Associazione Termotecnica Italiana

AIDIC

FIL ROUGE 2026

29.01.2026
Tecniche avanzate di produzione delle parti critiche di turbine a gas

Erica Vacchieri

Con il contributo di

KSB

MASOL Continental Biofuel

webinar FIL ROUGE 2026

Associazione Termotecnica Italiana
Sezione Lombardia

Erica Vacchieri

Tecniche avanzate di produzione delle parti critiche di turbine a gas

29.01.2026

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Fit for transition

Summary of the presentation

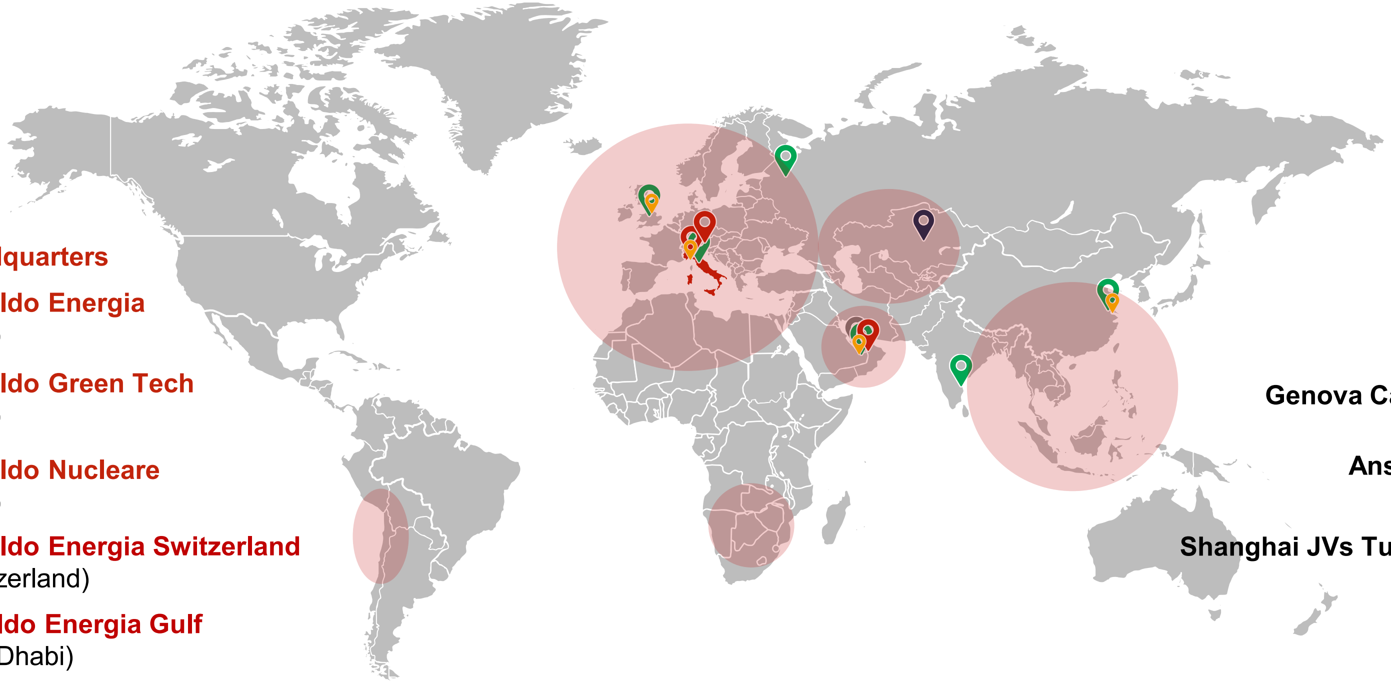
- Ansaldo Energia
- Introduction
- Gas turbine
- Blade and vane
    - Superalloys
    - Metallic coatings
    - Ceramic coating
    - Cooling systems
- Complex geometry parts
- Conclusion and future perspectives

ANSALDO ENERGIA

We are **leader in the field of power generation** and a key player of the **energy transition**.

We provide leading-edge technology machines and services to allow our customers to produce **affordable**, **reliable** and **sustainable** electric energy.

Our main shareholder is **CDP Equity**, Cassa Depositi e Prestiti Group, a national promotion institution that has supported the Italian economy and industry development since 1850.



Headquarters

Ansaldo Energia
(Italy)

Ansaldo Green Tech
(Italy)

Ansaldo Nucleare
(Italy)

Ansaldo Energia Switzerland
(Switzerland)

Ansaldo Energia Gulf
(Abu Dhabi)

Workshops

Genova Campi&Cornigliano
(Italy)

Ansaldo Energia Gulf
(Abu Dhabi)

Shanghai JVs Turbine Technology
(China)

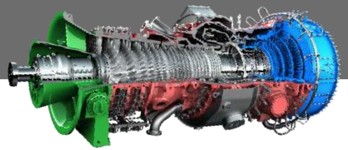
Ansaldo Nuclear
(UK)

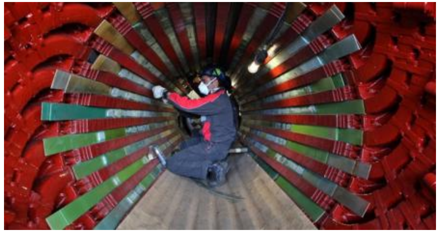
Company Headquarters | Subsidiary Companies and JVs | New 2025 branches | Workshops

A GLOBAL COMPANY

New Units

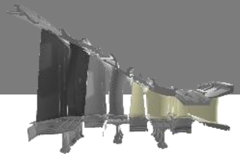
- Hydrogen-ready, operationally flexible heavy-duty Gas Turbines
- Steam Turbines
- Generators
- EPC





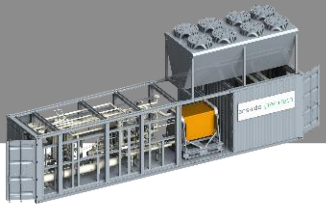
Service

- Engineering& Field Service
- Long Term Service Agreement
- Remote Monitoring & Data Analysis
- Hydrogen-proof retrofitting
- Digital Solutions



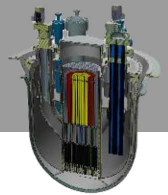
Green Tech

- Developing AEM electrolysers
- Producing microturbines for distributed generation
- Proving equipment for CO_2 sequestration
- Geothermal equipment



Nuclear

- Service for nuclear power plants
- Nuclear new builds
- SMR & LFR development
- Fusion
- Decommissioning & waste management

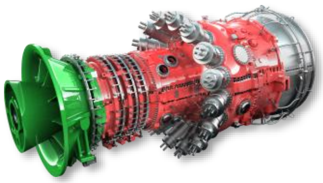


WHAT WE DO

Ansaldo Energia's entire fleet is designed to burn **hydrogen**. Our flagship GT36, capable of powering over 500,000 homes, **is able to burn up to 70% of hydrogen**.
AE94.3A offers up to 40% capability.

In January 2024 GT36 burner has been successfully tested with **100% hydrogen**.

We are committed to achieve 100% H_2 combustion for the whole fleet by 2030



NEW UNITS

H_2-committed

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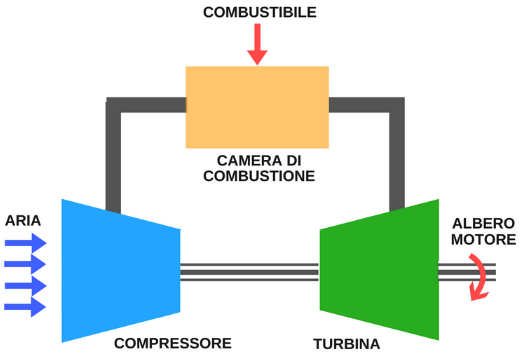
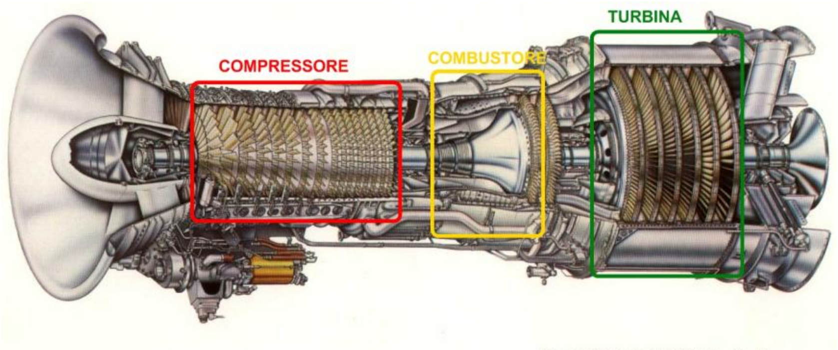
Introduction

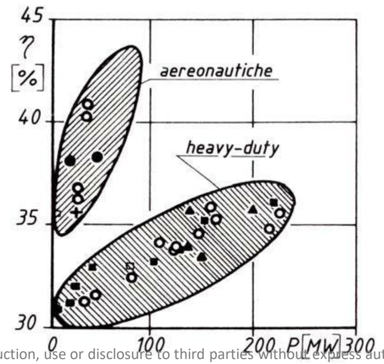
Gas Turbine



- Compressor
  - Draws in air & compresses it
- Combustion Chamber
  - Fuel pumped in and ignited to burn with compressed air
- Turbine
  - Hot gases converted to work
  - Can drive compressor & external load



General Electric LM2500 Gas Turbine



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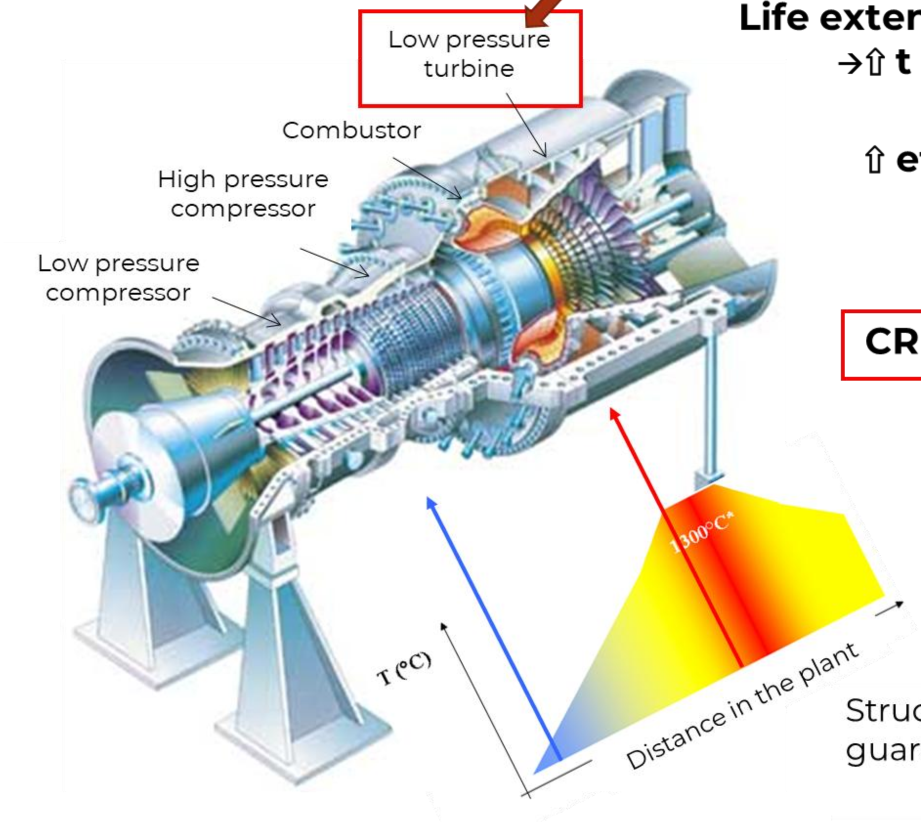
Gas Turbine

GT operating requirements

Hot gas path → TIT ~ 1300°C



Market Request

Life extension →⇧ t

⇧ efficiency →⇧ T → **CREEP**

⇧ cycling → **FATIGUE**

CREEP-FATIGUE

Hot gas path components withstand to:

- **High temperature**
- Multiaxial distribution of mechanical loads due to their **complex geometry** and **strong thermal gradients**

Structural materials for these components have to guarantee resistance to:

→ **Oxidation** **Creep** **Fatigue**

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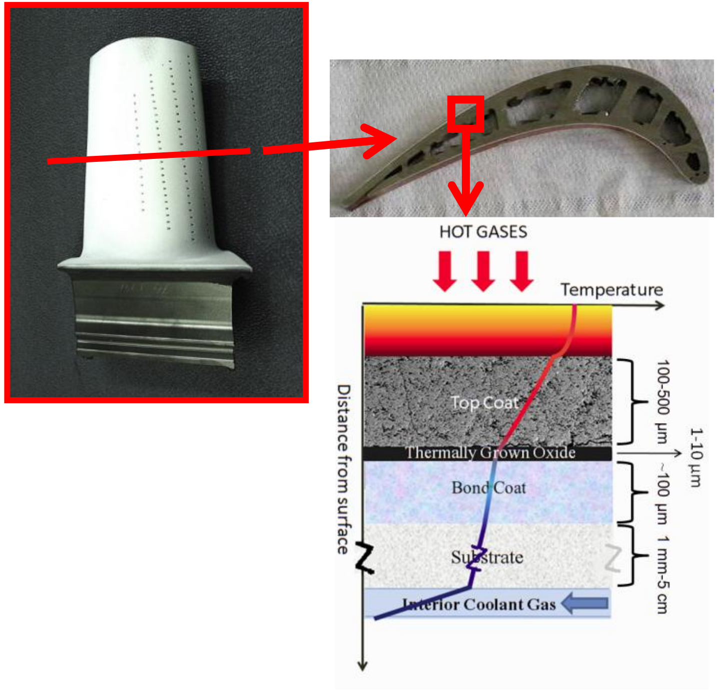
Gas Turbine

Blade and vane



High temperature material features

- Mechanical resistance at $T/T_m \geq 0.6$
- Creep resistance
- Low cycle fatigue and thermo-mechanical resistance
- Oxidation and corrosion resistance

Base materials → Superalloys

Co or Ni based

Coatings

Ceramic* and **Metallic**

*Ceramic coatings are important for temperature decrease from the external surface to the metallic coating and base material → Thermal Barrier Coating (TBC)

Blade and vane

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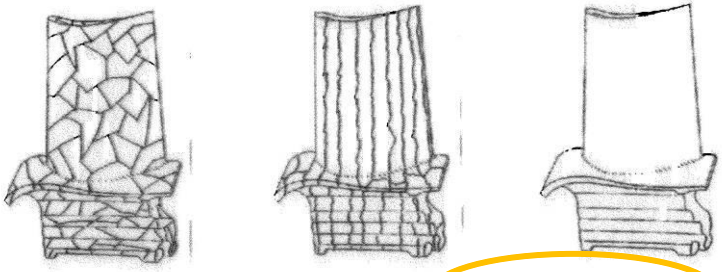
Superalloys

GT components materials evolution → **time**

Work-hardening → **Casting** → **Solidification**



Equiaxed **Directional** **Single crystal**

Chemistry

Strenghtening methods:

- Sostitutional hardening in the γ matrix
- Carbides precipitation at the grain boundary
- Coherent precipitation of intermetallic phase Ni_3Al, γ'

I generation → Re addition 3wt% → **II generation** → Re addition 6wt% → **III generation** → **IV generation** → Ru or Ir addition

BASE MATERIAL

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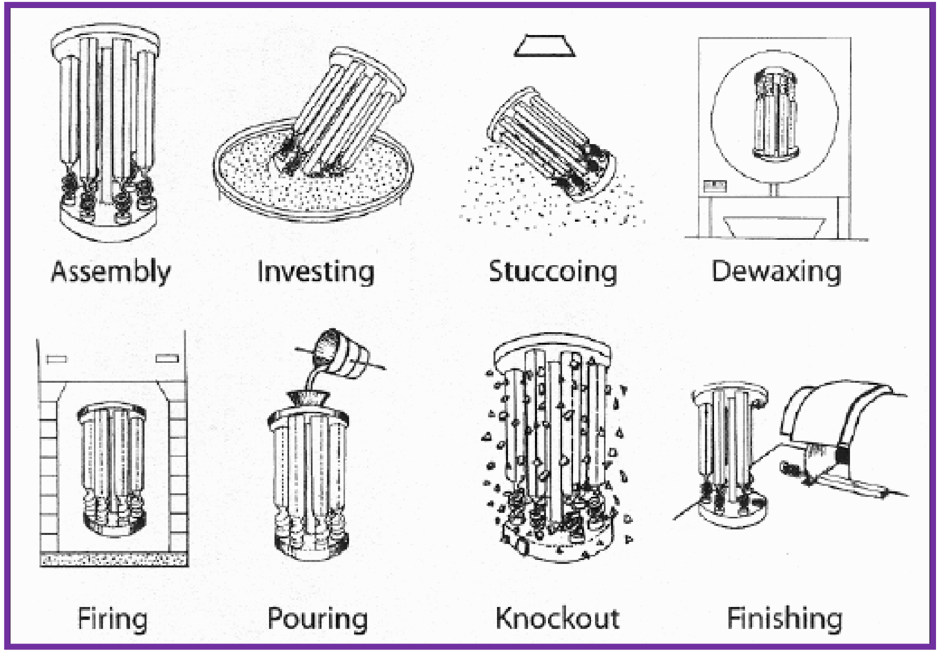
Blade and vane

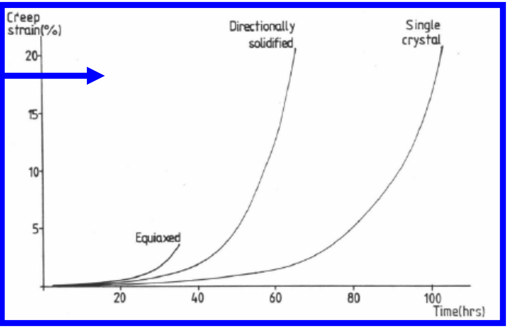
Component production → Solidification

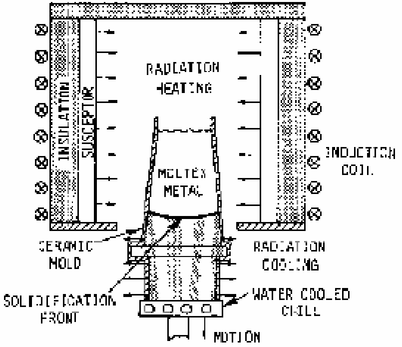
Investment casting → «lost-wax» casting



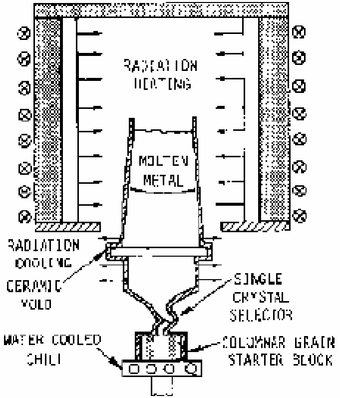
Policrystalline material

Solidification technique development to increse the component performance during service e.g. creep strenght





Directionally Solidified (DS)



Single Crystal (SX)

BASE MATERIAL

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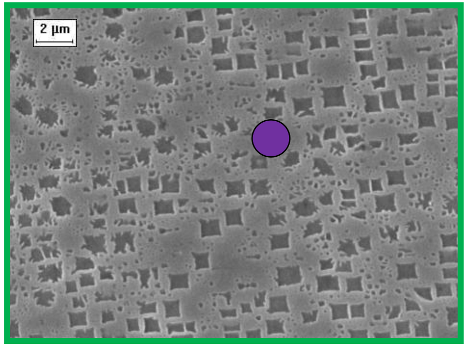
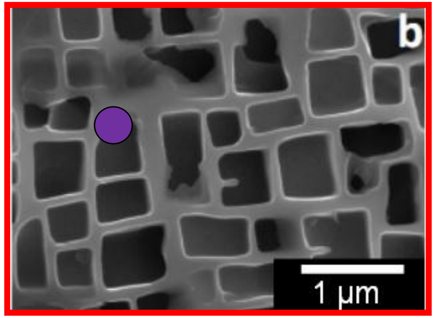
Blade and vane

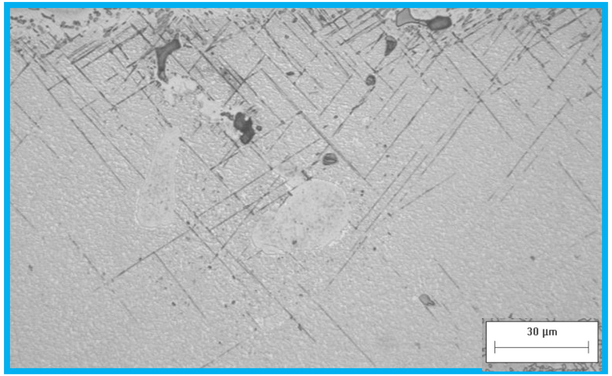
Microstructural features

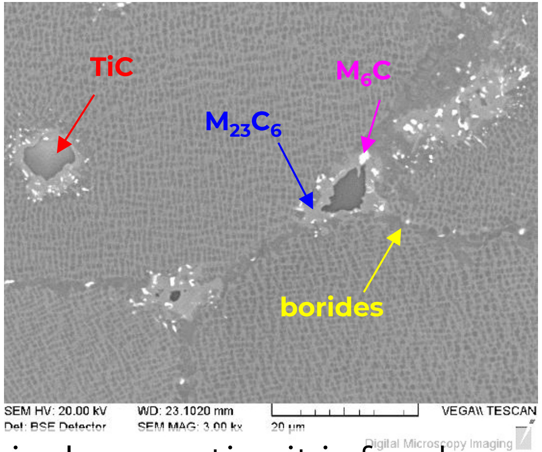


The microstructure in characterised by:

- Austenitic **γ matrix**
- γ' phase in **monomodal** or **bimodal** distribution
- Primary MC carbides and secondary carbides/borides (e.g. $M_{23}C_6$, M_6C, M_3B_2)
- **TCP phases** depending on alloy chemical composition







To obtain the desired mechanical properties it is fundamental to control and know the alloy microstructure, in particular in terms of **γ' phase**

METALLIC COATINGS

Blade and vane

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Surface protection → Deposition processes

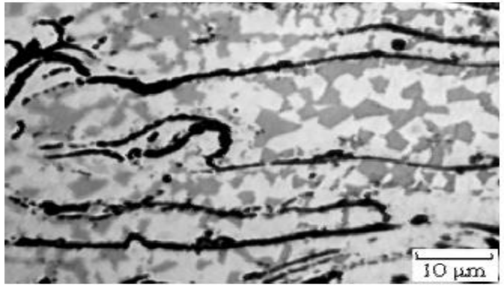
APS
(Air Plasma Spray)

Thermal spray processes

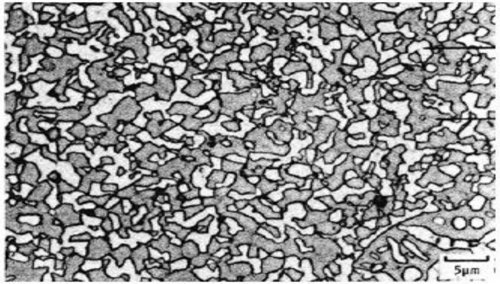
VPS
(Vacuum Plasma Spray)

HVOF
(High Velocity Oxygen Fuel)

APS



VPS



Blade and vane

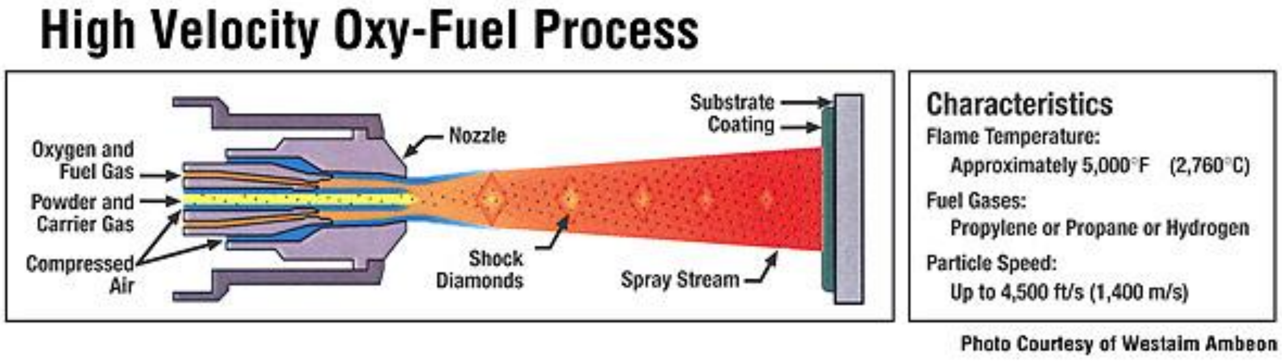
Surface protection → Deposition processes

<u>HVOF (High Velocity Oxygen Fuel)</u>

Respect to VPS/LPPS where the coating powders are molten completely, during HVOF the metal powders are softened and subjected to high kinetic energy.
The torch geometry allows to high pressured and hot gas (powder carrier) a supersonic velocity (much higher than plasma spray).

Gas (kerosene, acetylene, propylene and hydrogen) and oxygen are fed into the chambers.

The process is very fast (and loud)



METALLIC COATINGS

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Blade and vane

Surface protection → Deposition processes

CVD and pack cementation for alluminides or chrome aluminide

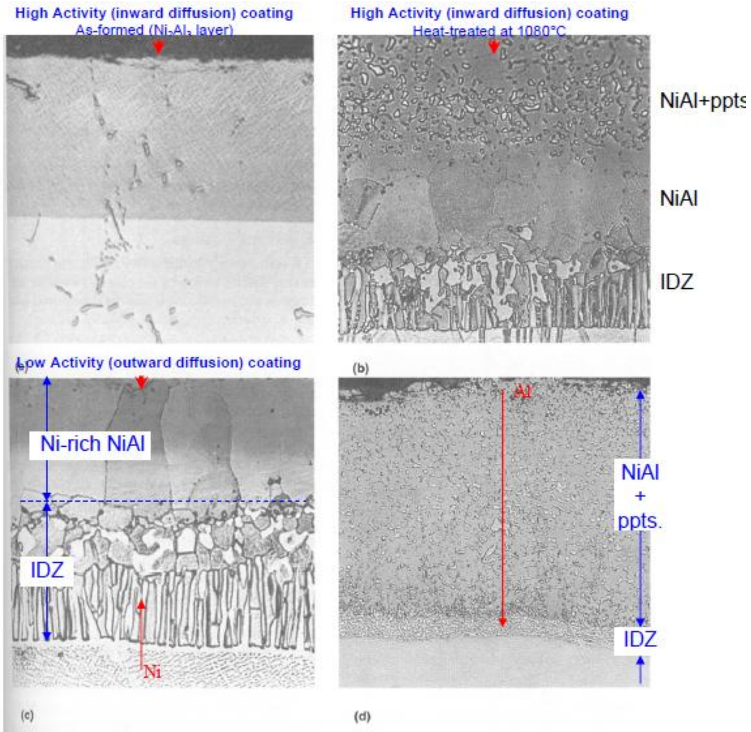


Fig. 3 Typical microstructures of aluminide coatings on a nickel-base superalloy. (a) Inward diffusion based on Ni_2Al_3 (and aluminum-rich NiAl). (b) Same as (a) but heat treated at 1080 °C (1975 °F). (c) Outward diffusion of nickel in nickel-rich NiAl. (d) Inward diffusion of aluminum in aluminum-rich NiAl

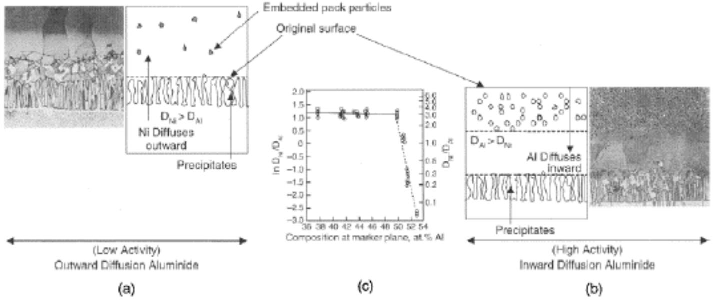
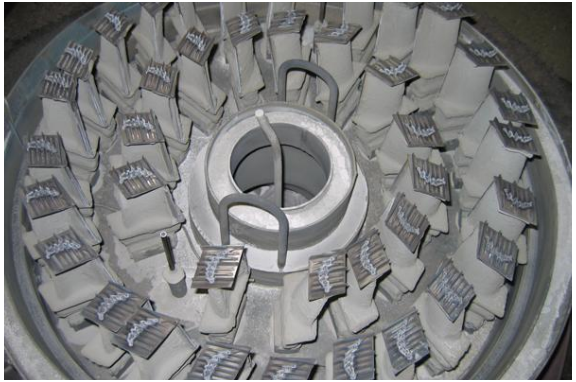


Figure 6.8 Microstructure of (a) low- and (b) high-activity aluminide coatings (G. W. Goward, Current research on the surface protection of superalloys for gas turbine engines, *JOM*, Oct. 1970, pp. 31–39). Reprinted with permission from The Minerals, Metals & Materials Society, (c) Dependence of Ni and Al diffusivities as a function of NiAl composition (S. Shanker and L. L. Seigle, Interdiffusion and intrinsic diffusion in the NiAl (β) phase of the Al–Ni system, *Metall. Trans.*, 1978, 9A, 1468–1476). Reprinted with permission from ASM International.



CERAMIC COATINGS

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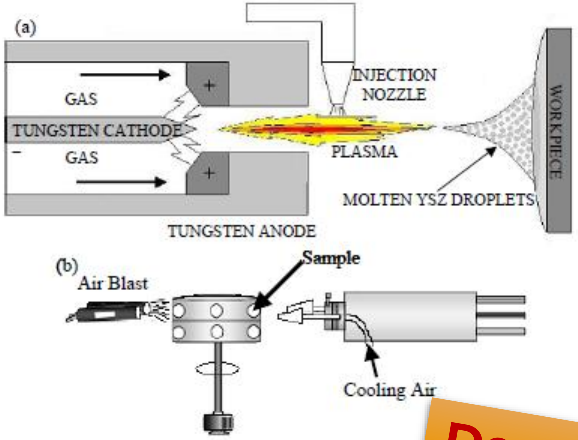
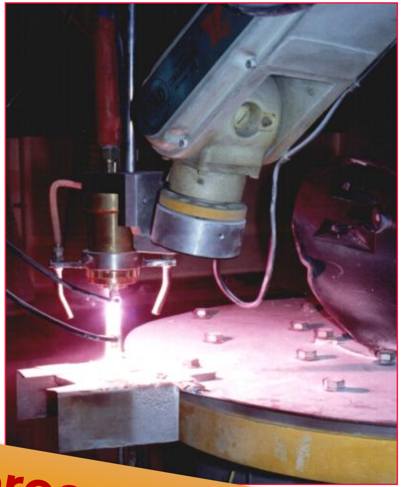
Blade and vane

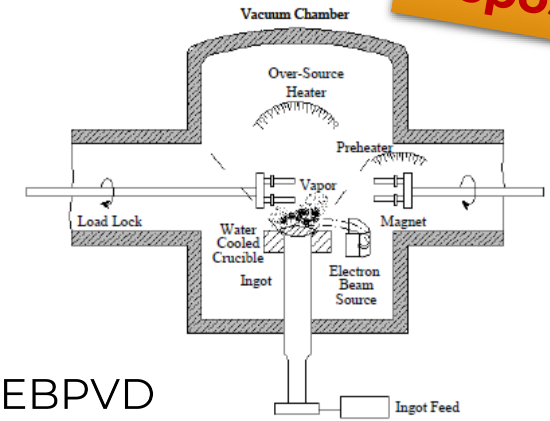
Surface T decrease → THERMAL BARRIER COATINGS TBC



APS

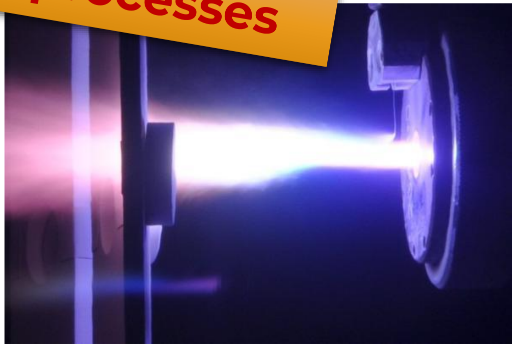


Deposition processes



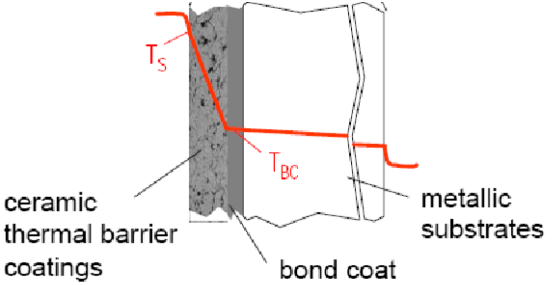
EBPVD

SPS

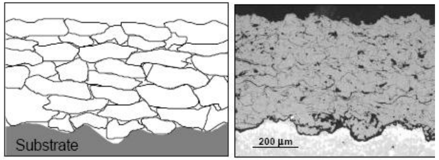


TBC effect is to decrease surface T

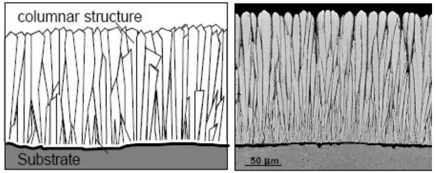
→ **Increase GT performance**



APS



EB-PVD



Blade and vane

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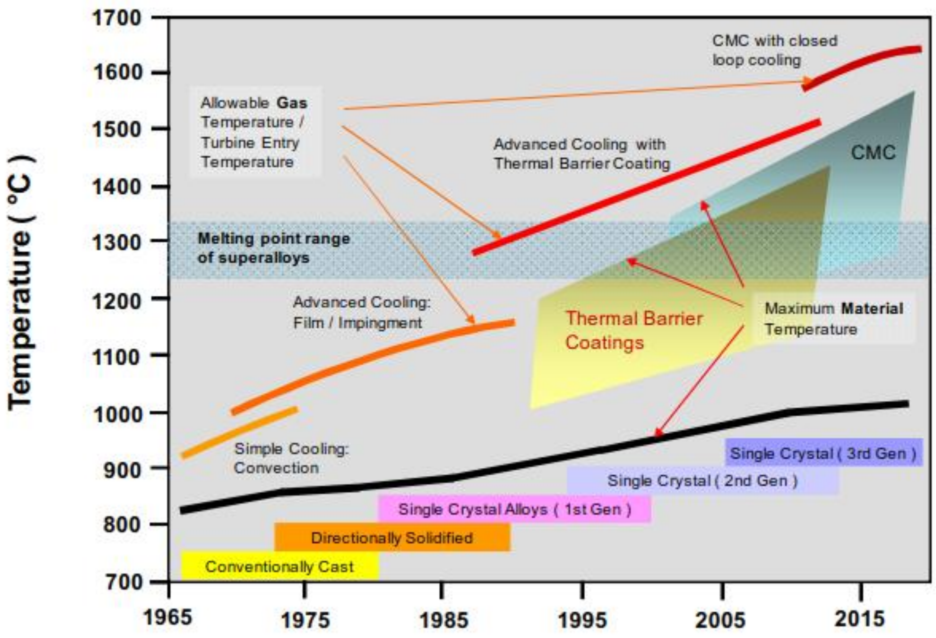
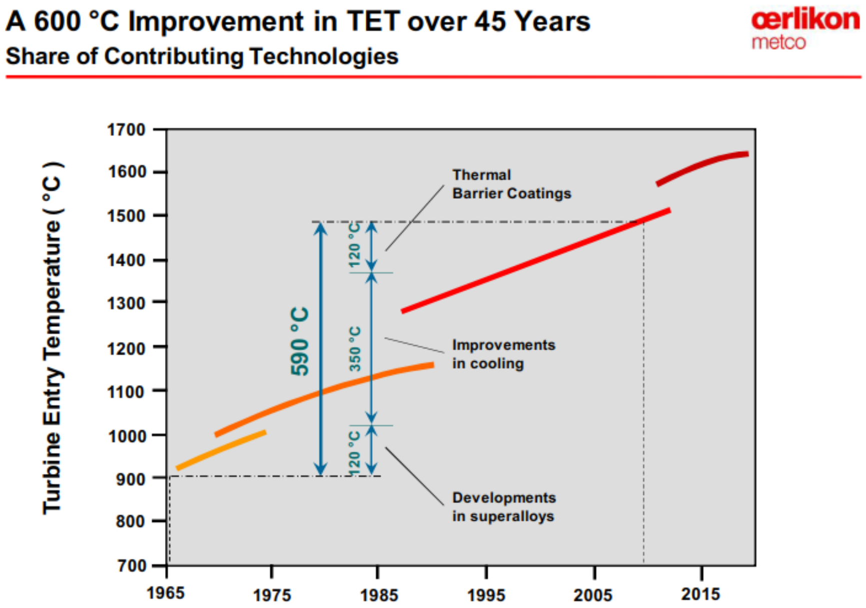
Surface T decrease → COOLING SYSTEMS





Reproduced from: B. Lakshminarayana, Fluid Dynamics and Heat Transfer of Turbomachinery; John Wiley & Sons, 1996

Cooling is a key point in gas turbine blades & vanes' lifetime and efficiency

Blade and vane

Surface T decrease → COOLING SYSTEMS

Drilling processes

- One of the greatest challenges in manufacturing of gas turbine blades and vanes
- Drilling needs to be reliable and able to produce accurate holes, with minimal damage of base material
- Several hundreds of cooling holes each part
- Cheap
- Different direction of holes, reach hard-to-access areas
- Complex diffuser shape
- Capability to drill through TBC
- High quality to
  - provide efficient cooling (low air consumption)
  - meet required lifetime

Blade and vane

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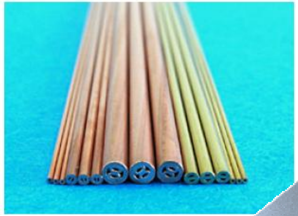
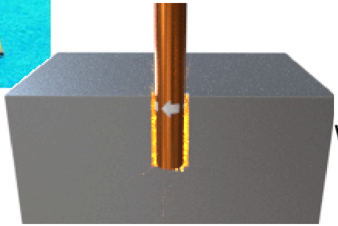
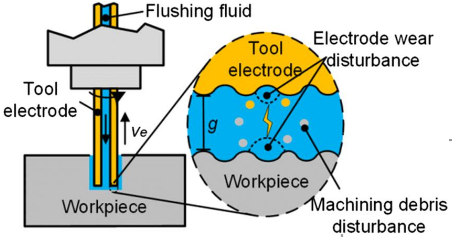
Drilling processes

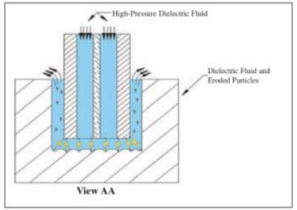
Surface T decrease → COOLING SYSTEMS

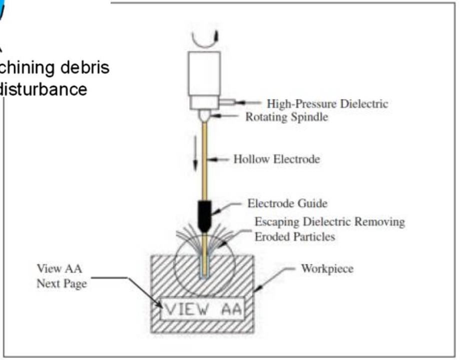
Fast Hole Drilling EDM



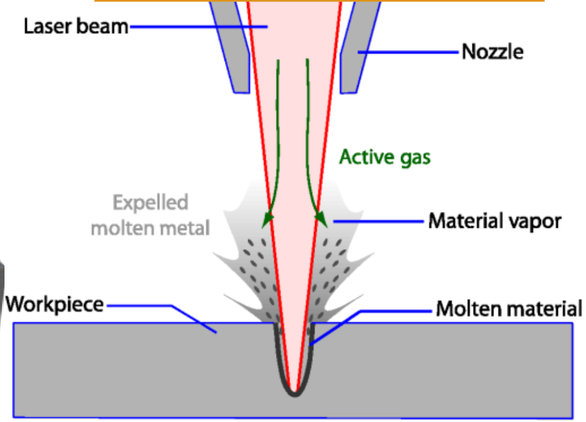








Laser drilling



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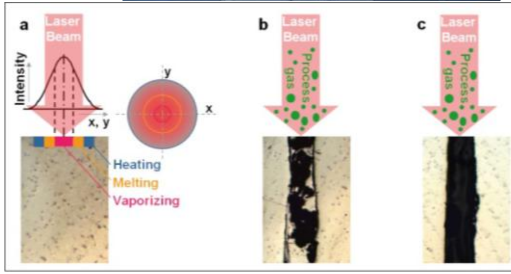
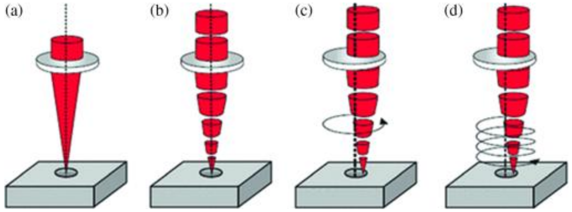
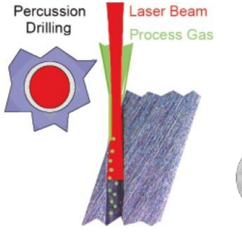


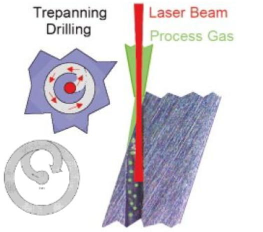
Schematic diagram of cylindrical laser drilling: (a) interaction laser/material, (b) hole with recast, (c) cleaning with laser pulses and process gas



single pulse drilling | percussion drilling | trepanning | helical drilling



Schematic diagram of percussion drilling



Schematic diagram of trepanning drilling

Gas Turbine

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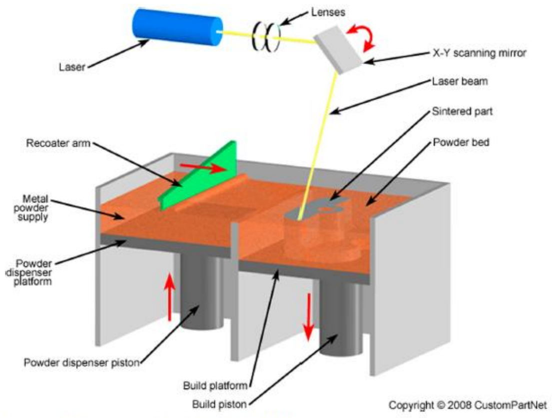
Complex geometries to achieve higher inlet T and high efficiency in cooling

Additive manufacturing techniques for Ni based superalloys

Selective Laser Melting (SLM)



2 SLM system schematic.[252] Image courtesy of CustomPartNet Inc.

Direct Energy Deposition (DED)

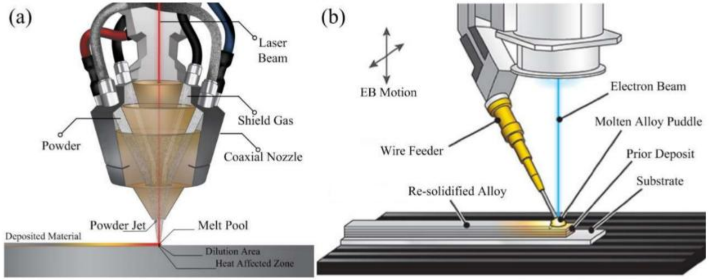
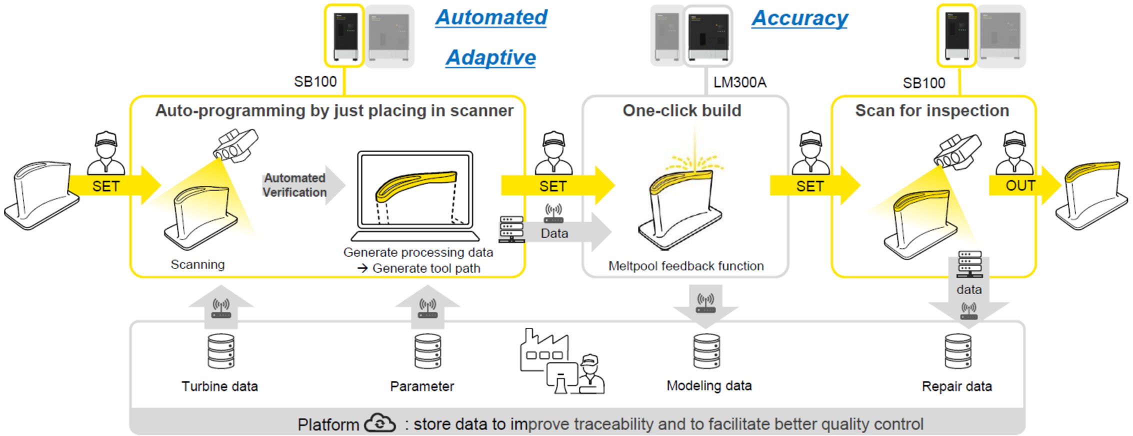


Figure 13. Schematic of directed energy deposition (DED): (**a**) Powder DED (laser source); (**b**) Wire DED (E-beam source) [111].



ACTUAL DEVELOPMENT AND PRODUCTION

Challenging

- New material development and characterization. Actually 3 SLM materials in AEN DB
- New design & post processing approach
- New service supplier network qualification

Benefits

- H_2 combustion optimization. Actual all AEN reach high capability in H_2 combustion. In 2024 H-class GT burner has been successfully tested with 100% hydrogen

Production

- Advanced burner component design in all GT of AEN portfolio

E-CLASS GT	E-CLASS GT	H-CLASS GT





SLM TECHNOLOGY FULLFILLED AEN GT PORTFOLIO

Gas Turbine

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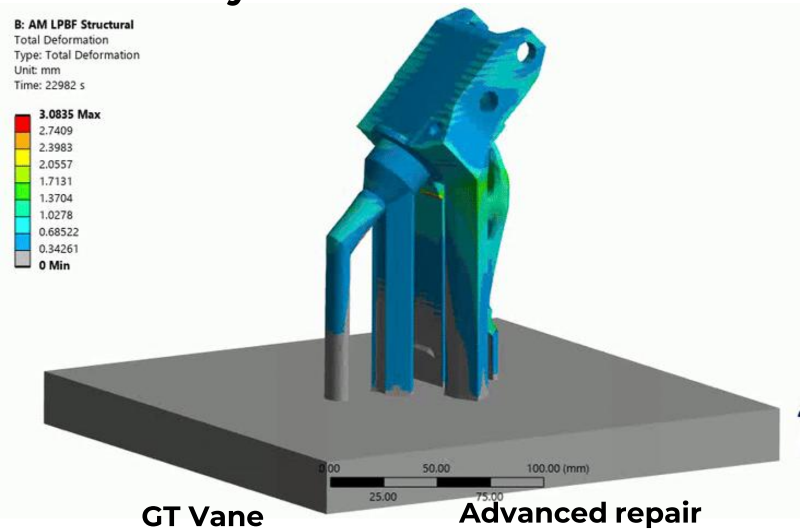
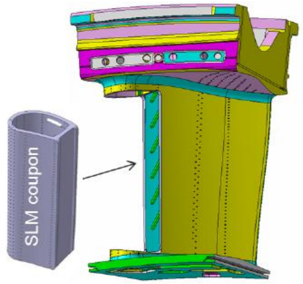
Complex geometry to achieve higher inlet T and high efficiency in cooling

Ansys: Part Deformation in mm



GT Vane

Advanced repair



RESEARCH

Optimization and simulation of the SLM-Build Process

- Part Deformation controll
- Residual Stress & SAC phenomenon mitigation in high γγ’ amount SLM alloy

Testing / Validation of the Simulation

- Special Build Jobs (with special geometries)
- X-Ray or Neutron Diffraction
- Hole-Drilling / Strain-Gage Method

Material of Interest

- High oxidation resistance and high T properties. In development SLM-IN738 – ABD1000 – SLM-H230

PROTOTYPE

Repair & design

- Complex cooling scheme
- New approach for very advanced repair – SLM COUPON PATCH

GT Component

- Turbine statoric component as spare

Conclusions

- Material development in GT field focused mainly their production strategy and component design in order to achieve desired performance rather than evolution of material composition and properties.
- The development comprises:
  - Solidification in order to achieve the best mechanical properties
  - Surface protection for high T oxidation
  - Surface T decrease
  - Complex cooling system
  - Complex geometry that cannot be accomplished by casting → AM techniques

- For the future new materials are under investigation, e.g. high entropy materials.

Grazie per l'attenzione!

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