Announcing the Final Examination of Marcel Otto for the degree of Doctor of Philosophy

Time & Location: November 8, 2019 at 11:00 AM in BA1 115
Title: Improving Turbine Performance: A Contribution to the Understanding of Heat Transfer and Vortical Structures in Staggered Pin Fin Arrays

Trailing edge cooling is mostly realized by incorporating turbulence promoters such as fins into the flow channel. The flow physics in arrays of wall-mounted cylinders is very complex and is not fully understood yet. The flow field consists of three distinct regions: a stagnation region with horse shoe vortex (HS vortex) system build-up, proceeding with boundary layer separation from the pin walls; and a wake region with transient vortex (von Káirmán vortex or K vortex) shedding that can also impinge on downstream pins. One key aspect is the interaction between these two sets of vortices: HS vortices and K vortices. The vortex structures contribute significantly to the heat transfer on the endwall of the cooling channel, thus a detailed understanding is required for design improvements. Conventional RANS models fail to predict the resulting flow and heat transfer accurately due to the highly anisotropic characteristic of the flow region.

Two different experimental approaches will be conducted on staggered pin fin array of four rows. First, particle image velocimetry (PIV) is used to understand the flow physics in the wake of the first and third row of the pin. Novel is the approach to not focus alone on the midplane area but rather investigate the near wall region where the correct characterization of local turbulent transport is essential for the proper prediction of local convective heat transfer. The transient thermochromic liquid crystals method reproduces the local Nusselt number distribution over the endwall. The aforementioned vortical structures significantly dominate the local endwall heat transport. The findings from the PIV experiment are used to describe local vortex and transport phenomena on the endwall.

The experimental data together with a Large Eddy Simulation to analyze the flow physics in pin array and used to pinpoint the shortcoming of RANS methods.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2010, TU Berlin
Master's of Mechanical Engineering, MS, 2013, TU Berlin
Master's of Mechanical Engineering, MS, 2015, University of Central Florida

Committee in Charge:
Jayanta S. Kapat, Chair, Mechanical & Aerospace Engineering
Kareem Ahmed, Mechanical & Aerospace Engineering
Samik Bhattacharya, Mechanical & Aerospace Engineering
Michael Kinzel, Mechanical & Aerospace Engineering
Paul Wiegand, IST

Approved for distribution by Jayanta S. Kapat, Committee Chair, on November 8, 2019.

The public is welcome to attend.