NOVEL TECHNOLOGIES RELATED TO THE HEAT EXCHANGERS FOR AVIATION

Outline of ETC15 workshop

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SYNOPSIS:

With an increased interest in electrification for aviation, attention is drawn to optimising the overall aircraft/engine thermal management, which involves designing more efficient heat exchangers (HEX). In this workshop, various technologies and software available for both design and optimisation of cold-plate HEXs will be discussed and reviewed. The Focus would be on heat sources that represents power electronics components for aviation applications.

A number of invited speakers (key experts) from both the academia and Commercial Sectors are invited to share their ongoing related work to thermal-fluid topology optimisation. Below is a synopsis of their talks.

TIME-TABLE (WEDNESDAY 26TH APRIL 2023 – 14:00-16:00):

14:00 Brief Introduction by Prof. Shahrokh Shahpar

14:10 -15:40 Three speakers roughly 20 minutes presentation Plus 10 minutes Q&A each.

15:40-16:00 Open the floor to all 3 speakers

*Introduction**: Topology Optimisation: New Paradigm in Heat-Exchangers Design.***

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In this short introduction: the problem statement, and opportunities for topology optimisation for the Heat Exchangers for turbomachinery jet-engine applications will be provided. Some of the Key technologies for an optimum design of HEXs would be hi-fidelity conjugate CFD simulation, automatic meshing of very complex geometries, multi-physics simulation, advances in Additive-layering Manufacturing (ALM) as well as testing and experimentation to support the design. Novel

shapes from topology optimisation that could only be manufactured using ALM will also be exhibited. Furthermore, we explore how these technologies can be extended to other design problem like the optimum fuel passages for PEMFCs (Fuel Cells), etc.

An ongoing R&D work as part of the EU Horizon Program (NextAir) to produce a fully-fledged Digital Twin of a Heat-Exchanger will also be touched on.

Talk 1: ***Design without boundaries.***

Dr Bradley Rothenberg

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While 3D printing has moved from mainly prototyping to production over the last decade, we still use mostly the same design software and methods from the early 80s. CAD's foundation is the BREP (boundary representation) that, when created, was ideal for digitizing drafting. CAD successfully replaced the drafting board for drawing, but what's next? Rather than incrementally improving upon CAD, a totally new underlying model is needed, breaking boundaries between analysis and design, to handle the ever-increasing complexity of modern manufacturing. Implicit modelling + Field-Driven-Design is built for the future of product development and already today is enabling a wide range of products from more efficient turbine engines to zero-energy hydrogen-powered aircraft to lightweight, autonomous factory robots. Engineering is about breaking boundaries and exploring the art of what's possible, and new software is the tool to enable us to deliver higher-performance products.

Talk 2: ***Topology and Shape Optimization of Heat Exchangers.***

N. Galanos, E. Papoutsis-Kiachagias, V. Asouti, K. Giannakoglou*
Parallel CFD & Optimization Unit (PCOpt), Lab of Thermal Turbomachines, School of Mechanical Engineering, National Technical University of Athens (NTUA).
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This presentation is dealing with a method that combines topology (TopO) and shape (ShpO) optimization for the design of bi-fluid heat exchangers. The porosity-based TopO method is adapted to conjugate heat transfer (CHT) problems and is capable of creating optimal flow paths for both the cooled fluid and the coolant; an evident constraint is that the two streams must remain separated by solid material of adequate thickness. Heat transfer is taken into account by solving the energy equation for the two fluids and the heat conduction equation for the solid. To reduce the computational cost, a good initialization of the porosity field is obtained by performing a low-cost TopO based on a Darcy-like flow model. Inaccuracies due to the weak treatment of the flow boundary conditions along the Fluid-Solid Interface (FSI) in TopO are overcome by means of an interpolation scheme for the thermal conductivity at the cell faces. The proposed method is demonstrated in the design of a compact bi-fluid heat exchanger, for maximum heat exchange and minimum total pressure losses in both streams, under the presence of flow-related constraints.

Talk 3: ***Fluid Topology Optimization for Next Generation Heat Exchangers.***

Dr Nicholas Raske1 and Prof Francesco Montomoli
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In aircraft engines there is a growing need of high-performance heat exchangers. From next generation cooling systems of conventional gas turbines to the request of new solutions for electrification, the new design can be driven by the advances in generative design, without relying on previous solutions. It will be shown how fluid topology optimisation is used for the design of cold plates for electrical applications and coolant systems of gas turbines. For cold plates, multi-objective optimization will be shown, minimizing pressure losses, reducing weight, while increasing heat transfer. For gas turbine cooling, internal coolant system will be presented with performance comparison with existing solutions. During the workshop printed parts will be also shown.