

HTM-next

Next generation of High Temperature Materials made by Plasma Metal Deposition for components in aircraft engines

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Brief description of the consortium partners

RHP Technology [process & materials] is a solution provider for customized materials and advanced processing techniques based on powder technology as well as additive manufacturing.

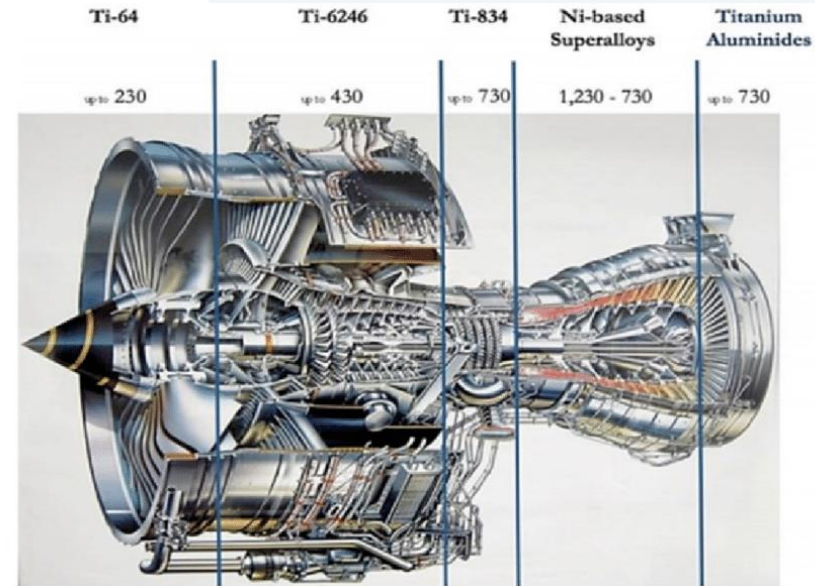
AAC [testing & characterization] is active in the development and qualification of materials. Its main business covers testing services to various demanding industries including space and aeronautics.

SBI [Additive manufacturing machine development] a company specialized in high-tech welding solutions, with a core focus on plasma welding for applications such as joining, cladding, and 3D printing



Project Motivation

- **Flexible Additive Manufacturing of Ni-based Superalloys :** Plasma Metal Deposition (**PMD**) enables large, complex Ni alloy components to be printed efficiently with high deposition rates, supporting advanced high-temperature applications
- **Enabling next-generation aerospace performance:** Improved engine energy efficiency through lightweight, high-strength, and thermally stable structures.
- **Integrating innovation in material design:** Development of Ni alloys with ceramic reinforcement enhances mechanical and thermal properties, contributing to sustainability and material savings.



Aim of the Project

- **Develop and Optimize** the PMD to print (including torch modification) for high temperature resistant materials.
- Create and test **five alloy families** (Ni, Modified Ni, Intermetallics, HEA-Low, HEA-Extreme).

→Yield Strength > 200 MPa @ 1000 °C (Modified Ni)

→Yield Strength > 300 MPa @ 800 °C (Intermetallics)

→Yield Strength > 500 MPa @ 1000 °C (HEA)

- Build a **high-temperature tensile testing system** capable of **1200 °C** for rapid material evaluation
- Validate the PMD process through an **engine pylon demonstrator** achieving > **60 % material saving**.



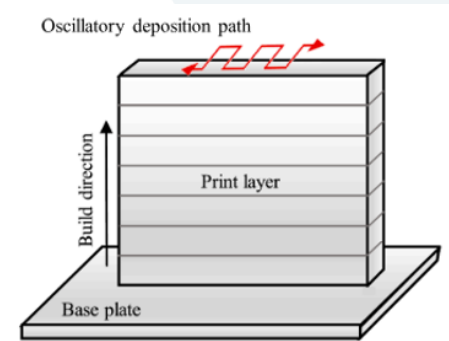
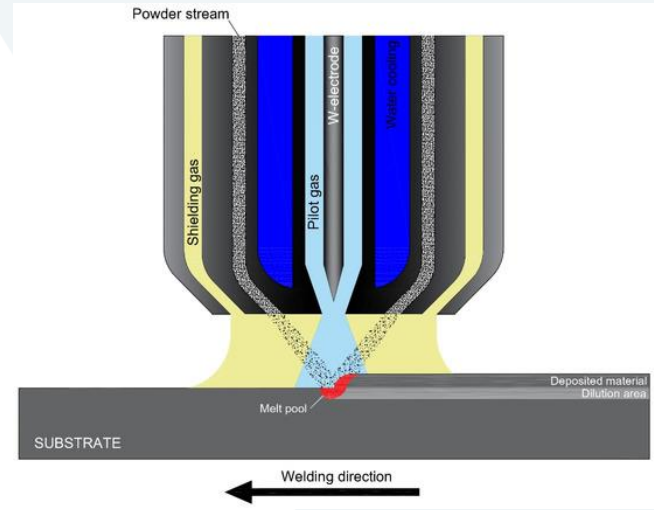
PMD printing station



1000 °C tensile test device

Technology – Plasma Metal Deposition

- Plasma : Energy source
- Argon gas (Plasma and shielding)
- Wire feeding and Blown-powder-feed technique
- High feeding rate (1-10 kg/h)
- System attached to a Gantry (XYZ) system + Tilt/Turn Table
- Large size components: Working area of 1.5m x 2m



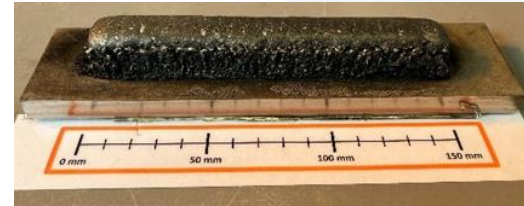
Project Results - Nickel Alloys and Modified Ni Alloys

Investigation of Modified Ni Alloys :

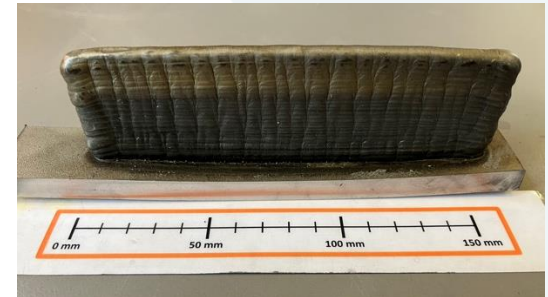
- PMD of a modified Ni alloy
- Ni-matrix composites with Al_2O_3 were also tested
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Results:

- **Yield Strength of >200 MPa at 1.000°C achieved**
- Optimization of Heat Treatments required in order to improve the elongation



IN718 wall + 1vol% Al_2O_3 , cross section of the IN718 with embedded Allumina

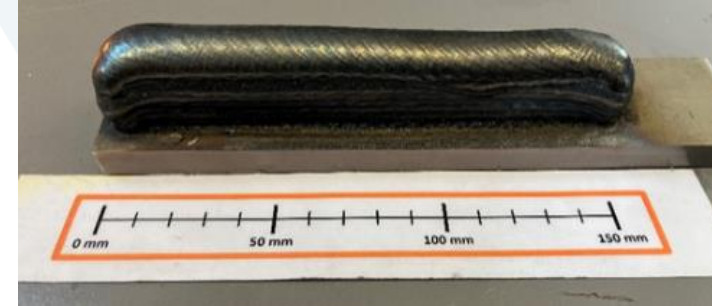


Ni alloy - AM test wall

Project Results - Intermetallics

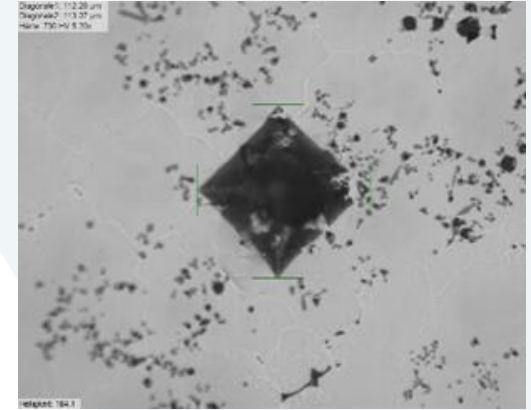
PMD Processing of intermetallics

- Ti based
- **TNM** – Titanium Intermetallic
- **Low ductility (<2%)** remains a limitation; future work focuses on microstructure refinement and alloying (e.g. by addition of alloying elements).
- **Yield strength > 400 MPa @800°C** achieved

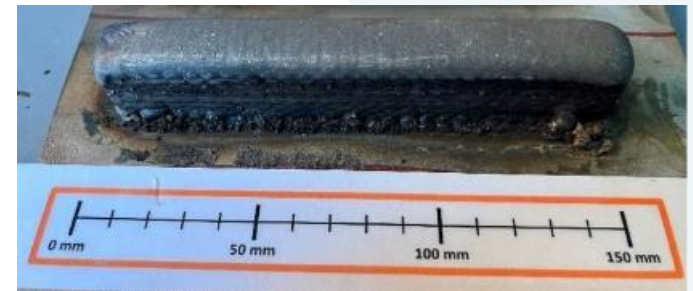


Project Results – High Entropy Alloy (HEA)

- Study of HEA materials *AlCoCrFeNi* and *AlCrMoNbTi*.
- Demonstrated **feasibility of multi-element alloying** via powder deposition.
- Refractory HEA *AlCrMoNbTi* produced dense structures with **dendritic morphology** and hardness up to **730 HV**.
- **Mechanical KPI not yet achieved** – further optimization of **heat treatment** and **feedstock design** required.



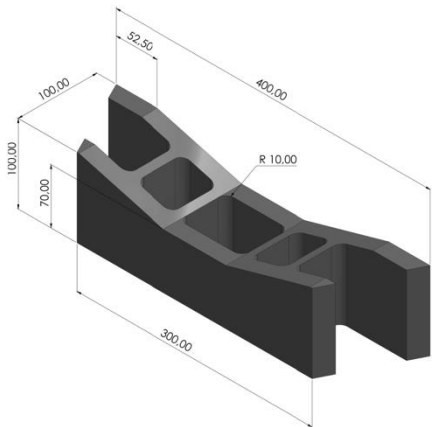
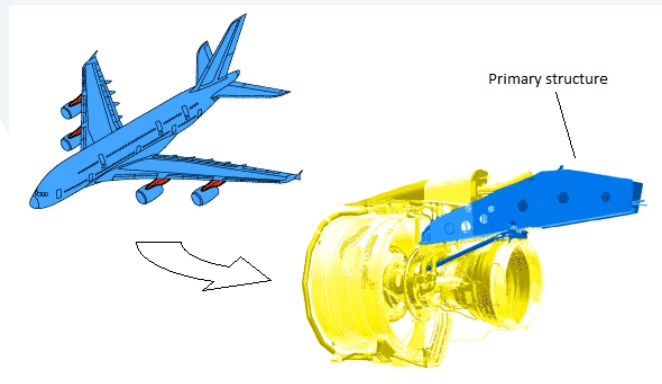
Hardness Indentation for the refractory HEA



Refractory HEA wall (*AlCrMoNbTi*)

Project results

- **Demonstrator : Engine Pylon (Ni-alloy)**
- 400 × 130 mm pylon printed and partially milled.
- Material saving of ca. 50 % (16.8 kg vs 33 kg conventional machining from a block).



Utilization of the project

- PMD validated for large Ni-based components.
- Rapid high-temperature testing capability established at AAC (1200 °C).
- Results presented at major conferences:
 - **MAMC 2023**
 - **EURO PM 2024**
 - **ECSSMET 2024**
 - **FORMNEXT 2024**

Published and submitted papers:

- *Characterization of the Anisotropic Behaviour of Inconel 718 Parts Manufactured by WAAM – Superalloy 718 & Derivatives 2023*
- *Study of Thermal Mechanical Properties of Inconel 718 Reinforced with Ceramic Particles Manufactured by PMD – EURO PM 2024*
- *Assessment of the PMD Process for Additive Manufacturing of High-Temperature Alloys – ECSSMET 2024*
- *High-Temperature Performance of ABD 900 AM Processed by PMD – EURO PM 2025 (submitted)*

Further steps/(potential) follow-up projects

- **DOMINANT project (2025-27):** optimization of ABD 900 AM including new version of alloy with partners from UK.
- Future focus: heat treatment optimization, creep testing, multi-material deposition.
- Company contracts:
 - Feasibility/Assessment of HEAs for thruster nozzles
 - Feasibility on assessment of HEAs for glass-forming processes
 - Products: High Entropy Alloy Sputtering targets for thin film deposition