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Aero engine manufacture & 3D printing

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Manufacture of aero engine component, especially these parts in the flow path – "The Airfoils", has never been considered an easy task, mainly due to the sophisticated 3D aerodynamic geometry, and highly demanded properties in fatigue, creep, and damage tolerance, just to name a few. Good aero engine parts depend upon the compatibility of three key elements: i) Design, ii) Material, iii) Manufacture. Among these three key elements, design deems to set the standard of performance, reliability, durability, safety and operability of the product to be made. Besides operating at high loading and high temperature conditions, what indeed differentiates aero engine components from other industry products is beyond blue print or something can be specified or measured physically. It could generally be categorized in one single term, i.e., "Implicit Technology". While the conventional forging/casting manufacture technologies are still in the process of continuous improvement to meet six-sigma target, a new technology – "3D Printing" was born. However, limited progress has been made by 3D printing in the aero engine arena. Apparently, there is much more need to be dealt with aero engine manufacturing, besides geometry and configuration of the component. This presentation is to discuss i) what is the implicit technology that associates with aero engine manufacture, ii) how it impacts the quality and integrity of the component to be made, iii) how to address these issues in 3D printing, iv) how to assess and substantiate 3D printing to meet certification requirements of continuous airworthiness, and v) what are these requirements.

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Computational Fluid Dynamics (CFD) and Neutron Imaging (NI) for PEM fuel cells

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Optimal water management in PEM fuel cells is still one of the main challenges in fuel cell design and operation, with significant research efforts being carried out both by industry and academia. Two major approaches are used for the investigation of water balance in fuel cells: Experimental testing and numerical modelling, the latest presenting a significant contribution of Computational Fluid Dynamics (CFD) tools. This work presents research activities carried out in the field of PEM fuel cells water management research, where both CFD and liquid water visualization by means of neutron imaging are used. First, a validation work of a three dimensional CFD 50 cm^2 PEM fuel cell model is presented, which is particularly focused on the prediction of liquid water distributions within the cell. Beyond the comparison of the polarization curves, an in-depth validation is presented by also comparing the local liquid water distributions predicted by the model with the liquid water distributions of the real cell measured by means of neutron imaging, for a set of different operating conditions. A model validation approach using local variable distributions (such as liquid water in this case) in addition to the integral quantities (i.e. polarization curves) is necessary to ensure the validity of models. In addition, novel CFD modelling frameworks for the simulation of the diffusive mass transport occurring at GDL local scale is presented, in particular in relation with the distribution of liquid water in the porous media. The distinctive characteristic of this framework is the fact that the distribution of liquid water is not predicted by the model but it is instead mapped into the simulation model from available experimental measurements, obtained with Neutron Imaging. The presence of liquid water is thus included in the model as a modifier for the gas diffusion transport, and not directly calculated by the model. This allows for a coupling of experimental measurements and model development that is expected to allow a further progress of highly reliable models for the understanding of local fuel cell phenomena.

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