The limits of gas turbine technology are heavily influenced by materials and manufacturing capabilities. Inconel remains the material of choice for most hot gas path (HGP) components in gas turbines, however recent increases in turbine inlet temperature (TIT) are associated with the development of advanced convective cooling methods and ceramic thermal barrier coatings (TBC). Increasing cycle efficiency and cycle specific work are the primary drivers for increasing TIT. Lately, incremental performance gains responsible for increasing the allowable TIT have been made mainly through innovations in cooling technology, specifically convective cooling schemes. An emerging manufacturing technology may further facilitate the increase of allowable maximum TIT, thereby impacting cycle efficiencies. Laser Additive Manufacturing (LAM) is a promising manufacturing technology that uses lasers to selectively melt powders of metal in a layer-by-layer process to directly manufacture components, paving the way to produce designs that are not possible with conventional casting methods. This study investigates manufacturing qualities seen in LAM methods and its ability to successfully produce complex microfeatures in a mock turbine blade leading edge. Various cooling features were incorporated in the design, consisting of internal impingement cooling, internal lattice structures, and external showerhead cooling. The internal structure is designed as a lattice of intersecting cylinders in order to mimic that of a porous material. Through a non-destructive approach, the presented design is analyzed against the departure of the design by utilizing X-ray computed tomography (CT). Employing this non-destructive testing (NDT) method, a more thorough analysis of the quality of manufacture is established by revealing the internal structures of the porous region and internal impingement array. Variance distribution between the design and manufactured test article are carried out for both internal impingement and external transpiration hole diameters from CT data. Flow testing is performed in order to characterize the uniformity of porous regions and flow behavior across the entire article for various pressure ratios (PR). Discharge coefficients of internal impingement arrays and porous structures are quantified. A numerical model of fluid flow through the exact CAD geometry is analyzed over a range of flowrates. By comparison of experimental and numerical data, performance discrepancies associated with manufacturing quality are observed. This study yields quantitative data on the build quality of the LAM process, providing more insight as to whether or not it is a viable option for manufacture of microfeatures in current turbine blade production.

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The public is welcome to attend.