Real-Time Closed-Loop Modulated Turbine Cooling

Principal Investigator: Vikram Shyam (NASA Glenn Research Center/RTT)
Investigator(s): Dennis Culley (NASA Glenn Research Center /RHC), Jeffrey Eldridge & Mark Woike (NASA Glenn Research Center /RHI), Scott Jones (NASA Glenn Research Center /RTM)

Purpose

The purpose is threefold: real-time detection of the thermal maps of turbine blades, modular cooling to target particular regions of the hot section based on the real-time thermal maps and a feedback loop to control the modular cooling based on the thermal maps.

Background

It has been noted by industry that in addition to dramatic variations of temperature over a given blade surface, blade-to-blade variations also exist despite identical design. These variations result from manufacturing variations, uneven wear and deposition over the life of the part as well as limitations in the uniformity of coolant distribution in the baseline cooling design. It is proposed to combine recent advances in optical sensing, actuation, and film cooling concepts to develop a workable active, closed-loop modulated turbine cooling system to improve by 10 to 20% the turbine thermal state over the flight mission, to improve engine life and to dramatically reduce turbine cooling air usage and aircraft fuel burn. A reduction in oxides of nitrogen (NOx) can also be achieved by using the excess coolant to improve mixing in the combustor especially for rotorcraft engines. Recent patents filed by industry and universities relate to modulating endwall cooling using valves. These schemes are complex, add weight and are limited to the endwalls. The novelty of the proposed approach is twofold – 1) Fluidic diverters that have no moving parts are used to modulate cooling and can operate under a wide range of conditions and environments. 2) Real-time optical sensing to map the thermal state of the turbine has never been attempted in realistic engine conditions.