# Advanced Materials & Manufacturing (AAM)

#### GROUND VEHICLE SYSTEMS ENGINEERING & TECHNOLOGY SYMPOSIUM & Advanced planning briefing for industry

### MICROSTRUCTURE ANALYSIS OF TIG WELD JOINTS OF NI-BASED SUPERALLOYS PRODUCED BY LASER POMDER BED FUSION

<sup>1</sup>Siemens Energy

<sup>2</sup>Siemens Gas and Power GmbH & Co. KG



### Siemens Energy Gas Turbine Portfolio

# Advanced Materials & Manufacturing (AMM)













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## Both a User and Service provider Advanced Materials & of AM Manufacturing (AMM)





Power Generation



Oil & Gas



Transmission

Positioned for technology partnerships and value add services

• >10 years AM user

200+ qualified AM

>1,500,000 operating

Extensive material

>40 DfAM engineers

experience

components

hours

data



- >15 years experience in AM (2006)
- Parts in serial production
- Aerospace qualified processes (AS9100, Nadcap, AMS7003)
- Aerospace



Tooling / Processing

- Automotive
- Range of Materials (Ni / Ti / Al / Steels / CO)
- >5000 parts delivered

Positioned for serial production in high performance industries

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- **Certifications** (AS9100, Nadcap, AMS7003)
- 48,000 sq/ft serial production factory
- Fully integrated AM Application Center in US ORL

50+ printers

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# AM use cases in Gas Advanced Materials & Manufacturing (AMM)

**Turbines** 



energy

### Product

- Higher combustion temps
- Fuel flexibility
- Improved sealing
- Reduced emissions

#### **Supply Chain**

- Faster repairs
- Faster time to market
- Spare part availability
- Risk reduction





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# Components

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**Goal**  $\rightarrow$  Print multiple (LPBF) parts separately to take advantage of various print orientations, materials and geometries and join them subsequently with tungsten inert gas (TIG) welding using standard industrial specifications.



# Why join metal AIVI parts? Advanced Materials & Manufacturing (AMM)

Laser Powder Bed Fusion (LPBF)

- Most mature metal AM technology today
- High resolution
- Can be slow
- Limited Build Volumes
- LPBF Stand alone  $\rightarrow$  Limited use cases
- Joining Methods  $\rightarrow$  Expanding the reach of LPBF

### When considering joining AM hardware:

- System Level Thinking → Features, components & location in the system
- Other Additive and Manufacturing Technologies must be considered (WAAM, Cast, Subtractive, etc.)



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## Joining AM Types

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### Modular setup: Test rig vane (LPBF IN718)

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#### Mixed Mig. 600011 combustion

### system

### IN625 LPBF on IN625 cast

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# Requirements & Approach Advanced Materials & Manufacturing (AMM)

- Application of our standard weld qualification within Siemens Energy
- Continuing with a known standard can increase acceptance
- Standard Weld processes & filler material used for Non-AM materials
- Weld Prep Machined? Or Printed? Both



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# Results, Benefits

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- LPBF IN625 samples are weldable using the same TIG welding setup as for conventional tubing.
- No cracks or out-of-spec defects were identified.
- Modular and Mixed setups in LPBF IN625 have been fully qualified based on the results of the study.



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#### **Advanced Materials &** by AM Manufacturing (AMM) Concept to Serial Qualification **Product Development Process Strategic Product Planning** Validation Design **Design Implementation Final Design** Manufacturing **Product &** Erection, Install, **Product** Conceptual Product Basic Development **Commissioning &** Monitoring ጲ Strategy Design Design Trial Ops & Validation Planning Procurement Assembly **Concept development, Verification and manufacturing trials Quality Assessments** Production Design approach: Reducing part volume 2. Reducing support structure volume Manufacturing trials: Support structure and removal for two build directions Line supports for vanes with varying line thickness Gap supports with varying gap lengths for burner tip 3. Easily removable supports Single-Vector Gusset Supports: Break away during sandblasting

Manually removable line supports

9/13/2022

# **Conclusions and Outlook**

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More still to be done:

- Qualify more material combinations (incl. dissimilar joints)
- Qualify joining of different (AM) technologies (e.g. LPBF to WAAM)
- Additional mechanical testing (fatigue, creep..)
  - Integrated fixture features into wed prep decreasing tooling dependency
    - Clocking orientation / manufacturing access



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### SIEMENS COCIGY

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Siemens Energy Additive Link Siemens Energy AM: <u>www.youtube.com/watch?v=8j86P2GKPvM</u>

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