Pratt & Whitney – Engine Low Pressure Turbine Vane Cluster Analysis

Overview
The goal was to provide Pratt & Whitney with a detailed finite element stress analysis of the 6th stage LPT vane cluster in the PW4000 turbofan engine in ANSYS, while teammates at the National University of Singapore worked in parallel using Abaqus. This data will help engineers mitigate thermo-mechanical fatigue cracking on the part caused by cyclic loading. A change in forward hook fillet size was also analyzed to assess the effect of changes in dimension on part life. The prediction of effectiveness of repairs on this fillet will be made easier by this study.

Objectives
- Convert 3D cloud data to useable CAD model
- Use finite element analysis to determine the areas of highest stress
- Investigate the effects of fillet size on stress magnitude
- Determine the life cycle and a function of fillet size

Approach
- Created an error-free solid model in SolidWorks
  - Imported point cloud data
  - Fixed self-intersecting geometry
- Created a parametric fillet
  - Locally recognized the necessary features
- Prepared the model for analysis using ANSYS Workbench
  - Applied mesh controls and meshed the model
  - Applied boundary conditions to reflect operating conditions
  - Created surface elements for load application
- Completed finite element model in ANSYS
  - Applied pressure to represent airflow
  - Applied temperature gradient to the leading edge of the airfoils
- Analyzed results
  - Investigated areas of highest stress concentration
  - Did iterations for different fillet sizes
  - Compared combined and superimposed loading conditions
- Sent results to Pratt & Whitney for life cycle analysis

Outcomes
- A 3D model to be used for design and evaluation of the part
- Discovered the areas that are most likely to fail as validated by cracking seen in the field
- Determined the life cycle based on geometry changes
- Found the critical fillet size necessary after each repair