A GLOBAL LEADER IN METAL AM

Testing and Analysis of Aerospace Parts Made by Additive Manufacturing

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The Importance Of Testing and Analysis

- QA Validation Pre and Post Process per Customer Specifications
  - Melt Pool and Powder
  - Material and Process Development
  - Mechanical Testing
  - NDT, FPI and CT
  - Engineering Drawing Conformity
- Parameter Development
- Process Development
- Heat Treat and HIP Confirmation
- Mechanical Testing

Sintavia Material Characterization Laboratory
Testing and Analysis in Aerospace AM

- Metal AM Process
  - Powder Analysis
  - Metal AM Build
  - Stress Relief
  - EDM
  - Heat Treat/HIP
  - Mechanical Testing
  - Microstructure/Chemistry
  - Density and Voiding
  - Dimensional Inspect

- Flow Testing
  - Morphology and Size
  - Chemistry – ICP/Gas
  - PSD
  - Density

- Static Testing
  - Dynamic Testing

- HAZ Evaluation
- Hardness
- Failure Analysis
- Chemistry – ICP/Gas
- Cross Section Analysis

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Why is a Metallurgical Service Laboratory Useful for Testing with Aerospace AM?

- Pre and Post Build Verification.
- Rapid Parameter, Process Validation and Part Qualification
- Verification of heat treatment and HIPing schedules
- Verification of post processing. Painting, plating, thermal spray etc.
- Failure analysis
Powder Analysis Pre Build

- PSD per ASTM B822 using laser diffraction analyzer
- SEM morphology and microscopic analysis
- ICP-OES per ASTM B215
- Gas analysis of Nitrogen, Oxygen, Hydrogen, Carbon and Sulfur
- Tap density per ASTM B527
- True Density ASTM B329
- Flowmeter testing per ASTM B213
Powder Chemical Composition

- Inductively Coupled Plasma (ICP-OES)
- Scanning Electron Microscope (SEM) with Energy Dispersive Spectrum (EDS)
- Gas analysis of Nitrogen, Oxygen, Hydrogen, and Carbon
Powder Testing and Analysis Process

- Powder management is extremely critical. Sintavia believes in controlling the process from initial powder characterization to conformity.
- Conducted in a laboratory within working distance of AM machines.
- Rapid analysis.
- Quickly and efficiently establish and maintain process control and parameter development.

Vendor A (17-4PH), Good Flow and Good Internal Porosity

Vendor A (17-4PH), Dense and Void Free Microstructure

Vendor B (17-4PH), Poor Flow and Poor Internal Porosity

Vendor B (17-4PH), Voids with Decreased Densities

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Powder Chemistry

Before a build, powder is tested to ASTM, customer, and Sintavia specifications.
Characterization Equipment

- Precision Cut Off Saws
- Chemical Hood
- Mounting Press and Polishing Equipment
- Metallographic Microscopes
- Hardness
- SEM
Material Characterization

Samples are mounted, polished and etched:

Magnification 20x

Magnification 50x

Magnification 100x

Magnification 500x

Magnification 200x

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Mechanical Testing

Part performance in real-world applications can be measured through mechanical testing. This is especially important when dealing with optimized parts that are to be used for replacement of traditional cast parts.

Sintavia’s in-house mechanical lab includes the following:

- High temperature fatigue testing
- High temperature tensile testing
- Creep testing
- Hardness testing
- Impact testing
Precision Scanning

Metrological scanning, both on the surface and internally, is a key part of ensuring quality production.

Sintavia’s in-house scanning capabilities include both a Nikon industrial CT scanner with both 225 kV and 320 kV x-ray sources, and a GOM blue light scanner.
In-Situ Monitoring and CT Scanning

- Currently, In-Situ Monitoring is complimentary to CT Scanning and traditional metallurgy techniques for quality control.
- The industry needs In-Situ Monitoring to move forward within the aerospace AM.
- The value of CT is far greater than just typical density analysis.
  - Machine and process contamination
  - Machine scaling
  - Consolidation of metrology and density analysis to lean out processes.
Comparison: CT vs In-Situ Monitoring

**In-Situ Data**
- ✗ Metrology (N/A)
- ✗ Residual stress (N/A)
- ✓ Downskin issues
- ✓ Delamination
- ✓ Recoater streaking
- ✓ Overexposure / thin powder layer
- ✓ Underexposure / thick powder layer
- ✓ In-situ detection

**CT Data**
- ✓ Metrology
- ✓ Residual stress
- ✓ Downskin issues
- ✓ Delamination
- ✓ Recoater streaking
- ✓ Overexposure / thin powder layer
- ✓ Underexposure / thick powder layer
- ✓ In-situ detection
HIP and Vacuum Heat Treatment

For most critical applications, particularly those in the aerospace industry, Hot Isostatic Pressing (HIP) is required to remove porosity of the finished part, increase ductility, and increase fatigue life.

After HIPping, vacuum heat treat refines the mechanical properties.

Sintavia operates both a hot isostatic press and a vacuum heat treatment furnace in-house.

- Porosity
- Lack of fusion
- Mechanical Property Refinement
AM Manufacturing Parameters

The AM manufacturing process is highly specialized with many different parameters. By controlling every step of the metal AM process under one roof, Sintavia is able to quickly validate parameters and proceed to the commercial manufacturing of critical components.