

Effect of Inlet Conditions on Endwall Secondary Flows in Gas Turbine Engines

Kristina S. Hermanson

Abstract

To accommodate the demand for high efficiency in a gas turbine engine, combustor exit temperatures are continually increasing. Furthermore, thermal and flow fields at the combustor exit are highly non-uniform entering the downstream stator vane passage. These conditions combined with the complex secondary flow pattern, which occurs near the endwall of the stator, attribute to high platform heat transfer and large aerodynamic losses. Endwall secondary flows and the effect of realistic combustor exit profiles on these flow patterns must be identified to maintain turbine durability.

This thesis presents an analysis of a parametric study on the effects of temperature and velocity profiles and inlet Mach number on the secondary flows in the endwall region of a first stage stator vane geometry. The analysis included experiment, theory, and computational fluid dynamics (CFD) simulations. Detailed flowfield measurements were obtained in a large scale, linear turbine vane cascade. These and additional experimental flowfield data were used to benchmark the CFD simulations prior to performing the parametric study. Good agreement occurred between the computational predictions and experimentally measured secondary flows.

Analysis of the results for several cases comparing spanwise gradients of velocity and temperature at the turbine inlet indicate that the stagnation pressure gradient is a key parameter in determining the character of the secondary flows. Temperature gradients applied at the inlet were distorted with severity proportional to the magnitude and direction of secondary flow in the passage.

Comparisons of CFD simulations at engine operating Mach numbers to the low-speed wind tunnel simulations indicate that the secondary flow pattern develops similarly for both cases. The analysis of the low speed parametric study is therefore valid for high speed conditions. The simulations at engine conditions have a much larger total pressure loss because of a shock occurring on the suction surface.