the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

High Temperature Capability and Innovative Cooling with a Spar and Shell Turbine Blade—Florida Turbine Technologies

Background

Florida Turbine Technologies, Inc. (FTT) is currently developing advanced aerothermal technologies centered on spar and shell airfoil concepts meant to provide highly durable turbine components that require the lowest cooling flow possible. The spar-shell system represents a unique opportunity for the use of advanced, high-temperature materials that are not presently available based on current design philosophies and manufacturing approaches.

A spar-shell airfoil is composed of an internal structural support (spar) and an external covering (shell) to provide the necessary aerodynamic envelope. The spar-shell concept allows the structural and aerodynamic requirements of the airfoil design to be considered separately, thereby enabling the overall design to be optimized for unique thermal-mechanical requirements. This optimization is one of the major advantages of the spar-shell approach that is not possible with today's conventional monolithic airfoils. In addition, the design opportunities permit novel cooling approaches that will allow higher turbine operating temperatures and/or a reduction in cooling flow. Combining higher operating temperatures and better cooling with less flow will lead to turbines with increased efficiencies, longer life cycles, and as a consequence, lower costs of electricity.

This project is managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). NETL is researching advanced turbine technology with the goal of producing reliable, affordable, and environmentally friendly electric power in response to the nation's increasing energy challenges. With the Hydrogen Turbine Program, NETL is leading the research, development, and demonstration of these technologies to achieve power production from high hydrogen content fuels derived from coal that is clean, efficient, and cost-effective, minimizes carbon dioxide (CO_2) emissions, and will help maintain the nation's leadership in the export of gas turbine equipment. This project was competitively selected under the Small Business Innovative Research (SBIR) Program.

Project Description

In Phase II of the project, FTT is developing a detailed design based on the concept design delivered in Phase I. To this end, conceptual cooling circuitry has been defined to provide the required heat transfer characteristics, and structural analyses have been performed within finite element models to verify the basic structural and vibration characteristics. Results from these analyses supported the feasibility of the design. Additional concept validation was performed to demonstrate manufacturing and fabrication feasibility. To

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
06/20/2007	01/14/2012

COST

Total Project Value
$1,085,335

DOE/Non-DOE Share
$1,085,335/$0

AWARD NUMBER

ER84668

facilitate this, actual spar and shell parts were produced in metal using the wire-slice electrical discharge machining method. Subsequent assembly of these parts verified the feasibility of the manufacturing and fabrication processes (Figure 1).

Goals and Objectives

The remaining goals of the project, necessary to conclude Phase II, include a detailed design review that allows the fabrication of hardware for an engine test. The main project objectives are as follows:

- Develop a detailed mechanical design concept that can be manufactured for test within a follow-on project.
- Identify materials best optimized to the spar-shell turbine blade for use in specific environments.
- Define cooling system features required to produce high thermal efficiency.
- Identify manufacturing and fabrication requirements.
- Evaluate benefits and costs of this system.

Accomplishments

- FTT is nearing completion of the detailed design of a rotating spar-shell turbine blade.
- The feasibility of the mechanical design, including cooling and structural aspects, has been supported by engineering calculations and analysis.
- Manufacture and assembly of the spar-shell blade has been verified with the construction of prototype models.

Benefits

This SBIR project supports DOE's Hydrogen Turbine Program which strives to show that gas turbines can operate on coal-based hydrogen fuels, increase combined cycle efficiency by three to five percentage points over baseline, and reduce emissions. FTT's spar-shell airfoil concept is an enabling technology for future gas turbine-based power systems, contributing to improvements in both efficiency and reliability. The optimization of higher operating temperatures and better cooling with less coolant flow will lead to turbines that are more efficient, have longer lifespans, and as a consequence generate power at a lower cost of electricity. The successful development of this technology would significantly contribute to the achievement of the Hydrogen Turbine Program goals.

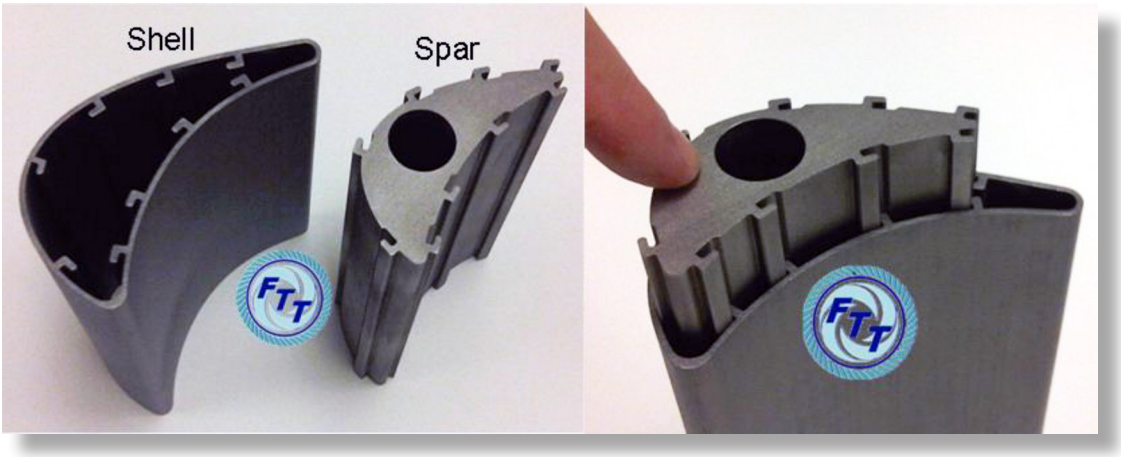

Figure 1. Spar-Shell Blade Manufacturing Trial and Fabrication Feasibility.