Design Concepts for Low Aspect Ratio High Pressure Turbines for High Bypass Ratio Turbofans, Phase I Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

The proposal is to identify cycle improvements and verify structural feasibility of shrouding a low aspect ratio High Pressure Turbine(HPT) rotor designed to use ceramic blades. When the clearance-to-span ratio between the rotating blades and the stationary casing is the same as the clearance-to-span ratio between the rotating shroud and the stationary casing, stage efficiency improves. However, shrouding rotor blades increases centrifugal stresses, and metallic HPT rotor blades are typically unshrouded in order to maximize stage output. Ceramic Matrix Composite(CMC) blades weigh much less than metallic blades. Shrouded CMC blades have lower centrifugal stresses than unshrouded metallic blades. The fuel burn reduction from an increase in stage efficiency due to shrouded HPT blades will be determined. The fuel burn reduction due to the higher temperature capability of CMC blades will also be determined. Cycle efficiency improvements from shrouding HPT rotor blades will increase for future engines. The HPT blade aspect ratio will decrease as engine Overall Pressure Ratio(OPR) increases. Future HPT blade aspect ratios may be less than half of current aspect ratios. While the absolute clearance may decrease in future engines, the relative clearance is likely to increase. Aerothermal analyses will determine the improvement in fuel burn from shrouding cooled HPT rotor blades. Structural analyses will determine stresses for unshrouded metallic and CMC rotor blades, and for shrouded CMC blades.

ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: The proposed work advances the NASA Aeronautics program goal of reduced fuel burn by increasing aerodynamic efficiency due to shrouding HPT rotor blades. Reducing fuel burn, and the consequent reduction of CO2 emissions, is a goal of the Environmentally Responsible Aviation(ERA) component of the NASA Aeronautics program.

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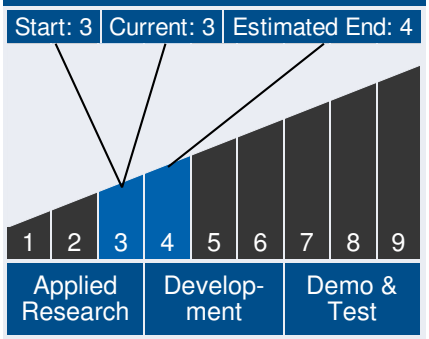
Technology Maturity



Management Team

Program Executives:

- Joseph Grant
- Laguduva Kubendran

Program Manager:

- Carlos Torrez

Continued on following page.

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The feasibility of shrouding HPT rotor blades is advanced by using Ceramic Matrix Composite(CMC) materials due to their lower density compared to conventional metallic materials. The structural analysis of CMC blades and shrouds differs from the analysis of conventional HPT materials because of the directionally dependent properties of CMC materials. CMC have a wide range of applications in gas turbines. N&R Engineering will provide NASA with analysis and design expertise for CMC components. The analysis of the benefits of to fuel burn reduction from improvements in component efficiency and/or reduced coolant requirements is an additional capability for commercialization.

To the commercial space industry:

Potential Non-NASA Commercial Applications: All gas turbine engines are expected to have reduced HPT blade aspect ratios because higher specific work is a consequence of higher efficiency. Military engines with the higher thrust-to-weight requirement have an additional incentive to reduce blade aspect ratio. Ground power gas turbines also have a strong incentive to improve HPT efficiency. Increasing rotor blade aerodynamic efficiency and increasing temperature capability is a route to reducing fuel consumption. N&R Engineering will offer design and analysis capability for CMC and conventional materials to gas turbine manufacturers and customers. Shrouded CMC blades may be costly to fabricate, and manufacturers may offer shrouded blades as an option.

Management Team *(cont.)*

Principal Investigator:

- Robert Boyle

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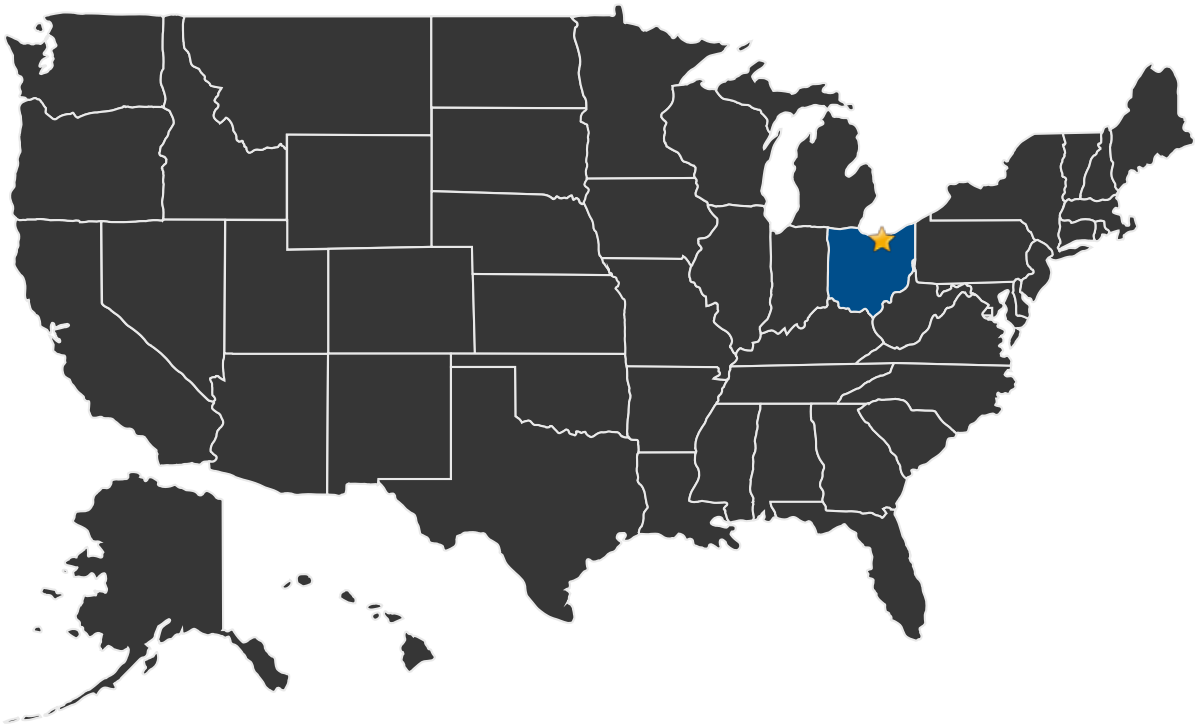
U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Glenn Research Center

Other Organizations Performing Work:

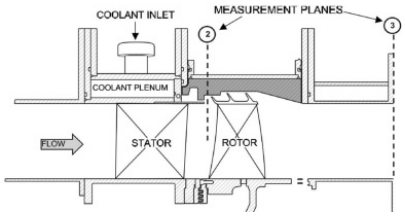
- N&R Engineering (Parma Heights, OH)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/23135)

IMAGE GALLERY



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DETAILS FOR TECHNOLOGY 1

Technology Title

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Potential Applications

The proposed work advances the NASA Aeronautics program goal of reduced fuel burn by increasing aerodynamic efficiency due to shrouding HPT rotor blades. Reducing fuel burn, and the consequent reduction of CO2 emissions, is a goal of the Environmentally Responsible Aviation(ERA) component of the NASA Aeronautics program. The feasibility of shrouding HPT rotor blades is advanced by using Ceramic Matrix Composite(CMC) materials due to their lower density compared to conventional metallic materials. The structural analysis of CMC blades and shrouds differs from the analysis of conventional HPT materials because of the directionally dependent properties of CMC materials. CMC have a wide range of applications in gas turbines. N&R Engineering will provide NASA with analysis and design expertise for CMC components. The analysis of the benefits of to fuel burn reduction from improvements in component efficiency and/or reduced coolant requirements is an additional capability for commercialization.