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Effect of Rotation on Flow and Heat Transfer Performance of Vortex Cooling for Gas Turbine Blade Leading Edge

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Abstract. The turbine inlet temperature is an important operating parameter of gas turbine engines. The increase in the turbine inlet temperature leads to significant improvement of the thermal efficiency and power output of gas turbine engines. In modern gas turbines, the turbine inlet temperature is higher than and far beyond the material thermal resisting limit of turbine blades. Therefore, the leading edge of gas turbine blades requires more effective cooling methods because the incoming hot gas directly impacts on its surface. The vortex cooling is one of the effective internal cooling methods for the leading edge that is applied to reduce the blade temperature for safe and long-life operation. This paper presents a numerical study of the flow and Nusselt number distributions inside the vortex chamber of vortex cooling under the rotating condition. The rotating condition at 3,000 rpm is specified to mimic the real operating condition of gas turbine engines. The numerical simulation is performed based on the 3D viscous steady Reynolds Averaged Navier-Stokes (RANS) equations coupled with the standard k-ω turbulence model and the energy equation. The enhanced wall treatment is also applied to capture the viscous sublayer in the turbulent boundary layer. The comparison of the present computed heat transfer under the static condition with that of the experiment without rotation reveals that the present result is in good agreement with the experimental data. Under the rotating condition, results show that the rotation has a considerable effect on the vortex cooling. The centrifugal force affects the flow structure, which increases the axial flow velocity and enhances the vortex or swirl strength, leading to the increase in heat transfer performance.

Keywords: Gas turbine blade, Leading edge, Vortex cooling, Rotating condition