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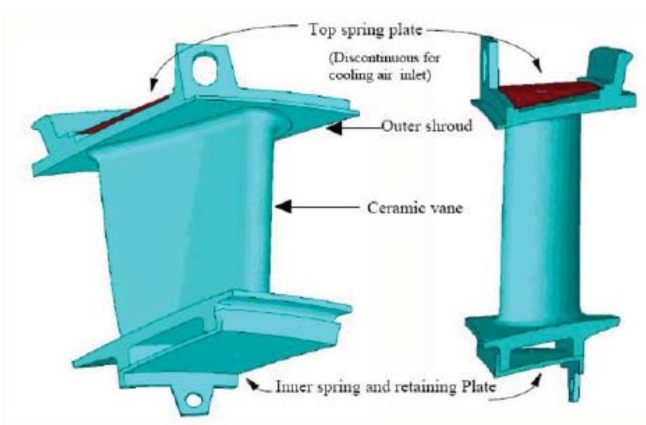
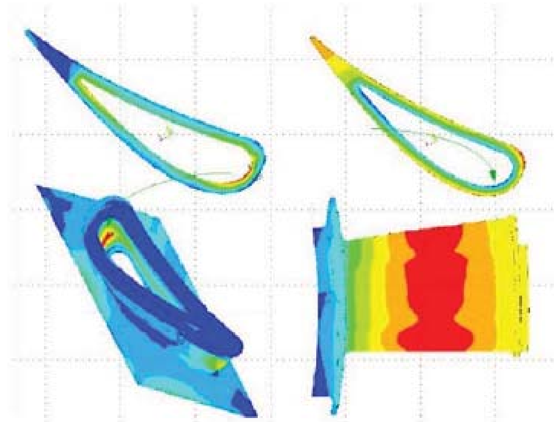
Case Study



Pratt & Whitney FT8 Stationary Turbine Engine Vane Airfoil



Airfoil Analysis Results

Analysis of Ceramic Vane Airfoils

Aircraft engine manufacturers are always seeking to increase power and efficiency of their engine designs via lighter engine components and higher operating temperatures. Current engine designs use traditional aircraft metal alloys that are pushed to their design limits of temperature and weight.

Pratt & Whitney, along with United Technologies Research Center, sought to improve the design of vane airfoils in terms of temperature range and weight by using a ceramic material. Ceramics such as silicon nitride can operate at higher temperatures and have lower density than metal alloys. Ceramics, however, are more brittle, and thus extreme care is required in the vane design, particularly at the support locations where stresses are the highest.

A possible solution to a viable ceramic vane design is to hold the vane in place between the metallic support structures using a spring. For example, by using a bolt with two restraining plates to compress the metal shrouds against either end of the ceramic vane, the vane could potentially be held in place without a rigid connection. This idea was used in the design of an Pratt & Whitney FT8 stationary turbine engine vane airfoil.

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Analysis of Ceramic Vane Airfoils / *Continued*

CAE Associates created three-dimensional models of several different vane designs to determine stresses in the ceramic at room temperature and operating conditions. Steady-state heat transfer analyses were performed to determine the thermal loads at operating conditions, and these loads were combined with the pretension spring load and the loading from the air flow. The structural analyses included contact between all of the non-integral components.

Results from the analyses were used to evaluate the spring preload that would provide clamping force at both room temperature and operating conditions. Stresses in the ceramic vane and the metallic restraining plates, shrouds, and spring were evaluated. Stress levels in the ceramic were fed back to UTRC for additional probabilistic life prediction.

The ceramic vane design and analysis effort is described in an ASME paper: Development of Cooled, Ceramic First Stage Vanes for the FT8 Aeroderivative Gas Turbine by W. Day et al. The paper acknowledges the key contributions made by CAE Associates in performing the finite element modeling.

Based on the successful development project, ceramic vanes were built and tested. A second ASME paper describes the testing program: Sector Testing of Cooled Silicon Nitride Ceramic HPT Vanes for the FT8 Aeroderivative Engine by J. Holowczak et al.

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