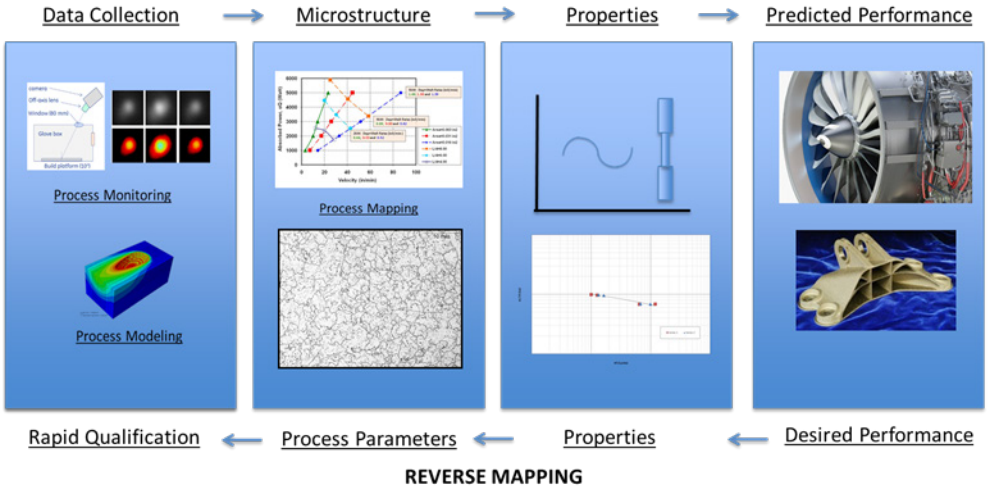
PROJECT SUMMARY 4045

Conformal Fan Duct Heat Exchanger for Engine Thermal Management Systems



Thin section geometry additive manufacturing process development for conformal heat exchangers, from concept through creation.

PROBLEM

In the current state of additive manufacturing (AM) for heat exchangers (HEX) there are three critical gaps/risks that need to be addressed including established manufacturability constraints and variability data to define achievable key product characteristics (KPCs); a prescriptive methodology for selecting build parameter specifications given a set of KPCs; and feedback of real-time process data to support computer-aided AM and the control of manufacturing process parameters.

OBJECTIVE

The program seeks to address fundamental risks/gaps in AM processes including in-situ defect detection, nondestructive evaluation (NDE), and thin fin manufacturing capability. A further objective is to establish a quantitative link between KPCs and the manufacturing process parameters required for repeatable and reliable fabrication. The technology is to be demonstrated on an AM air-air HEX and value proposition relevant to the Department of Defense (DoD) and Air Force Research Laboratory (AFRL). A preliminary optimization and benefit assessment suggests a 40% improvement in precooler UA per unit volume can be achieved, corresponding to a 29% improvement in cooling capacity or an 11% decrease in the amount of engine bleed needed to drive the thermal management system (TMS).

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to: MATERIAL

ASTM PROCESS CATEGORY: Powder Bed Fusion

EQUIPMENT: 3D Systems' ProX 300, ProX200

MATERIAL: Inconel 625

TECHNICAL APPROACH

United Technologies Research Center (UTRC), United Technologies Aerospace Systems (UTAS), Pratt and Whitney (PW), Stratonics (STR), 3DSIM, and University of Connecticut (UConn) propose to advance the laser powder bed fusion (LPBF) technology for heat exchanger components in propulsion applications. The overall technical approach involves an extensive design of experiments (DOE) and subsequent sample builds of the characterization unit with in-situ process monitoring to understand the limitations of LPBF for HEX fabrication, identify the root causes of HEX-critical defects, and understand how to avoid or correct these defects. Existing process modeling capability, X-ray CT scanning, performance testing, and a suite of current HEX acceptance tests are being utilized. A comprehensive data management is being executed to organize all data for each part that is built so that linkages can be made from an acceptance test failure to a defect identified in a CT scan to the appearance of that defect on the in-situ process sensor during the build. The development builds of multiple characterization units and the subscale and full scale HEX demonstration units are all being built on 3D Systems' ProX 300 and ProX 200 machines using Inconel 625 powder.

PROJECT PARTICIPANTS

Project Principal:
United Technologies Research Center

Public Participants:
U.S. Department of Defense

Other Project Participants:
United Technologies Corporation Aerospace Systems
Pratt & Whitney
Stratonics
3DSIM
3rd Dimension
University of Connecticut

PROJECT START/END DATE

June 2015 - June 2019

EXPECTED DELIVERABLES

- PW-Precooler requirements and interface control document
- UTRC- Solid Models of full-scale, subscale, and characterization HX units
- Coordination memo documenting KPCs, sensitivities and required tolerances
- UTRC/UTAS- Fabrication plan including defective and defect-free heat exchanger solid models
- Stratonics/UTAS- Modified sensor installed in UTAS Phenix ProX300 machine
- UTRC/UTAS- Characterization unit prototypes with NDE and process sensing datasets
- Stratonics- Process sensing demonstration results with key process metrics and defect detection criteria
- UTRC- Preliminary characterization unit prototypes with NDE datasets
- Optimized characterization unit prototypes with NDE dataset
- 3DSim- Report with process simulation results and build parameter recommendations
- UTRC/UTAS- Baseline manufacturing capability assessment
- Optimized manufacturing capability assessment
- UTRC- Detailed design and pretest predictions of subscale heat exchanger segment
- UTRC/UTAS- Subscale heat exchanger prototypes with NDE datasets
- UConn- Machine-to-Machine variability report
- UTRC/UTAS- Subscale thermomechanical test report
- Detailed design and pretest predictions of full-scale heat exchanger segment
- Full-scale heat exchanger prototypes with NDE datasets
- UTRC- Full-scale thermomechanical test report

FUNDING

$2M total project budget
($1.3M public funding/$675K private funding)

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