Rotating Heat Transfer in High Aspect Ratio Rectangular Cooling Passages with Shaped Turbulators

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ABSTRACT

The objective of this two-part investigation is to provide the designers with new internal cooling data for improving the cooling performance and thermal efficiency of power generation and industrial gas turbine engines. More specifically, this investigation ventures into the heat transfer phenomenon of internal cooling channels with shaped turbulators. The research is divided into two parts: Part I - Rotating Heat Transfer and Part II - Numerical Prediction. The objectives of part I are to obtain experimental data from rectangular, two-pass internal cooling passages with higher aspect ratios of 2:1 and 4:1. The following parameters will be altered: (1) Surface geometry, (2) Reynolds numbers, (3) rotation number, (4) rotation angle, and (5) channel aspect ratio. Angled ribs, V-shaped ribs, and delta-shaped turbulators will be installed on the leading and trailing sides of a rectangular internal cooling passage with rotation. The ratio of inlet coolant temperature to surface temperature (TR) will be around 0.8 - 0.9. The experiments are designed to measure (a) regionally averaged heat transfer coefficients at different locations along the cooling passages with enhanced surfaces, and (b) pressure drops along the cooling passages under rotating conditions. The objectives of part II are to predict flow and heat transfer behaviors from rectangular, two-pass internal cooling passages with higher aspect ratios of 2:1 and 4:1. An ongoing Chimera Reynolds-Averaged Navier-Stokes (RANS) code together with an advanced state of the art second-order Reynolds stress (second moment) turbulence model is currently being used for the prediction of rotating rectangular cooling channels with angled ribs and V-shaped ribs. The RANS code will also be used later for delta-shaped turbulators. The numerical predictions will be calibrated/compared with the part I-rotation heat transfer data. The ultimate goal is to predict and optimize flow and heat transfer in rotating rectangular channels with various shaped turbulators at very high Reynolds number and buoyancy parameter conditions.