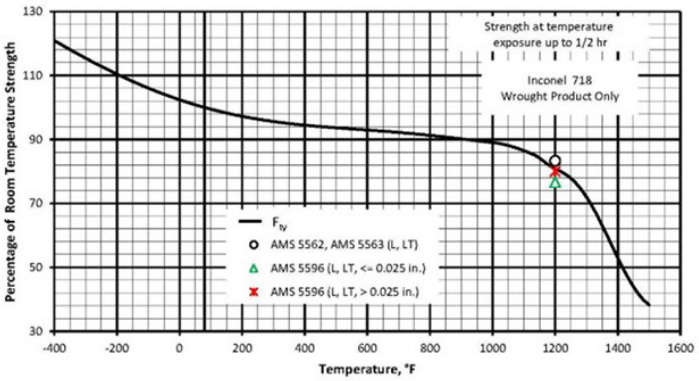
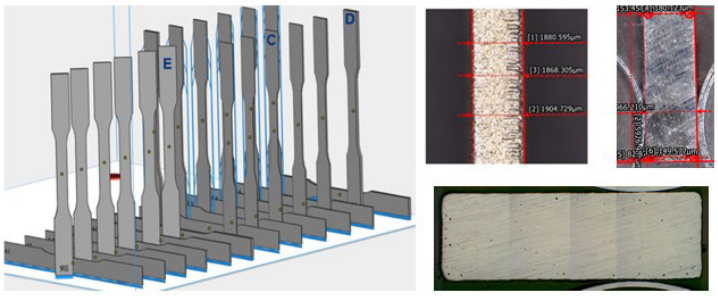
PROJECT SUMMARY 3025.001

Advancing AM Post Processing Techniques (AAPT)





The laser powder bed fusion process requires testing and validation to establish surface finish, porosity, and thin section build effects.

PROBLEM

Current wrought material properties of Inconel 718 (IN718) are well known, however the material properties of thin section components utilizing the laser powder bed fusion (LPBF) additive process are less known, specifically the property enhancement obtained through hot isostatic pressing (HIP). The HIP process has long been a standard practice, as opposed to a well understood requirement, for the manufacture of flight components. The development of a quantitative understanding of the HIP process can provide a better understanding of the cost-benefit analysis of additively manufactured (AM) flight parts and further foster adoption through the reduction in cost and lead time.

OBJECTIVE

The objective of this program is to expand the knowledge base of mechanical properties for thin sections in components produced by LPBF in IN718, including the effects of HIP. The project seeks to understand the underlying morphological and/or microstructural mechanisms to enable implementation into finite element analysis (FEA) software. The ultimate goal is to encourage the use of LPBF for flight components through the development of quantitative material data (e.g., static and fatigue strength, density, etc.), analysis and testing, and integration of these findings into FEA software through the creation of an ANSYS Workbench file.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

MATERIAL

ASTM PROCESS CATEGORY: Powder Bed Fusion

EQUIPMENT: Concept Laser M2

MATERIAL: IN718

TECHNICAL APPROACH

The technical approach for this program is to design and build test specimens for analysis and testing. The quantitative data is then integrated into an FEA package, which is qualified through modeling and comparison to honeycomb compression testing previously conducted outside of this project. Chronologically, a specimen is designed, taking into consideration build, analysis, and testing needs. The parts are built (with a Concept Laser M2), stress relieved, and removed from the build plate. Half of the parts are HIPd and all parts are then heat treated following AMS5663 procedure. Computed tomography is being used to obtain porosity, grain size, and orientation; a Keyence VR3200 scanner measures surface roughness; dimensional analysis is conducted utilizing a blue light scanner; density values are then obtained; static and fatigue strength testing is conducted utilizing ASTM E466 standards and an Instron 8801 machine; and ASTM E8 standards and an Instron 5989 machine are used for determining modulus strength. Finally, modeling and validation are conducted through honeycomb compression modeling utilizing an ANSYS Workbench file created for the FEA analysis with the quantitative information from the project.

PROJECT START/END DATE

January 2019 - August 2021

EXPECTED DELIVERABLES

- Relationships between mechanical properties, specimen size, HIP condition for IN718 to include an experimental dataset, and a draft standard for ASTM consideration
- Validated constitutive model for elastic-plastic behavior as a function of wall thickness detailed in a document showing development of constitutive model and evidence of validation
- Implementation of model in FEA through the creation of an ANSYS Workbench file with document on usage
- Training on size and HIP dependence of IN718 properties through a created video class

FUNDING

$944K total project budget
($646K public funding/$298K private funding)

PROJECT PARTICIPANTS

Project Principal:
Arizona State University

Other Project Participants:
Phoenix Analysis and Design Technologies (PADT)
Quintus Technologies
Phoenix Heat Treating, Inc.

Public Participants:
U.S. Department of Defense

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