CONJUGATE HEAT TRANSFER CALCULATION OF A COOLED GAS TURBINE BLADE

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Energy savings, by way of efficiency gains, have ultimately forced gas turbines to operate in increasingly aggressive conditions. These operating conditions reduce the lifetime of the blades resulting in large maintenance and downtime costs. Reducing maintenance and downtime costs requires improving the estimated lifetime.

The objective of this present project is to perform a conjugate heat transfer (CHT) analysis of an operationally cooled gas turbine blade and to develop an accurate prediction of the blade stresses. The model is based on prior knowledge acquired during previous years in the area of conjugate heat transfer at the von Karman Institute for Fluid Dynamics.

The numerical analysis is preformed through coupling of a fluid flow solver in the blade row (3D Navier-Stokes Computation) and a conduction calculation within the solid blade (Finite Element Calculation). The novelty of the present project is the addition of internal coolant passages which maintain the blade temperature within acceptable limits.

Flow inlet and outlet boundary conditions are determined through a non-isentropic simple radial equilibrium flow analysis. Thermal boundary conditions applied to the shroud, coolant passages, and root are calculated and mapped using experimental correlations as well as experimental measurements. In addition, a sensitivity analysis is performed with the goal of determining which boundary conditions have the greatest impact on the final results. Following the completion of the model, thermal, centrifugal, and pressure stresses are calculated.

The final results show that the conditions applied to the shroud have the largest impact on the temperature distribution. The boundary conditions applied to the coolant passages and root also impact the final results, albeit at an order of magnitude less than those at the shroud. The thermal stress results show critical regions of high stress at the shroud and hub surface. The magnitude of the thermal stresses are in the order of the centrifugal and pressure stresses. In conclusion, the conjugate heat transfer method has been applied successfully to the analysis of an internally cooled gas turbine blade. Improvement of the model is possible by an analysis of the shroud flow coupled with the external blade row and coolant passage flow.

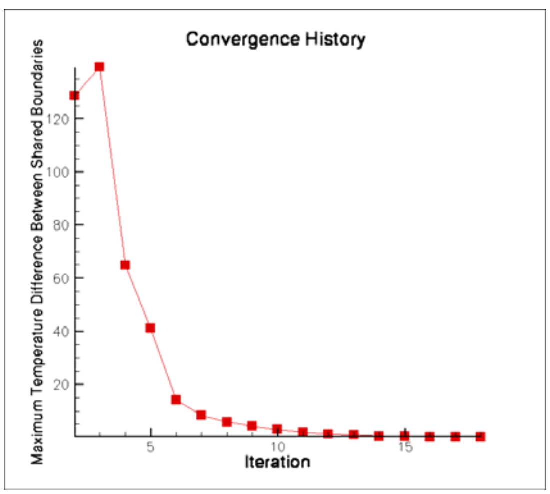

Figure 1: Decrease of maximum temperature difference between boundaries shared by the flow and solid solver

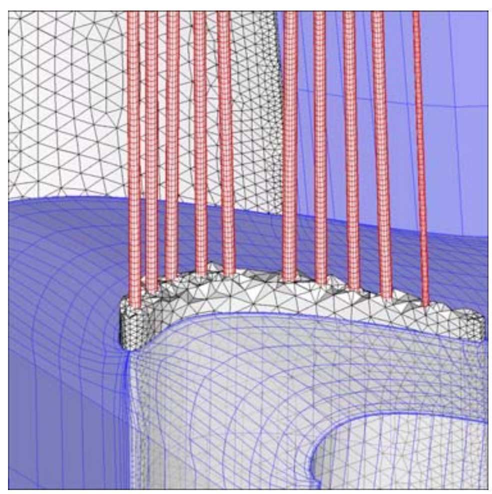

Figure 2: Computational Model: Solid Blade + Coolant Passage Flow + External Flow