

# Gas Turbine Industrial Fellowship Program 2005

## Cooling Effectiveness of Internal Passages



VIRGINIA POLYTECHNIC INSTITUTE  
AND STATE UNIVERSITY

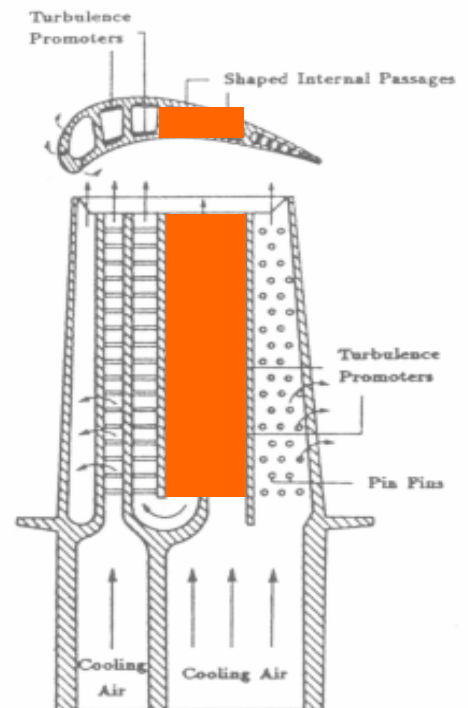
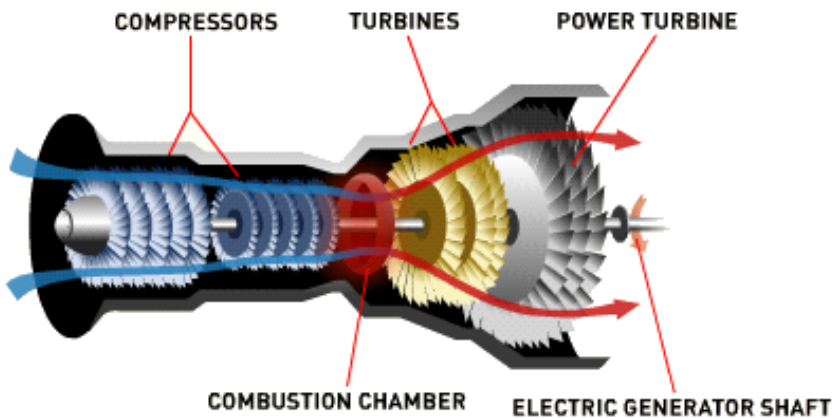


**Fellow:**  
**Mentor:**

**Nicholas Cardwell, Virginia Tech**  
**Mike Blair, Pratt and Whitney**

# Gas Turbine Needs

- Combustor exit temperatures are continually rising above turbine component melting temperatures
- Increased efficiency requirements require increased effectiveness from existing turbine cooling strategies



<http://www.pratt-whitney.com/how.htm>

A new turbine vane and an turbine vane which has been in service.

# Project Objectives

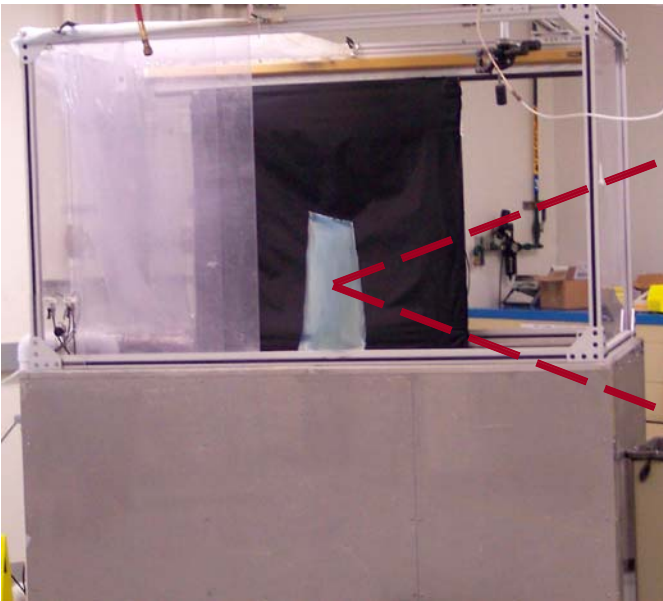
- Use cutting edge experimental techniques to determine the effectiveness of an existing turbine vane internal cooling geometry
- Using the same techniques, analyze the effectiveness of a new internal geometry for the same turbine vane
- Compare the two geometries and provide qualitative and quantitative feedback to the turbine designers



Rapid prototyping machine are used to construct experimental models (build time for one model ~ 2 days).

## Project Approach

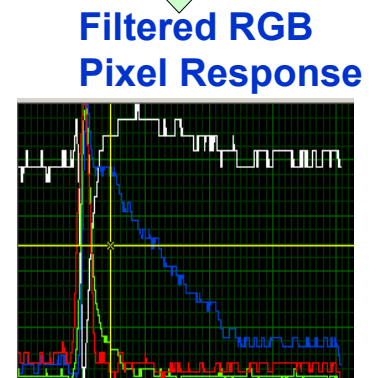
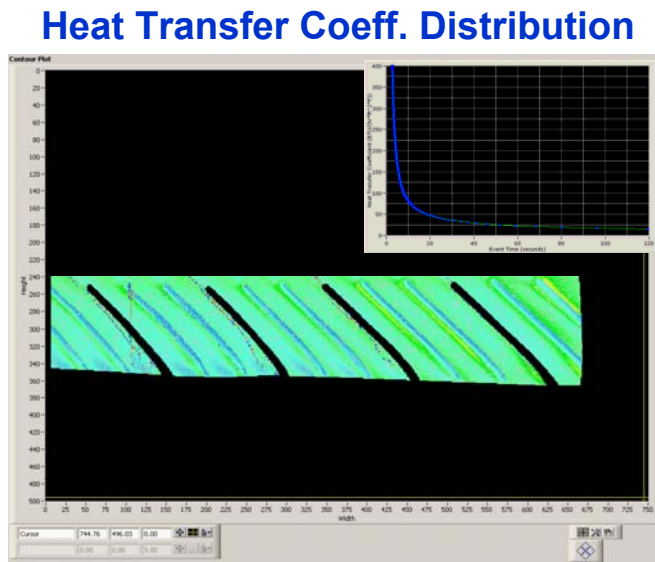
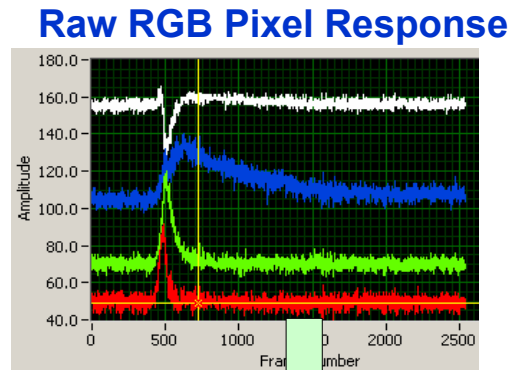
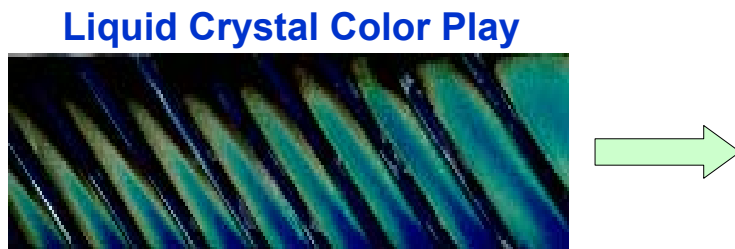
- Rapid prototype scaled models of the vanes using a stereolithograph apparatus (SLA)
- Perform flow visualization techniques on the models
- Perform heated tests on the models to deduce internal heat transfer coefficients



Waterflow bench used for flow visualization.

# Project Results

- For a rib-roughened channel, changes in rib geometry have large effects on both near-wall and mid-channel flow structures
- These changes in flow structure in turn affect the local heat transfer coefficients on the channel surface



Raw image and processed contour of heat transfer coefficient within a rib-roughened passage.

## **Project Summary and Conclusion**

- **Improvements in optically clear SLA technology provide a fast, powerful, and cost effective tool for testing of complex internal geometries**
- **Water flow visualization still provides fast and meaningful data to engineers at a low cost**
- **New experimental techniques can determine**