Electricity has become so ingrained in everyday life that the current generation has no knowledge of life without it. The majority of power generation in the United States is the result of turbines of some form. With such widespread utilization of these complex rotating machines, any increase in efficiency translates into improvements in the current cost of energy. These improvements manifest themselves as reductions in greenhouse emissions or possible savings to the consumer.

The most important temperature regarding turbine performance is the temperature of the hot gas entering the turbine, denoted turbine inlet temperature. Increasing the turbine inlet temperature allows for increases in power production as well as increases in efficiency. The challenge with increasing this temperature, currently the hottest temperature seen by the turbine, is that it currently already exceeds the melting point of the metals that the turbine is manufactured from.

Active cooling of stationary and rotating components in the turbine is required. Cooling flows are taken from bleed flows from various stages of the compressor as well as flow from the combustor shell. This cooling flow is considered wasted air as far as performance is concerned and can account for as much as 20% of the mass flow in the hot gas path. Lowering the amount of air used for cooling allows for more to be used for performance gain.

Various technologies exist to allow for greater turbine inlet temperatures such as various internal channel features inside of turbine blades, film holes on the surface to cool the outside of the airfoil as well as thermal barrier coatings that insulate the airfoils from the hot mainstream flow. The current work is a study of the potential performance impact of coupling two effusion technologies, transpiration and discrete hole film cooling. Film cooling and transpiring flows are individually validated against literature before the two technologies are coupled. The coupled geometries feature 13 film holes of 7.5mm diameter and a transpiring strip 5mm long in the streamwise direction. The first coupled geometry features the porous section upstream of the film holes and the second features it downstream. Both geometries use the same crushed aluminum porous insert of nominal porosity of 50%. Temperature sensitive paint along with an ‘adiabatic’ Rohacell surface (thermal conductivity of 0.029W/m-K) are used to measure adiabatic film cooling effectiveness using a scientific grade high resolution CCD camera. The result is local effectiveness data up to 50 film hole diameters downstream of injection location. Data is laterally averaged and compared with the baseline cases. Local effectiveness contours are used to draw conclusions regarding the interactions between transpiration and discrete hole film cooling. It is found that a linear superposition method is only valid far downstream from the injection location. Both coupled geometries perform better than transpiration or the discrete holes far downstream of the injection location. The coupled geometry featuring the transpiring section downstream of the film holes matches the transpiration effectiveness just downstream of injection and surpasses both transpiration and film cooling further downstream.

Major: Mechanical Engineering

Educational Career:
Bachelor's of Mechanical Engineering, BS, 2010, University of Central Florida

Committee in Charge:
Jayanta Kapat, Chair, MMAE
Chengying Xu, MMAE
Subith S. Vasu, MMAE

Approved for distribution by Jayanta Kapat, Committee Chair, on June 15, 2012.

The public is welcome to attend.