Turbomachinery Workshop on
ADVANCED DESIGN AND ADDITIVE MANUFACTURING OF TURBINES FOR PROPULSION AND POWER GENERATION

November 15th, 2022 | Auditorium 235, Aerospace Engineering, Technion - IIT | 08:15 - 18:00
Open for students, industry and academia | Free with mandatory registration until 27/10/2022
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Program-at-a-Glance

08:15 - 08:45	Breakfast, Registration and Introductions	
08:45 - 10:45	Ms. Anna Sailor Mr. Jens Karnapp EOS, Germany	Design and material selection for additive manufacturing in turbomachinery
11:00 -14:45	Dr. Iliya Fedorov Siemens Energy, Finland	Design, production preparation, and quality assurance for laser powder bed fusion
14:45 - 18:00	Prof. Sergio Lavagnoli von Karman Institute, Belgium	Tip leakage flows and blade tip design in high-speed turbines

Detailed Program

8:15  Registration and Introductions

8:45 - Ms. Anna Sailor - EOS

- Advanced design for additive manufacturing – an overview
  - Design approaches for success in post-processing
    - Addressing machining challenges
    - Powder removal
    - Dimensional accuracy
    - Harnessing power of design space complexity
    - Topology optimization for AM constraints
- Design simulation tools - how to speed up design cycles
- Process-driven design for improving productivity, quality, and reducing manufacturing steps

9:45 - Mr. Jens Karnapp - EOS

- Material selection for turbomachinery
  - Material and process development, implementation and qualification methodology
    - Why all casting materials can't be used for additive
    - High temperature material and process development challenges - micro cracks, post-process cracks, grain size, anisotropy
  - Laser powder bed fusion optimized materials
    - Available materials: IN-HX, IN939, IN738, Haynes282
    - Process, chemistry, micro-structure, mechanical properties, applications
    - Under development: TiAl, MAR-M247LC
    - Porous structures
  - Optical tomography and feedback loop for better quality and less support structures
  - Application specific challenges on a nozzle guide vane example
    - Internal channels, porosity, surface roughness

10:45 

11:00 - Dr. Ilya Fedorov – Siemens Energy

- Design for additive manufacturing with laser powder bed fusion
  - Design rules and methods with an example of a combustor part, optimization of geometry for printing
  - Cooling systems for AM components (stator parts)
  - Discussion about lifetime and performance aspects for printed parts (dependence of properties on the print direction, accounting for roughness of AM channels)

12:00

- AM production preparation
  - Industrial workflow description: roles of AM Engineer, production engineer, production manager, steps in AM production
  - Print program preparation (general overview, commercial tools and preparation steps)
  - Addition of quality control specimens to print job
  - Simulation to achieve first-time-right print results
    Industrial release of program for manufacturing

13:00 

13:45

- AM quality assurance
  - Quality assurance during printing (AM monitor)
  - Post-print QA: geometry checking, flow checking, material testing and microstructure evaluation
  - Allowable scatter in geometry or flow characteristics.
  - Morphing of parts to compensate for print distortions
  - How to handle lessons learnt
  - Emerging quality assurance standards in AM industry

14:45 - Assoc. Prof. Sergio Lavagnoli – von Karman Institute

- Fundamentals of turbine blade tip flows
  - Aerodynamics of tip leakage flows
  - Blade tip heat transfer and tip cooling
  - Tip leakage loss modelling

15:45 

16:00

- Design and optimization of advanced blade tip designs
  - Design strategies to mitigate tip losses
  - Tip shape parametrization and optimization strategies
  - Engine constraints for blade tip design
  - Some advanced blade tip geometries

17:00

- Experimental testing of turbine tip flows
  - Scaling of engine tip flows for aero-thermal lab testing
  - Low- and high-speed testing of blade tip flows
  - Experimental validation of optimized tips in a high-speed stage with rainbow rotor

Biography of Speakers:

Ms. Anna Sailor
(EOS, Germany)

Ms. Anna Sailor has 5 years of experience in advanced and additive manufacturing in the aerospace industry in both US and European markets. Anna Sailor studied mechanical engineering at the University of Wisconsin-Madison, received a Master's degree from Johns Hopkins and worked at a US-based aerospace OEM prior to joining EOS GmbH as a technical consultant in the Additive Minds team. Anna currently supports companies in developing their metal additive manufacturing solutions by supporting design, process development, and qualification.

Mr. Jens Karnapp
(EOS, Germany)

Mr. Jens Karnapp has more than 10 years of experience in the manufacturing supply chain of the gas turbine industry. He worked for major Tier 1 suppliers of the industry in conventional manufacturing. As Key Account manager for turbomachinery at EOS GmbH he supports many international OEMs and Tier One players of the gas turbine industry in developing and scaling their additive production.

Dr. Ilya Fedorov
(Siemens Energy, Finland)

Dr. Ilya Fedorov studied applied mathematics at Bauman Moscow State Technical University where he obtained his M.Sc. and Ph.D. degrees (2007), the latter in the field of aeroelastic gas turbine blade vibrations simulation. He has been working in gas turbine research and development since 2004; initially, at Alstom Power and at Siemens Energy since 2017. For the last 9 years, he has been involved in projects that leverage additive manufacturing of gas turbine components and currently leads activities aimed at development and implementation of printed hot turbine components in industrial gas turbines.

Moreover, Ilya actively participates in the development of turbine materials for additive manufacturing, methods for thermal and lifetime assessment of components manufactured by laser powder bed fusion and has a professional interest in hybrid manufacturing and repair techniques that combine traditional and additive manufacturing processes.

Prof. Sergio Lavagnoli
(von Karman Institute, Belgium)

Dr. Sergio Lavagnoli is an Associate Professor in the Turbomachinery and Propulsion department of the von Karman Institute for Fluid Dynamics. He received his MSc in mechanical engineering from the Polytechnic University of Marche (Italy) in 2006 and in 2008 he obtained the Research Master degree from the von Karman Institute. He received his PhD in Applied Sciences from the Polytechnic University of València (Spain) in 2012. He continued to work at the von Karman Institute as a post-doctoral researcher and research engineer, before being appointed assistant professor in 2015 and associate professor in 2020.

He is also a lecturer of turbomachinery in the engineering master program of the Université Catholique de Louvain. Professor Lavagnoli has 15 years of experience in experimental and numerical aerothermal studies on gas turbine engine turbomachinery. His research area includes fundamental studies on the aerodynamics and heat transfer of jet-engine turbines, turbomachinery optimization and development of instrumentation and data processing techniques. He has coauthored over 50 technical papers and journal articles and two patents.