the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

Turbine Component Rapid Manufacturing Via Electron Beam Melting/Electrochemical Machining—Barber-Nichols

Background

Development of new, more efficient gas turbine engines is achieved by a lengthy process of maximizing performance through engine test iterations. This engine development cycle time is driven to a large extent by the manufacturing process used to produce the engine hot section turbine components. Barber-Nichols Inc., with support from Teledyne Brown Engineering (TBE), proposes combining a newly developed rapid manufacturing process technology, Electron Beam Melting (EBM), with Electrochemical Machining (ECM) to reduce manufacturing cycle time and cost by replacing the existing investment casting and/or multi-axis machining methods used to produce turbine nozzles and blades.

Parts made using a combination of EBM and ECM could substantially compress the manufacturing cycle time for new turbine blade designs and other hot section components. Successfully combining EBM with ECM in relevant high temperature materials would meet both surface finish and dimensional accuracy and offer an opportunity to reduce early prototype engine development cycle time with a more cost-effective low-rate production method for the hot section components. In some cases, a year or more is required to produce the first cast component and this period could be reduced to a matter of weeks while benefiting from the elimination of costly tooling. Rapid manufacturing of high-quality, dimensionally-accurate turbine components using EBM combined with ECM would enable multiple options for gas turbine manufacturers to iterate and develop new, higher performing industrial gas turbine engines.

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 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.

CONTACTS

Richard A. Dennis
Technology Manager, Turbines
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4515
richard.dennis@netl.doe.gov

Patcharin Burke
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-7378
patcharin.burke@netl.doe.gov

Thomas Yost
Principal Investigator
Barber-Nichols Inc.
6325 West 55th Avenue
Arvada, CO 80002-2707
303-421-8111
tyost@barber-nichols.com

PARTNERS

Teledyne Brown Engineering

PROJECT DURATION

Start Date	End Date
06/17/2011	03/16/2012

COST

Total Project Value
$149,366

DOE/Non-DOE Share
$149,366/$0

AWARD NUMBER

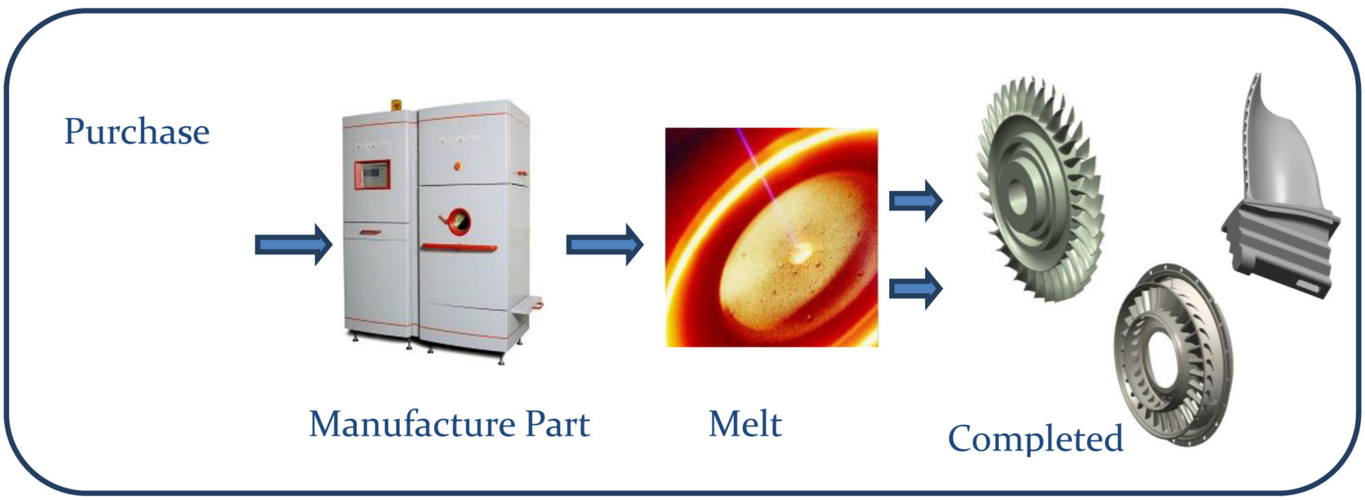
SC0006186

Project Description

This project will combine the near-net-shape rapid manufacturing EBM process with the rapid removal rate afforded by the ECM process in two relevant high temperature superalloys, Inconel 625 and Mar-M 247, and demonstrate feasibility by rapidly manufacturing representative high-quality, dimensionally accurate turbine blade geometries and internal cooling passages in both materials. Material tensile test data for EBM produced Inconel 625 and Mar-M 247 tensile specimens will enable comparison to handbook cast properties of these materials. It is anticipated that the high temperature mechanical properties will be equal to or better than equiax cast properties. EBM fabrication will be performed at North Carolina State University (NCSU). TBE will coordinate the fabrication onsite at NCSU. Barber-Nichols has developed and supplied computer aided design models of airfoil samples to TBE. Barber-Nichols will perform ECM process development and validate the ability to polish or machine the internal channels using the ECM process.

Accomplishments

- Development and fabrication of ECM tooling and processes.
- Development and fabrication of EBM work pieces and tensile samples.
- TBE has delivered the EBM produced Inconel 625 samples to Barber-Nichols for ECM process to improve surface finish on internal channels and external surfaces. All samples had roughness 250 RMS or better. All samples also showed dense structure.



EBM Process.

Goals and Objectives

The goal for Phase I is to demonstrate the integrated EBM/ECM process with acceptable material properties, surface finishes, and profile tolerances that enable parts made using this process to be used in gas turbine hot section components. The primary objective is to produce a surface finish equal to or better than that which is currently obtainable with the investment casting process.

- From EBM – 250 microinches (µin) root mean square (RMS) roughness height average (sand casting)
- After ECM – 125 µin RMS (investment casting)

Secondary objectives are to reduce the profile tolerance on an airfoil shape from .015" to .006" and to assess tensile test data for EBM Inconel 625 and Mar-M 247.

Benefits

This SBIR project supports DOE's Hydrogen Turbine Program that is striving 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. The combined process developed under this SBIR will provide a low-cost, high-quality alternative to the traditionally expensive and time consuming casting processes for industrial gas turbine engines.

NETL