that are currently evolving.

The AIT HEAT research team pursues an integrated model-based cell-to-system approach, leveraging the results of in-house battery development and testing. Various aeronautic end-user applications from general aviation to large passenger aircraft are steering the development of next-generation battery cells and the design of airworthy energy storage systems in the European research projects HighSpin, HELENA, IMOTHEP, ORCHESTRA and HECATE. In addition, AIT is developing aeronautic structural batteries (SBs) as multifunctional lightweight alternative to conventional batteries in SOLIFLY, MATISSE and USAF-SB.

To facilitate the discovery and rapid development of novel materials for next generation batteries, AIT contributes to the European materials acceleration platform (FULL-MAP).

This poster presents AIT's approach to the electrification of aircraft supporting the decarbonization of aviation.

14 Investigation of the Degradation Mechanisms of PtCo Oxygen Reduction Catalysts in Polymer Electrolyte Fuel Cells Under Humidity Gradients.

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Understanding the degradation mechanisms of Pt-alloy catalysts is crucial for advancing the durability of low-temperature polymer electrolyte fuel cells (PEFCs). This study employs an accelerated stress test protocol, as recommended by the US Department of Energy[1], to systematically evaluate the effects of relative humidity gradients on Pt_3Co oxygen reduction reaction catalysts[2]. Two specific conditions were examined: uniform 100% relative humidity at both the anode and cathode and a gradient of 30% relative humidity at the anode with >100% at the cathode. While degradation pathways of pure Pt catalysts under humidity conditions are well-documented, Pt-alloys such as Pt_3Co may exhibit unique degradation mechanisms when exposed to humidity gradients. The results reveal a pronounced sensitivity of Pt_3Co, with a 77% performance loss and significant reductions in electrocatalyst surface area, highlighting structural instability relative to pure Pt. Small-angle X-ray scattering exposes changes in particle and cluster sizes, and scanning electron microscopy reveals heterogeneity in catalyst layer and membrane thickness. Ostwald ripening emerges as the predominant degradation pathway under these conditions, with additional effects from active surface area reduction, increased resistances, and dealloying. These insights elucidate the underlying mechanisms driving structural and functional degradation in Pt-alloy catalysts, contributing to developing more robust materials for PEFCs and advancing the understanding of catalyst durability under operating conditions.

Acknowledgments

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15 PEM Fuel Cells – Assessing degradation during dynamic operation

Session: Session 3 – Advanced Propulsion Systems

Authors: Johanna Bartlechner[*1], Stefan Jakubek[1], Christoph Hametner[1]

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Abstract:

Proton Exchange Membrane (PEM) fuel cells are a key technology in the development of eco-friendly vehicles, helping to reduce emissions and promote sustainable transportation. However, to ensure their long-term reliability, it is important to monitor how the fuel cells degrade over time.

We present a novel monitoring algorithm that keeps track of the internal conditions and health of PEM fuel cells during highly dynamic operation. By separating the fast-changing conditions (like hydrogen concentration and membrane humidity) from the slower-degrading components (like the catalyst layers and membrane), the monitoring system's stability and accuracy is improved.

The monitoring algorithm uses only readily available measurements of a fuel cell system (like voltage, pressure and temperature), which are processed in real time – a necessity for further usage in control strategies that minimize degradation and prolong the lifetime of fuel cells. It periodically checks for changes in key components to detect any signs of degradation. Unlike other methods that provide only a general idea of the system's health, our approach offers precise monitoring of critical components, such as the membrane and the catalyst layer.

The system has been tested using both simulated scenarios and real-world data, proving its usefulness for monitoring the degradation processes inside a fuel cell during highly dynamic operation.

16 HeAD – High performance electrical Austrian Drivetrain, a highly integrated and high-speed electric axle

Dr. Matthias Hofer
Institute of Energy Systems and Electric Drives / ESEA, Technische Universität Wien

The funded project HeAD was executed by a consortium of Zoerkler Gears (project leader), Thien eDrives, Power I.D., e.battery systems and TU Wien/ESEA with the target of developing a highly integrated and high-speed electric axle drive for passenger vehicles with innovative control concepts. During the project period from 01.03.2021 to 31.05.2024 a novel electric axle 140kW/800VDC was designed, a prototype was manufactured and specific experimental tests on several test-rigs were performed. This poster presents selected results of simulations and experiments of the built prototype.

The HeAD key innovations are

- a high system power density >2kWp per kg,
- a high system power density >2kW per liter (box-volume),
- a high-speed electric machine with 24.000rpm,
- a high system efficiency >93% at highest point,
- development of a thermal model (thermal management),
- concepts for sensor supervision and monitoring and
- concepts for sustainability (maintenance, repair und recycling).

The HeAD e-axle drive consists of a three phase interior permanent magnet synchronous machine and a two-stage gearbox which are highly integrated into a common housing. The compact e-machine has only 170mm stator outer diameter and the rotor rotor is designed with respect to the high rotational speeds of 24.000rpm in operation. At 350ARMS phase current the e-machine machine produces a peak torque of 194Nm and a power up to 142kW at nominal voltage. The e-axle cooling system was implementd as a standard liquid water/glycol cooling, other complex cooling technologies were intentionally avoided. The integrated gearbox has a total gear ratio of 15,04 which is realized by a planetary gear stage combined with a spur gear stage.

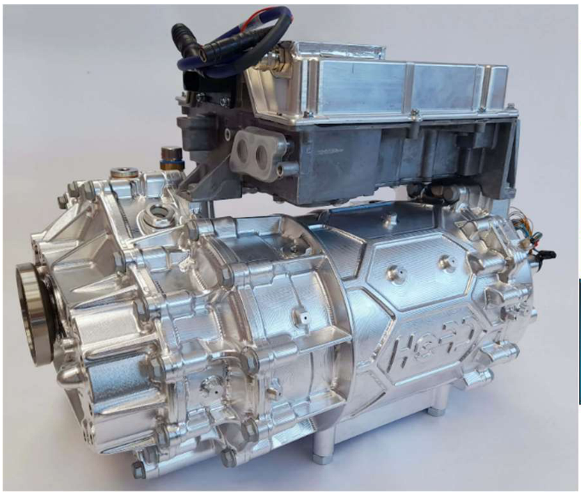

Fig. 1.: HeAD e-axle prototype

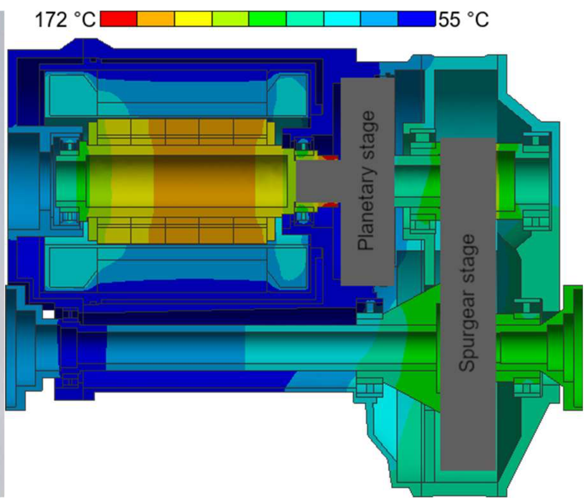

Fig. 2.: Thermal FE model of the e-axle

Furthermore, the differential is fully integrated in the spur gear stage and a combined splash and forced lubrication ensures optimal lubrication in the whole operation range. The axle is equipped with a mount-on three-phase voltage source inverter using SiC semiconductors for the prototype setup, which operates up to 870VDC.

The high integration level of the electric axle with a high power density (prototype with 2,216kW/kg and 2,35kW/liter) leads to a strong thermal mutual interaction of the sub-components electric machine, gearbox and inverter. One focus of the project HeAD was set to an overall holistic thermal consideration of the axle drive and development of thermal models. Thus, thermal models, first by Finite Element (FE) simulations and second, by a Lumped Parameter Thermal Network (LPTN) approach were developed. These models are used to ensure a sufficient and optimal cooling under consideration critical temperatures of specific components, to improve thermal utilization of materials and components and avoid local hot-spots, to improve test case generation of system and component tests, to predict thermal behavior at various environmental conditions and finally to optimize the vehicle control strategy.

For the investigation of the e-axles system behavior, experimental tests with focus on the performance and the internal thermal behavior were performed. The prototype setup was equipped with certain temperature sensors including a rotor telemetry system. Several test cases like continuous and peak operation as well as the WLTC cycle were evaluated and analyzed. For example, Fig. 3 presents the measured efficiency of the e-machine with the gearbox, which confirms the very high system efficiency in a wide operational range.

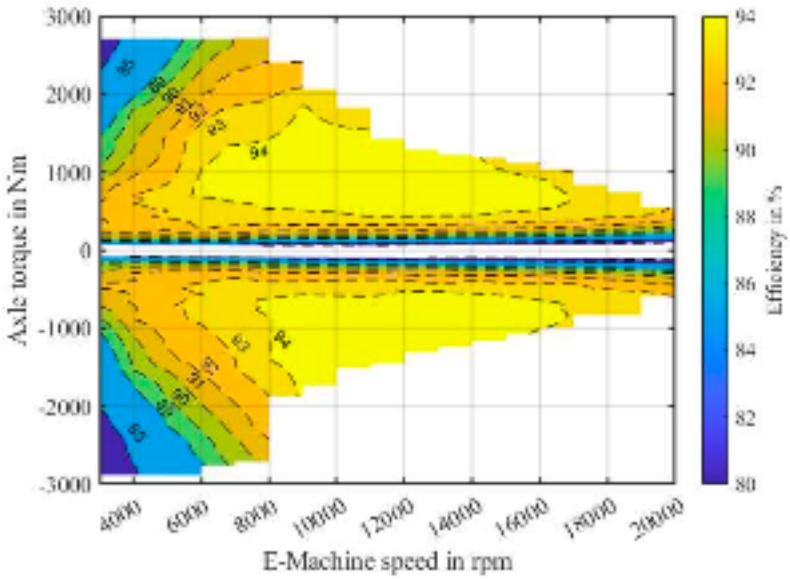

Fig. 3.: Measured efficiency map at 645VDC (without inverter)

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17 Optimizing Water Management for Sustainable Fuel Cell Electric Vehicles

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Keywords: FCEVs, Degradation Mechanisms, Water Management, Over-Humidification, Sustainability

Abstract

The global adoption of fuel cell electric vehicles (FCEVs) is gaining traction, particularly in the United States and Europe, driven by advancements in hydrogen technology and a push for greener transportation solutions [1]. However, widespread distribution of FCEVs faces significant challenges, with fuel cell system degradation being a major hurdle. Among these, water management is critical for maintaining fuel cell efficiency and longevity. Poor water management can lead to severe disruptions, such as membrane dehydration, excessive condensation, or flooding, all of which degrade performance [2,3]. To tackle these issues, advanced sensor systems are being developed to monitor water transport and detect liquid water accumulation within the fuel cell. These sensors can help mitigate problems like over-humidification, ensuring stable performance. Insights gained from controlled laboratory conditions will be adapted to real-world environments, especially for automotive applications, making FCEVs more viable and practical. A key aspect of this research focuses on creating humidity profiles adapted to operational parameters, enabling dynamic optimization of fuel cell conditions to prevent issues such as flooding or drying. By addressing water management and other degradation mechanisms, this research aims to enhance the efficiency and sustainability of FCEVs, pushing towards clean transportation technologies.

Acknowledgement

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18 Simulation toolchain for the development of metallic bipolar plates for PEMFC

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Session 3 – Advanced Propulsion Systems

Abstract:

The broad commercialization of PEM fuel cells within the mobility market requires the development of fuel cell stack components matching high quality requirements and cost-effective solutions. Compared to graphite plates, metallic bipolar plates offer better performances as higher mechanical strength, thinner construction, and superior electrical and thermal conductivity. At the same time, their manufacturing processes can be upscaled to meet mass production requirements.

Nonetheless, the development process of metallic bipolar plates shows an intrinsic challenge given by the manifold functions that this component must absolve, including: conducting electrical current between cells, evenly distributing gases (hydrogen and oxygen), managing heat and water removal as well as providing the stack structural integrity. An agile and efficient development of the plates requires therefore a multidisciplinary approach supported by simulation tools.

At HyCentA, we embrace a development approach based first on a multi-physical simulation of fuel cell operation based on a Computational Fluid Dynamic (CFD) software. This tool efficiently highlights opportunities and limits set by a variety of different flow-fields, each characterised by gases distribution, cooling homogeneity and eventually specific performances. In parallel, the manufacturability of complex flow-fields is supported by a Finite Element Method (FEM) analysis of the forming process to predict and reduce issues like stress and deformation of the thin metal foil. Altogether, this multidisciplinary simulation toolchain can allow to improve the quality of the plates while reducing manufacturing costs.

19 Investigation of Advanced Membrane Electrode Assemblies in High Temperature Proton Exchange Membrane Fuel Cells for Heavy Duty Vehicle Applications

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Abstract:

The transport sector is a major contributor to the world's greenhouse gas emissions. High temperature proton exchange membrane fuel cells (HT-PEMFCs) offer a carbon neutral way for powering heavy duty vehicles (HDVs). A major advantage over low temperature PEMFCs is their higher tolerance for fuel impurities due to the higher operating temperature, which could enable the use of cheaper hydrogen [1].

In HT-PEMFC, phosphoric acid is critical for the proton conductivity in the membrane and the loss of phosphoric acid is a major degradation mechanism limiting the lifetime of the system. Membrane electrode assemblies (MEAs) with an innovative ion-pair membrane target to overcome this issue by a higher bonding strength between phosphoric acid and the membrane [1, 2].

However, for the commercialization of this technology, experimental approaches and simulations are needed to understand the ageing behavior of this new material. In the course of this work, MEAs based on the new ion-pair technology are investigated via in-situ methods and compared with state-of-the-art reference materials. In addition, a novel method for the detection of phosphoric acid in the effluent water based on the molybdenum-blue reaction will be used to assess the phosphoric acid leaching [3].

The obtained data will support the project partners in material development and in the generation of simulation tools to predict the performance and durability of the new MEAs. This approach will allow for a time and resource efficient way of investigating the lifetime of HT-PEMFCs in HDV applications.

Acknowledgement:

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20 Next Generation Emission-Reduced Charging System Technology

NECST - **N**ext Generation **E**mission-Reduced **C**harging **S**ystem **T**echnology (Zero emission mobility funded project)

Major subjects for achieving Austrian government's climate-neutrality targets will be a higher overall efficiency in the mobility chain also by using electric vehicles, supported by a higher customer acceptance, which is also influenced by the charging time as well as fast charging points in cities. Currently, the expansion of the so-called High-Power Charging (HPC) Technology takes major steps forward, which enables significantly faster charging times. But HPC stations cause noise emissions which show problems especially in urban regions. The excessive waste heat, that appears in the power electrics is currently released to the ambient air via a fan in all applications.

NECST starts exactly here and wants to introduce adequate countermeasures because these drawbacks (efficiency and acoustic) will significantly increase with higher charging power in the coming years. In the project NECST, real demonstrator systems will be built, in which thermal losses will be transferred by appropriate heat exchangers to an end user of the waste heat. Therefore, use cases with significantly different boundary conditions are chosen so that benefits and limits of the NECST approach can be widely evaluated. In one case, a heat pump is used to transfer the heat to the required temperature levels but for financial reasons in most cases, an implementation without a heat pump will be enforced. In all cases one main goal is to omit the fan and hence avoid acoustic disturbance in the surrounding area of the HPC stations. For installers & operators of HPC stations, the operation becomes more economically attractive. (250 words)

Best fitting to: Session 4 – Environmental Impact

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