ETN Additive Manufacturing Working Group

Benchmarking Initiative

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ETN Additive Manufacturing Working Group
Introduction

- During the last ETN Additive Working Group held on Friday 12th of October 2018, the following action #5 was identified within the topic "**Product Quality & Control":**

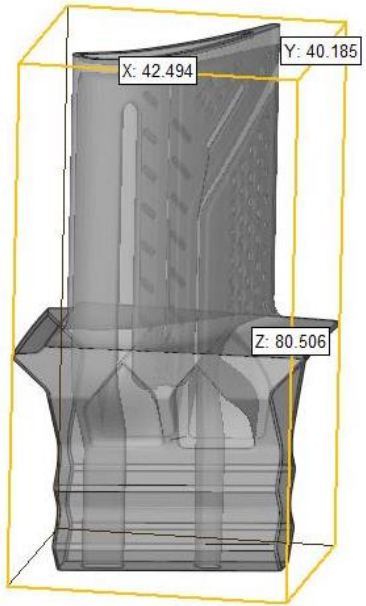
  Action 5:

  S. Nardone and V. Navrotsky to propose a component and material for conducting a case study on AM product quality and control.

- The Benchmark proposal:
  - Identify most suitable material to be processed by the ETN members with AM capacity
  - Validate one or two test cases without IP issues
  - Define assessment program

Proposed Benchmark Program

- Assess the performance of an AM system by manufacturing a demonstration industrial part for evaluating geometrical accuracy, surface finish, minimum feature sizes and mechanical performance based on design data



- Identification of a mainstream demonstration part with generic design features (no IP) for all ETN WG AM members
- Selected component: cooled turbine blade
  - Dimensions: ~ 42mm x 40mm x 81mm
  - Volume: ~ 21,5cm³
- Material: Inconel 718

Methodology & Assessment Program

Selection of Material Feedstock

Purchase of one single powder batch for benchmark program
→ Limit process variability

- Specifications to be agreed
- Powder characterization

Build capacity & Production

ETM AM WG member's equipment proposed for benchmark, covering a wide range of machine manufacturers:

• 3D Systems	Siemens
• Concept Laser	MAN ES
• DMG Lasertec 30	COMOTI
• EOS M 400/4	Siemens
• EOS M 300	Siemens
• RenAM5000Q	HiETA
• SLM®280	Engie
• TruPrint5000	Siemens
• 3DS ProX300	Solar Turbines
• Concept Laser M2	Solar Turbines

Heat Treatment

Condition for assessment to be discussed:

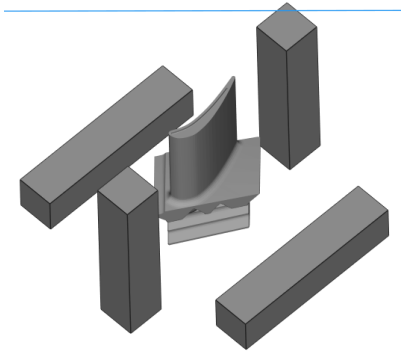
- As-build condition
- Stress relieved
- Solution annealed & Aged
- Hot Isostically Pressed

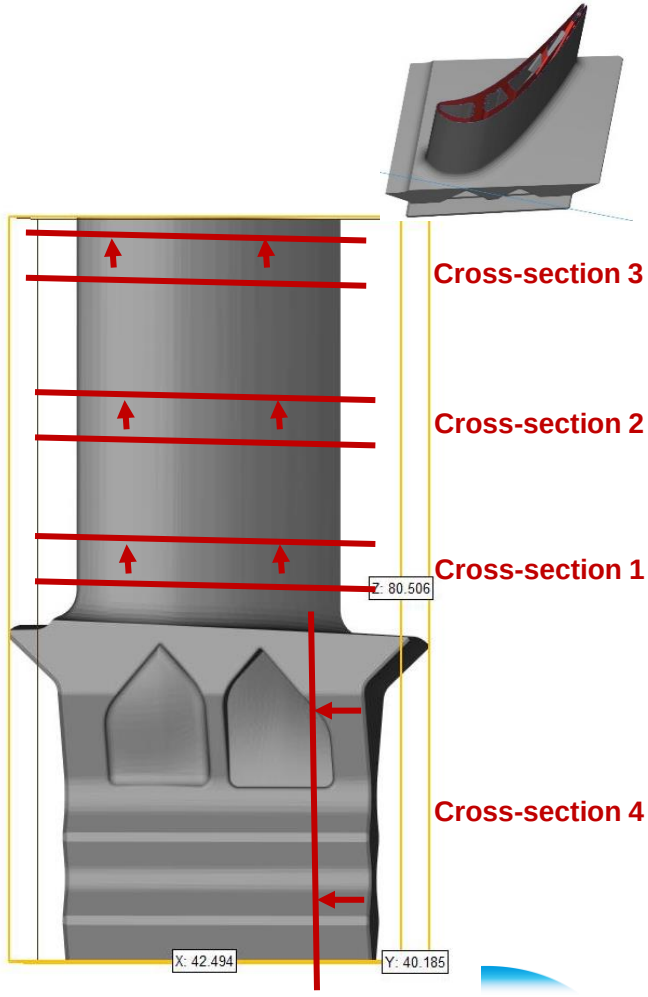
Assessment Program

Assessment program to cover:

- Geometrical accuracy
- Non-destructive testing
- Destructive examination
- Mechanical testing (limited scope)

Assessment Program





- Geometrical accuracy
  - CMM on specific locations (root and airfoil)
  - 3D scanning for overall deviation from original design
- Non-destructive testing
  - Penetrant testing
  - CT scanning for porosity assessment (expensive)
- Destructive examination
  - Four metallographic cross-sections (3 at airfoil and 1 at root)
  - Microstructural analysis, incl. porosity assessment
  - Surface quality, incl. internal features
- Mechanical performance
  - Limited scope to be defined, including hardness
  - Optional: Tensile & Creep: extra sample(s) to be produced

Funding principle to be defined and agreed with ETN & WG Members

- Expenditure Items for Benchmark Initiative
  - Purchase of one single batch of SLM Inconel 718
  - Build preparation time & Build time
  - Assessment program for all printed parts
  - Data assessment & Reporting

- Two strategies to be discussed with WG members
  - Option 1: Well-balanced in-kind contribution among members
    - Needs: define standard rate for all activities (printing cost per hour, engineering hours for all activities) and distribute activities among members
  - Option 2: External founding (H2020 or other initiative)
    - Needs: scope to be aligned and integrated within H2020 call

Assessment Program

- Baseline from existing standards:
  - On Materials: *ASTM F3055-14a Standard Specification for Additive Manufacturing Nickel Alloy (UNS N07718) with Powder Bed Fusion*
  - On Materials Feedstock: ASTM *F3049-14 Standard Guide for Characterizing Properties of Metal Powders Used for Additive Manufacturing Processes*
  - On Process & Performance: *ASTM F3303-18 Standard for Additive Manufacturing – Process Characteristics and Performance: Practice for Metal Powder Bed Fusion Process to Meet Critical Applications*