

Adjoint Based Turbomachinery Optimization and Uncertainty Quantification in Gas Turbines

Date: Tuesday, November 6th, 2018 **Location:** Aerospace Faculty Library
Time: 08:00-17:30

The training activities will be open for all students, industry and academic staff. There is no cost for registration; however it is mandatory for all participants. Please reserve your spot until 21/10/2018 by contacting Vered Seginer <veredseg@ae.technion.ac.il>, with subject line "Turbomachinery Workshop Registration 2018", indicating the full name of all participants.

Program

- ❖ 08:00 - 08:30 Registration and Introduction

- Prof. Francesco Montomoli
- ❖ 8:30 - 9:45 Impact of uncertainties and manufacturing defects in gas turbines
 - Fan variations: the strange case of NASA Rotor 37
 - Axial Compressors: Do we know the real geometry? How leading edge shape and fillets can change efficiency and stall point
 - High Pressure Turbine and Turbine Inlet Temperature: Most important parameter in a turbine affecting life and efficiency is not directly measured
 - High Pressure Turbine and Coolant System: Up to 30% of engine life is reduced by microscopic variations and its impact on small core engines
 - Low Pressure Turbine: Roughness and cast surfaces may be beneficial for UAVs and civil engines
- ❖ 9:45 - 10:00 Coffee Break
- ❖ 10:00 - 11:30 Introduction to Uncertainty Quantification for turbomachinery
 - How random errors are modeled in CFD
 - Monte Carlo Methods: coin toss approach applied to engine design
 - Non-Intrusive Polynomial Chaos and SAMBA
 - Aircraft Accidents and Black Swans
- ❖ 11:30 - 11:45 Coffee Break
- ❖ 11:45 - 12:45 Improving Gas turbine Efficiency by Uncertainty Quantification
 - Axial Compressors: Polynomial Chaos geared towards Small Engines
 - Turbine: Reducing the impact of manufacturing errors using UQ
 - Accidents: Is it possible to design an engine inherently safe?

- ❖ 12:45 - 13:30 Break (Light Lunch will be served)

- Prof. Tom Verstraete
- ❖ 13:30 - 14:15 Introduction to multidisciplinary design optimization for turbomachinery
 - Optimization problem formulation
 - Zero and first order optimization methods
- ❖ 14:15 - 14:30 Coffee Break
- ❖ 14:30 - 16:15 Sensitivity Analysis for Shape Optimization

- Computation of gradients: finite difference, complex step, Algorithmic Differentiation
 - The adjoint principle, what are the benefits?
 - Toward hybrid optimization methods: combining gradients in evolutionary algorithms
- ❖ 16:15 - 16:30 Coffee Break
- ❖ 16:30 - 17:30 Application of adjoint methods
- Internal Cooling Channel U-Bend, extension to LES
 - Radial Turbine, including stress and aerodynamic requirements.
 - Benefits of gradient based optimization methods compared to classical methods.

Bio:

Prof. Francesco Montomoli

Dr. Francesco Montomoli studied mechanical engineering at University of Florence where he obtained his M.Sc. and Ph.D. degrees. During this time frame, he was also a visiting scholar at Texas AM University, Turbine Heat Transfer Laboratory. Completing his graduate education, he joined the R&D group of General Electric Oil & Gas. In 2006, Dr Montomoli started working at University of Cambridge, Whittle Laboratory. Conducting research in the field of aerospace propulsion and power generation, his research at the time was sponsored by Rolls-Royce and Mitsubishi Heavy Industries. In 2009, he was appointed Mitsubishi Senior Fellow and College Lecturer at Girton College, University of Cambridge. In 2011, Dr Montomoli was also Research Professor and leader of CFD group at the Basque Centre for Applied Mathematics. In following, he served as Senior Lecturer in Thermofluids at the University of Surrey. Since 2014, Dr Montomoli is at the Imperial College of London where is currently a Reader and the director of the Uncertainty Quantification Laboratory, Aeronautics Department.

Prof. Tom Verstraete

Dr. Tom Verstraete is currently an Associate Professor at the Von Karman Institute for Fluid Dynamics. Previously, he was a visiting professor at Queen Mary University of London after obtaining a Marie-Curie Individual Fellowship. With over 14 years of experience in the design of various turbomachinery components, his interests range from axial/radial compressors/turbines, internal cooling channels to space propulsion inducers, nuclear pumps, to steam turbines diffusers. He has authored or co-authored over 90 journal papers, conference papers and contributions to books. His current focus is on multidisciplinary shape optimization, conjugate heat transfer and micro gas turbines.