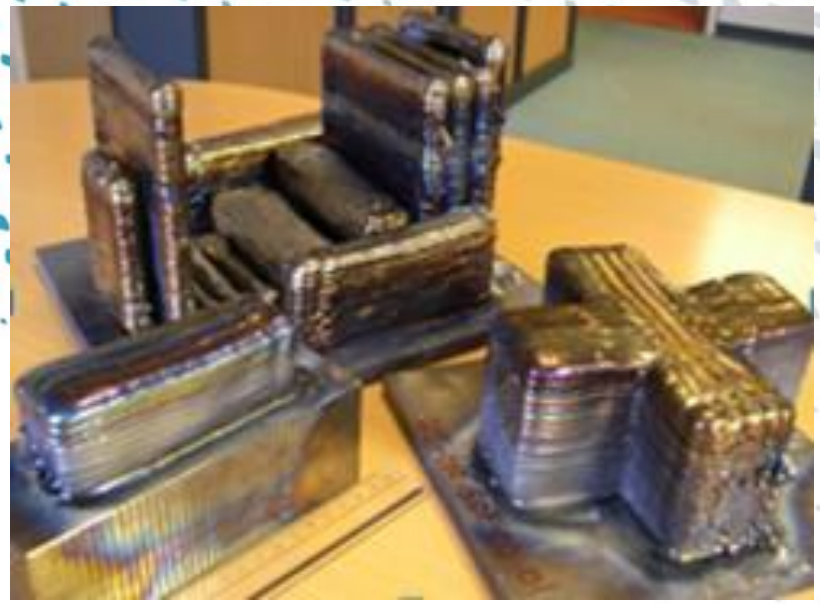


EASA 2nd Workshop September 2017

Status of National, European and International Aerospace Standardization for Additive Manufacturing

Holger KRUEGER – Airbus Welding Expert

V2 / September 2017

AIRBUS

Contents:

AIRBUS

1 General and Scope

Additive Manufacturing offers near-net-shape manufacturing with new opportunities for shapes and designs, e.g. bionic design principles.

This presentation will address the status of standardization for additive manufacturing in aerospace.
The emphasis will be on metallic products.

Public standards serve to develop a common set of basic requirements along the value chain for a harmonized supplier-customer relationship.

2 Process Variants: Is it a Welding Process? (1/3)

Non-metallic (plastic):

- Material Extrusion: Material is selectively dispensed through a nozzle or orifice
- Photopolymerization: Liquid photopolymer is selectively cured by light-activation
- Powder Bed Fusion: Thermal energy selectively fuses regions of a powder bed

Very few similarities to welding.
Powder bed fusion uses energy sources from laser welding.
The resulting products are fully made of fused or solidified plastic material.

AIRBUS

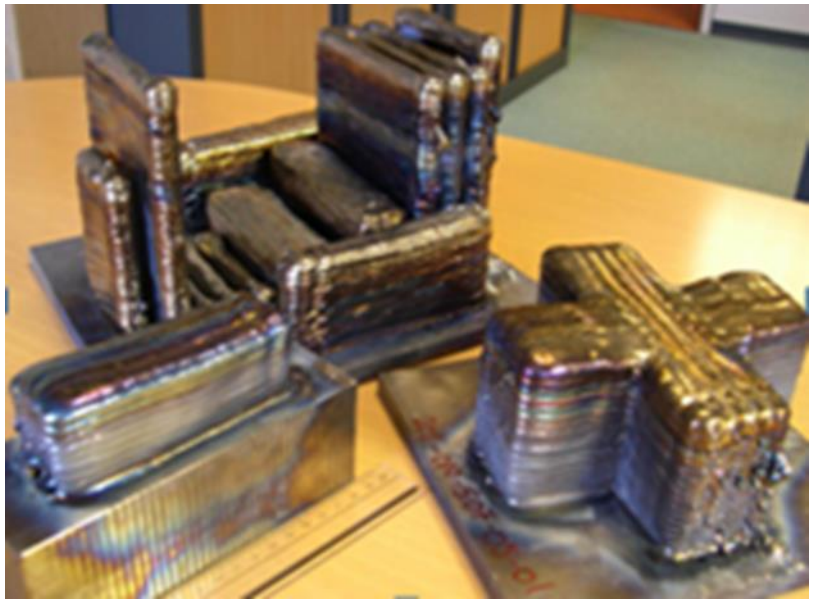
2 Process Variants: Is it a Welding Process? (2/3)

Directed Energy Deposition:

ISO/ASTM 52900:2015: “Process in which focused thermal energy is used to fuse materials by melting as they are being deposited.”

Example: Weld wire, fused by laser beam, electron beam or electric arc.

Processes with many similarities to existing weld methods (energy sources, machines, feedstock, parameters). Differences exist in the resulting product, which is fully made of fused material (internal stresses, grain structure).



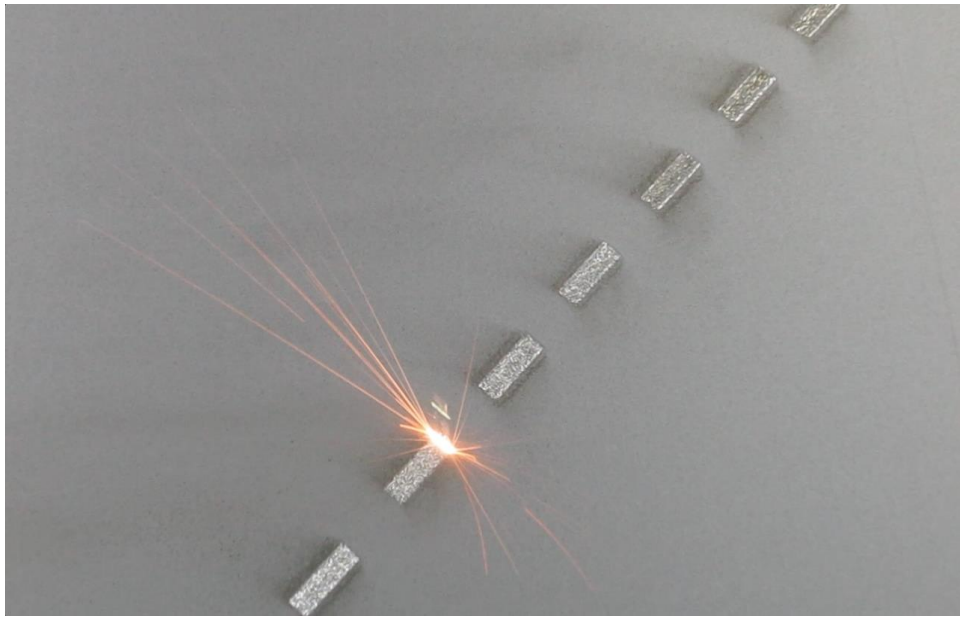
AIRBUS

2 Process Variants: Is it a Welding Process? (3/3)

Powder Bed Fusion (metallic material):

ISO/ASTM 52900:2015: “Additive manufacturing process in which thermal energy selectively fuses regions of a powder bed.”

Energy sources in use are laser beam and electron beam.



Process with many similarities to existing weld methods (energy sources, parameters, material types, defect types).

Differences exist in the resulting product, which is fully made of fused material (internal stresses, grain structure).

AIRBUS

3 National Standardization (1/6)

United States (1/2):

ASTM (member of ANSI, USA) Committee F42 on additive manufacturing technologies – formed in 2009.
Collaboration with ISO/TC261 in a joint working group - since 2011

→ More details in “International Standardization”

AWS – Committee D20 on additive manufacturing.
Presently drafted:
D20.1, Standard for Fabrication of Metal Components using Additive Manufacturing

ASTM - American Society for Testing and Material
ANSI - American National Standards Institute
AWS - American Welding Society

AIRBUS

3 National Standardization (2/6)

United States (2/2):

SAE AMS AM, Additive Manufacturing, developing and maintaining aerospace material and process specifications and other SAE technical reports for additive technologies.

- AMS7003 Laser Powder Bed Fusion Process (WIP)
- AMS7002 Process Requirements for Production of Ni-base 625 for Production of Aerospace parts via Laser Powder Bed Additive Manufacturing (WIP)
- AMS7001 Ni Base 625 Super Alloy Powder for use in Laser Powder Bed Add Mfg Machines (WIP)
- AMS7000 Additive Manufacture of Aerospace parts from Ni-base Superalloy 625 via the Laser Powder Bed Process (WIP)

SAE – Society of Automotive Engineers
AMS – Aerospace Material Specification

3 National Standardization (3/6)

Europe (1/4):

AFNOR (France), Group UNM 920 “Fabrication Additive”

VDI (Germany), Group FA105 “Additive manufacturing”

For a list of standards (Ge/En) and projects, see next page

Note: All listed standards are not specific for aerospace

AFNOR - Association Francaise de Normalisation
VDI - Verein Deutscher Ingenieure

3 National Standardization (4/6)

Europe (2/4):

- VDI 3405: Additive manufacturing processes, rapid manufacturing, Basics, definitions, processes (2014-12)
- VDI 3405 Part 1: Additive manufacturing processes, rapid manufacturing, Laser sintering of polymer parts, Quality control (2013-10)
- VDI 3405 Part 2: Additive manufacturing processes, rapid manufacturing, Beam melting of metallic parts, Qualification, quality assurance and post processing (2013-08)
- VDI 3405 Part 2.1: Additive manufacturing processes, rapid manufacturing, Laser beam melting of metallic parts, Material data sheet aluminium alloy AlSi10Mg (2015-07)
- VDI 3405 Part 2.2: Additive manufacturing processes, Laser beam melting of metallic parts - Material data sheet nickel alloy material number 2.4668 (2017-07)
- VDI 3405 Part 2.3: Additive manufacturing processes, rapid manufacturing – Beam melting of metallic parts – Characterisation of powder raw material (Draft 2017-07)
- VDI 3405 Part 3: Additive manufacturing processes, rapid manufacturing, Design rules for part production using laser sintering and laser beam melting (2015-12)
- VDI 3405 Part 3.5: Additive manufacturing processes, rapid manufacturing – Design rules for part production using electron beam melting (Draft 2017-04)

AIRBUS

3 National Standardization (5/6)

Europe (3/4):

DIN (Germany),

- Group NA092-00-17-01 AK “Welding in Aerospace – Acceptance Criteria for generative Laser Manufacturing” – since 2014
- Group NA131-02-06 AA „Additive Manufacturing in Aerospace“ – since 2015

These 2 groups joined to work together on aerospace standards for additive manufacturing.

For a list of standards (Ge) and projects, see next page

Note: English translations are presently in progress.

DIN – Deutsches Institut für Normung

AIRBUS

3 National Standardization (6/6)

Europe (4/4):

- DIN 35224: Welding for aerospace applications – Acceptance inspection of powder bed based laser beam machines for additive manufacturing (09/2016)
- DIN 35225: Welding for aerospace applications – Qualification testing of operators for powder bed based laser beam machines for additive manufacturing (06/2017)
- DIN 65122: Aerospace series – Powder for additive manufacturing with powder bed process – Technical delivery specification (01/2017)
- DIN 65123: Aerospace series – Methods for inspection of metallic components, produced with additive powderbed fusion processes (08/2017)
- DIN 65124: Aerospace series — Technical Specification for additive manufacturing of metallic materials with the powder bed process (WIP)

AIRBUS

4 European Standardization (1/2)

ASD-STAN

Association which establishes, develops and maintains standards on behalf of the European aerospace industry.

Current members of ASD-STAN:

- France: GIFAS
- Germany: BDLI / DIN-NL
- Italy: AIAD
- Spain: TEDAE
- Sweden: SOFF
- United Kingdom: ADS
- Europe: EASA, ASD

ASD-STAN - Aerospace and Defence Industries Association of Europe - Standardization

AIRBUS

4 European Standardization (2/2)

ASD-STAN D4/WG 14 “Additive Manufacturing”

- Formed in 11/2016
- Secretariat: DIN
- Presently evaluating potential work items for standardization

AIRBUS

5 International Standardization (1/4)

ISO/TC261 “Additive manufacturing”

- Secretariat: DIN
- Joint working group with ASTM F42 since 2011
- Joint working group with ISO/TC44/SC14 (Welding in Aerospace) to be confirmed
- 7 published ISO standards
- 10 ISO standards under development

For a list of published standards, see next page

Note: All listed standards are not specifically for aerospace

ISO - International Organization for Standardization

AIRBUS

5 International Standardization (2/4)

ISO/TC261 “Additive manufacturing”

- ISO 17296-2: Additive manufacturing -- General principles -- Part 2: Overview of process categories and feedstock (01/2015)
- ISO 17296-3: Additive manufacturing -- General principles -- Part 3: Main characteristics and corresponding test methods (09/2014)
- ISO 17296-4: Additive manufacturing -- General principles -- Part 4: Overview of data processing (09/2014)
- ISO/ASTM 52900: Additive manufacturing -- General principles – Terminology (12/2015)
- ISO/ASTM 52901: Additive manufacturing -- General principles -- Requirements for purchased AM parts (10/2016)

AIRBUS

5 International Standardization (3/4)

ISO/TC44/SC14/WG1 “Additive manufacturing in Aerospace”

- Working group under ISO/TC44/SC14 “Welding and Brazing in Aerospace”
- Established 10/2016
- Secretariat: DIN
- Joint working group with ISO/TC261/ASTM F42 unilaterally confirmed

For proposed work items see next page

AIRBUS

5 International Standardization (4/4)

Proposed work items of ISO/TC44/SC14/WG1:

- Aerospace applications — Qualification of laser beam machines for metal powder bed additive manufacturing (first draft based on DIN 35224)
- Aerospace applications – Qualification testing of operators for powder bed based laser beam machines for additive manufacturing (first draft based on DIN 35225)
- Aerospace applications – Technical Specification for Additive Manufacturing by directed Energy Deposition

AIRBUS

6 No Standardization, but setting Standards: Nadcap (1/3)

“Nadcap is an industry-managed approach to conformity assessment that brings together technical experts from both Industry and Government to establish requirements for accreditation, accredit Suppliers and define operational program requirements”

Nadcap is used by most aerospace OEMs for surveillance audits of special process applications at suppliers.

6 No Standardization, but setting Standards: Nadcap (2/3)

Nadcap OEMs

AIRBUS

6 No Standardization, but setting Standards: Nadcap (3/3)

Nadcap Document AC7110/14: “AUDIT CRITERIA FOR LASER AND ELECTRON BEAM METALLIC POWDER BED ADDITIVE MANUFACTURING”

- Developed by Nadcap Welding task Group (WLD)
- Released 12/2016
- Based on public standards and “specified requirements common among subscribers”
- In use as a questionnaire for auditing of additive manufacturing at aerospace suppliers
- Most audit questions are process specific
- Audits encourage a standardized approach to process related topics.
  ASTM has created a list of projects that are reflecting AC7110/14 topics

AIRBUS

7 Good to know: The Key Players (1/2)

ASTM F42

Chair: Carl Dekker (Met-l-flo Inc), Vice: John A. Slotwinski (NIST), Secretariat: ASTM

AWS D20

Chair: Doug Kautz (Los Alamos National Laboratory), Secretariat: AWS

SAE AMS AM

Chair: Alan Fletcher (Air Force Reserch Laboratory), Secretariat: SAE

AFNOR UNM 920

Chair: Eric Baustert (VOLUM-e), Secretariat: UNM

VDI FA105

Chair: Prof. Dr.-Ing. habil. Gerd Witt (University Duisburg-Essen)

Vice: Dr. Olaf Rehme (Siemens), Secretariat: VDI

DIN NA131-02-06 AA

Chair: Stefan Ritt (SLM Solutions), Vice: Holger Krueger (Airbus), Secretariat: DIN

AIRBUS

7 Good to know: The Key Players (2/2)

ASD-STAN D4/WG 14

Chair: Stefan Ritt (SLM Solutions), Vice: Holger Krueger (Airbus), Secretariat: DIN

ISO/TC261

Chair: Joerg Lenz (EOS), Secretariat: DIN

ISO/TC44/SC14

Chair: Holger Krueger (Airbus), Secretariat: DIN

ISO/TC44/SC14/WG1

Chair: Ralph Kropp (MTU), Secretariat: DIN

Nadcap Welding Task Group (WLD TG)

Chair: Steven Tooley (R-R PLC), Vice: Holger Krueger (Airbus)

AIRBUS

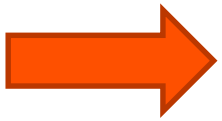
8 What will be next? A Look into the Future

8 What will be next? A Look into the Future

Predictions can be difficult, because they are related to the future…

For additive manufacturing, we can expect:

- More and new applications in aerospace
- Modular manufacturing systems with automated powder handling, powder reconditioning and powder testing
- Modular manufacturing systems, integrating after-treatment of products
- Larger machine dimensions with multiple laser beam sources
- Innovative topology improvement processes
- Innovative solutions for non-destructive testing
- Advances in wire feed technology
- ???



New topics for standardization

AIRBUS

A Space for Questions

AIRBUS

Thank you

AIRBUS