Project No. SR113
Heat Transfer from Rotating Blade Platforms With and Without Film Cooling

FACT SHEET

I. PROJECT PARTICIPANTS

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II. PROJECT DESCRIPTION

A. Objective(s) – The objective of this project is to provide turbine engineers with detailed heat transfer and film cooling data for design of rotating turbine blade platforms. The experimental results will also be used to validate the numerical predictions performed for the blade platforms.

B. Background/Relevancy – Turbine designers have limited data pertaining to film cooling on the blade platform (base of the blade). The majority of data has been obtained for non-rotating conditions. Also, the available data does not accurately predict the temperature (and heat transfer) distributions on rotating blade platforms. Data for rotating platforms is needed to guide the engineers to create a better blade platform cooling geometry that saves cooling flow, prevents hot spots, and thereby increases the durability and efficiency of turbines. An approach to reduce corrosion in syngas turbines might be to decrease surface temperatures by greater and more efficient cooling.

C. Period of Performance – 7/1/03 to 7/1/06

D. Project Summary – Under the University Turbine Research (UTSR) program, Texas A&M University is experimentally to investigate the heat transfer on rotor blade platforms with coolant ejection from the rotor-stator seal and film cooling on the endwall. Task I of this project involves the extensive modification of the existing rotating research facility to incorporate coolant ejection from the stator-rotor seal. This includes the design and fabrication of a new rotor for the existing facility (including the implementation of two separate cooling loops for the seal purge flow and end-wall film cooling) and instrumentation of the rotor platforms. Task II of the project will obtain detailed rotor blade platform pressure (PSP), heat transfer coefficient (TSP), and film cooling effectiveness (PSP) distributions due to various leakage conditions between the rotor and stator. For Task III, detailed pressure, heat transfer coefficient, and film cooling effectiveness distributions resulting from coolant ejection from the stator-rotor seal coupled with end-wall film cooling will be measured on the rotating platform. The experimental results from this project will provide turbine engineers with detailed data to implement advanced platform cooling techniques into turbine blade designs. The experimental results will also be used to validate a numerical prediction method for the design of blade platforms.

III. PROJECT COSTS

A. DOE Costs	$361,024
B. Cost Sharing (Texas A&M University)	$100,000

IV. MAJOR ACCOMPLISHMENTS SINCE THE BEGINNING OF THE PROJECT

- The existing experimental research turbine facility has been redesigned to incorporate two separate cooling systems. The modifications have been completed, and the new rotor of the turbine has been installed and instrumented.
- Pressure sensitive paint (PSP) and temperature sensitive paint (TSP) experimental techniques have been developed and tested. Detailed pressure (using PSP) and film cooling effectiveness (using PSP) measurements have been taken on the rotor blade platform with stator-rotor coolant ejection (purge flow), with end-wall film cooling flow, as well as with a combination of purge and end-wall film cooling flows, respectively.
- Numerical predictions of the detailed pressure, heat transfer coefficient, and film cooling effectiveness distributions have been obtained on rotating platforms with coolant ejection from the annular slot between the stator and rotor (purge flow), as well as with a combination of purge and end-wall film cooling flows, respectively.
- The film cooling effectiveness has also been measured on the platform in a five blade linear cascade using the PSP technique. Numerical predictions of the film cooling effectiveness on an identical geometry have also been completed.

V. MAJOR ACTIVITIES PLANNED DURING THE NEXT 6 MONTHS

- Analysis of the experimental heat transfer coefficient data (using TSP) collected on the rotor platform with stator-rotor coolant ejection (purge flow), as well as a combination of purge and end-wall film cooling flows, respectively, is the immediate priority. These experimental heat transfer coefficient results will then be compared to the numerical simulations in order to validate these predictions.

VI. MAJOR ACTIVITIES PLANNED IN OUTYEARS (6 - 18 MONTHS)

- The project will end by December 2006.

VII. ISSUES

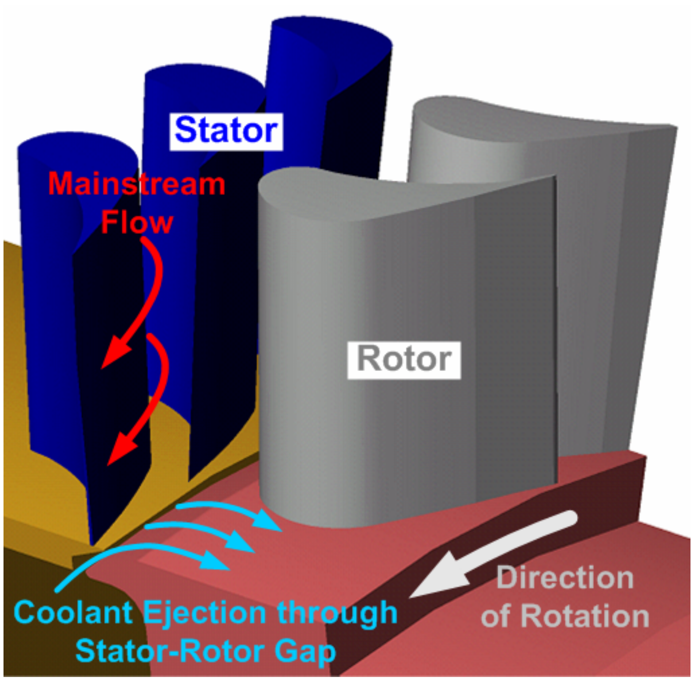
- The design and fabrication of the rotor platform to incorporate the rotor-stator seal ejection (purge flow) and end-wall film cooling required more time than was initially anticipated.

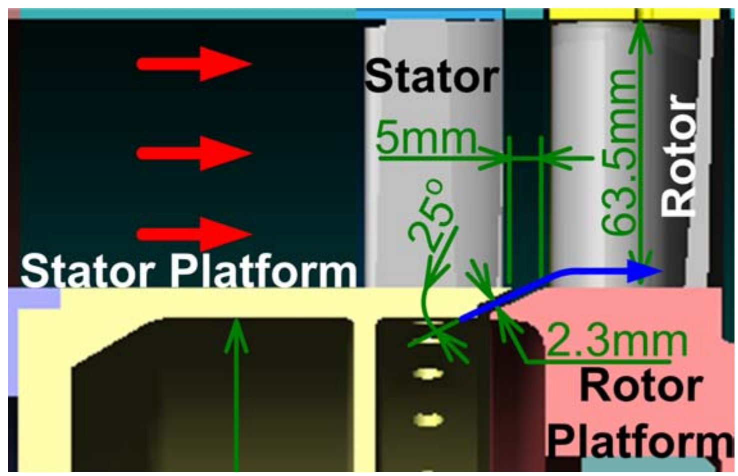
- Upon installation of the new rotor into the research turbine facility, the platform was instrumented with a custom heater that is required for the TSP technique to determine the heat transfer coefficients on the platform.

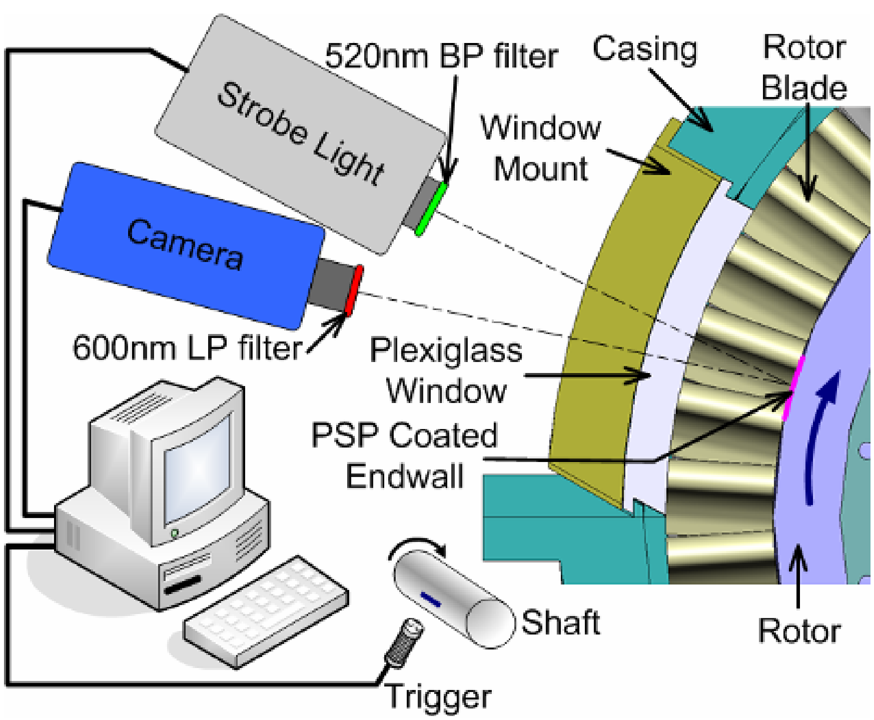
- Additional time was required for the final assembly (slip ring, coolant loops, instrumentation) and balancing of the new rotor.

VIII. <u>ATTACHMENTS</u>

Existing Setup for Experimental Investigation of Film Cooling and Heat Transfer on a Rotating Blade Platform with stator-rotor seal injection (purge flow)







Measured Film Cooling Effectiveness on Rotating Blade Platforms with Stator-Rotor Purge Flow and Downstream Discrete Film Cooling Holes