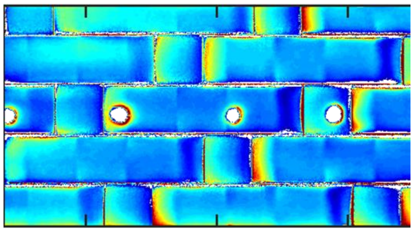
Investigations of Convective Heat Transfer for Ceramic Matrix Composite Materials



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Zoom Link: https://tinyurl.com/FrontiersGTE; ID 928 5110 0795; Passcode 836503

ABSTRACT: Ceramic matrix composites (CMCs) are being commercialized in turbine engines due to their advantageous weight benefit and temperature tolerance relative to superalloy materials. However, they can have irregular surface morphology that can impact the external flow, convective heat transfer, and use of film cooling over the part surface. Furthermore, manufacturing limitations can influence the possible internal cooling designs; it is imperative to make this cooling as efficient as possible to maintain the overall cycle benefit of incorporating CMCs. This presentation will describe two technical thrusts being pursued at Penn State: one to understand convective heat transfer and film cooling on the external surface of conventional woven-matrix-based CMCs; and a second to investigate the potential of polymer-derived ceramics to create additively manufactured (AM) CMCs with complex internal cooling features. For the first thrust, measurements of convective heat transfer and local boundary layer profiles were taken on a scaled CMC surface in a large-scale wind tunnel at representative Reynolds numbers. The results indicate that the CMC weave pattern results in augmented heat transfer that significantly varies locally relative to a smooth surface, due to local separation/reattachment zones. Simulations of film cooling also indicate disturbance due to a weave pattern. In the second thrust, progress has been made toward additively manufacturing a 1X scale first stage vane in silicon oxycarbide (SiOC), with a complex internal lattice structure. The cooled vane will be imaged with an infrared camera in a high speed linear cascade at matched Mach and Reynolds numbers, to test the maturity of the AM process.

BIOGRAPHY: Dr. Stephen Lynch is an associate professor of Mechanical Engineering at Penn State, and is the director of the Experimental and Computational Convection Laboratory (www.me.psu.edu/psuturbine), which investigates turbine cooling technologies and design and development of metal additive heat exchangers. He received his BSME from the University of Wyoming in 2003, and his MS and PhD from Virginia Tech in 2007 and 2011, respectively. He joined Penn State in 2013, after working as a senior research engineer for two years with United Technologies Research Center (now Raytheon Technologies Research Center).

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