aalberts
mission critical technologies

Hot isostatic pressing of additive manufactured parts

Viviane Kettermann Fernandes

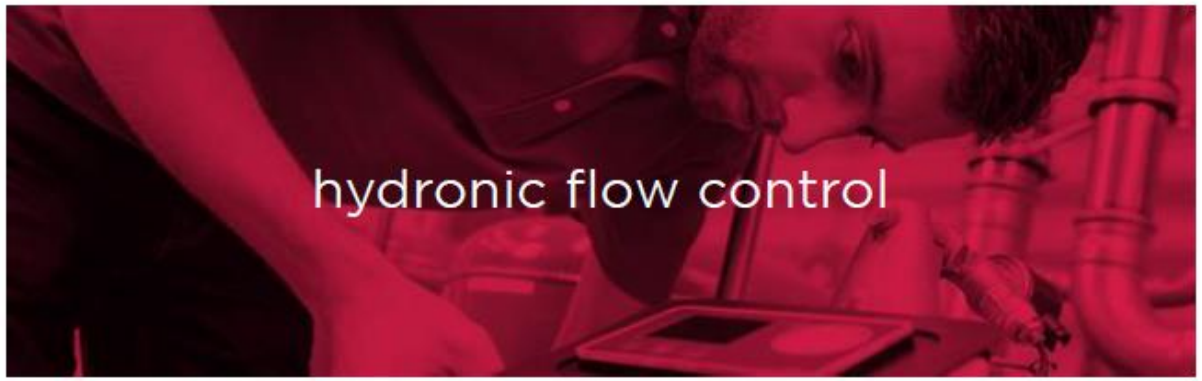
aalberts global footprint

our businesses

installation technology

material technology

climate technology



industrial technology

aalberts surface technologies

Our niche technologies & brands

aalberts heat treatment

HAUCK HEAT TREATMENT

aalberts surface treatment

AHC

IMPREGLON SURFACE TECHNOLOGY GROUP

aalberts specialised manufacturing

METALIS

MIFA

16 countries

more than 100 locations

6,200

colleagues

> 200 patents

that highlight innovations

>€ 51 million

investments per year

Our end markets

automotive

general industries

power generation, aerospace

Accredited Nadcap™

REGISTERED AS 9100

bsi. ISO 13485 Medical Devices Quality Management

QUALITY MANAGEMENT SYSTEM IATF 16949

ISO 14001:2004 Certified Environmental Management System

ISO 50001 ENERGY MANAGEMENT

Previous AHC Group

facts & figures

€ 143

million revenue

app. 1.250

colleagues

9 countries

19 locations

unique

own chemistry used

processes available

- Anodic Processes
  - HART-COAT® (hard anodic oxidation)
  - SELGA-COAT® (selective galvanic coatings)
  - TUFRAM® (aluminum oxide with polymer particles)
- Plasma Chemical Processes
  - KEPLA-COAT® (for aluminum and titanium)
  - MAGOXID-COAT® (for magnesium)
- Chemical Processes
  - DURNI-COAT® (electroless nickel)
  - NEDOX® (electroless nickel with polymers)
  - MAGPASS-COAT® (chromium-free passivation for magnesium)
- Galvanic Coating
  - DURALLOY® (optimization of friction occurrences)
  - SELGA-COAT® CHROME (selective hard chrome plating)
- Special Processes

Previous Impreglon Group

facts & figures

€ 160

million revenue

app. 1.654

colleagues

12 countries

26 locations

unique

technology portfolio

processes available

- Electroplating (Zi/Fe, Zi/Ni)
- Dip Spinning (Zinc Flake Coating)
- Cathodic Dip Painting (KTL)
- Polymer Coating (Anti Stick Coating)
- Thermal Spraying (Metal, Ceramic Coatings)
- Powder Coating (Corrosion Protection)
- Sherardizing (Cathodic Corrosion Protection)
- Patching, Screw Connections
- Nano Coating (transparent thin film corrosion protection)
- Wet Painting (Decorative and Functional)

heat treatment

facts & figures

€ 151

million revenue

app. 1.132

colleagues

7 countries

27 locations

unique

> 550 ovens available

processes available

- hardening
- case hardening
- carbonitriding
- salt-bath hardening
- vacuum hardening
- nitriding (gas & plasma)
- nitrocarburising (gas & plasma)
- brazing
- HIP (hot isostatic pressing)
- tempering
- freezing
- hard-soldering
- normal annealing
- solution annealing
- soft annealing
- stress-free annealing
- sintering

aalberts surface technologies

A wide portfolio of heat and surface treatments!

15

Heat treatments

58

Surface treatments

Already applied on additive manufactured parts:

- Hot Isostatic Pressing (HIP)
- Heat treatments
- Polymer Coating (Anti Stick Coating)
- Chemical processes
- Powder coating (Corrosion Protection)
- Wet Painting (Decorative and Funcional)
- Anodic Processes

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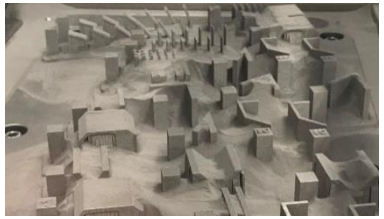
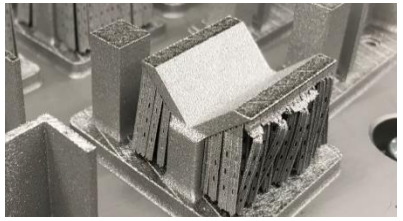
mission critical technologies

hot isostatic pressing

post processing chain

Cleaning → Heat treatment and HIP → Removal of support structures → Surface treatment → Finished part





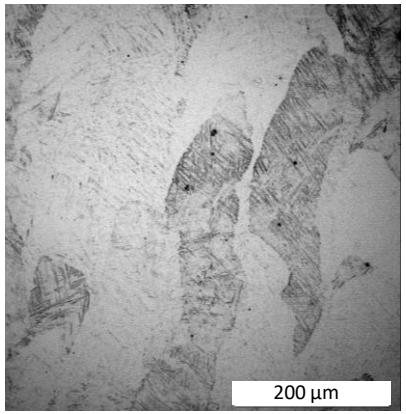

General remarks:

- there are almost no standards or guidelines for post-processing of AM components
- standards for subtractive and formative technologies have been used
- post-processing have to be thought in the design step of the components project

hot isostatic pressing in AM parts

- Under pressure gases, pores will diffuse to the surface and collapse. During the process, plastic flow, diffusion, and dislocation creep processes also occur in the material.

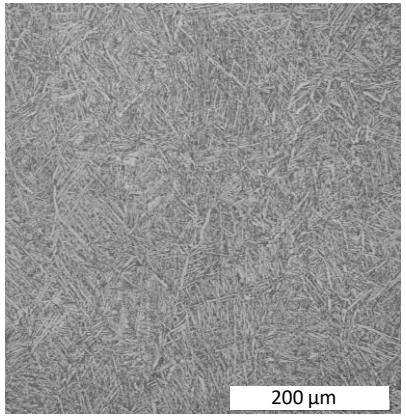
As Built (TiAl6V4)



- Density of 99,8%
- Fine lamellar microstructure
- Reproducibility issues

Hot Isostatic Pressing (HIP)

HIPed



- Density of 99,99%
- Improvement of ductility and fatigue life
- Homogenization of the microstructure

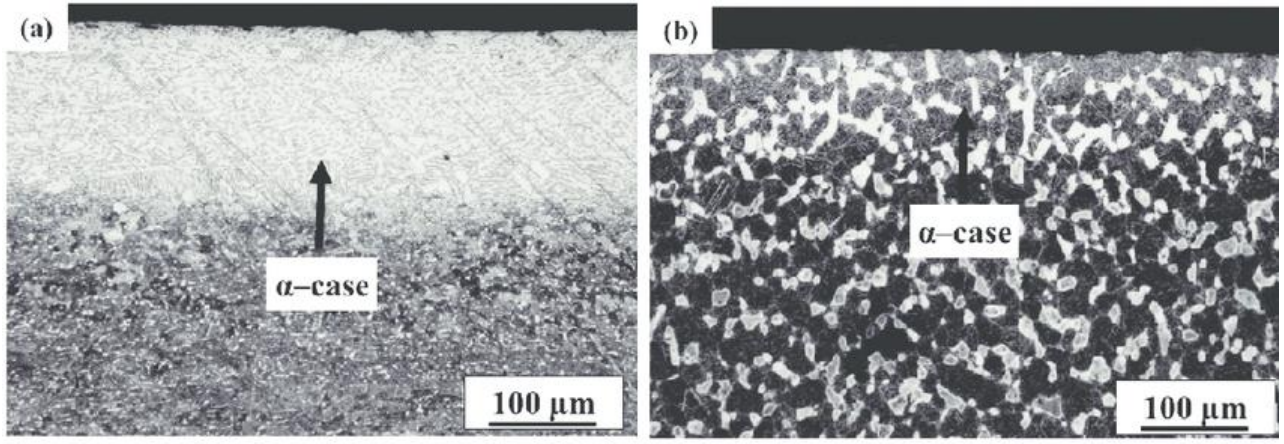
hot isostatic pressing

- **Alpha case:** continuous, hard and brittle oxid layer.

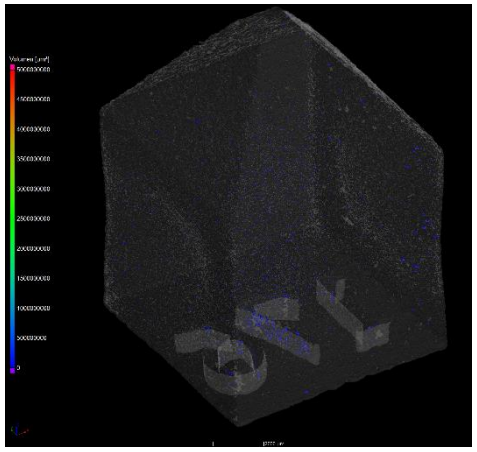
  Created due to the contact of titanium with oxygen in high temperatures.

  Reduces mechanical properties of Ti alloys.

- **Distortion:**
  - residual stresses
  - temperature gradients
  - densification
  - shape and size of the component



[Sefer, 2014]

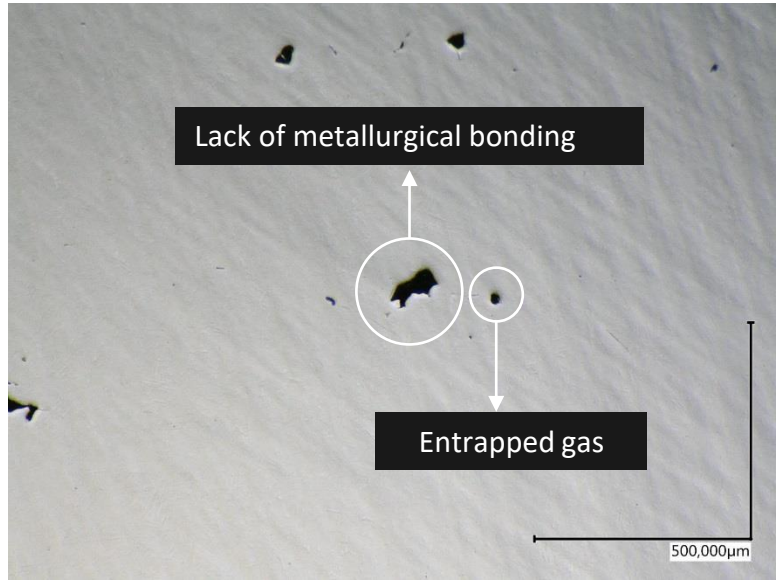


Initial density: 84%

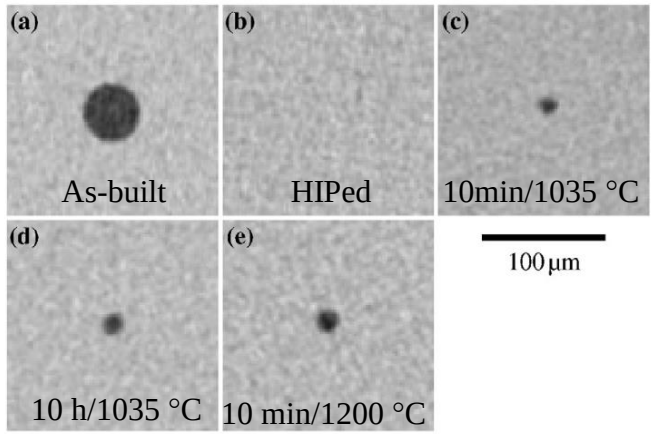
Both can be avoided!

hot isostatic pressing

- **Porosity during AM process are created by:**
  - » lack of metallurgical bonding between layers
  - » entrapped gas in the fabrication of the powder
  - » entrapped gas during the formation of the melt pool



- **Regrowth of porosity**

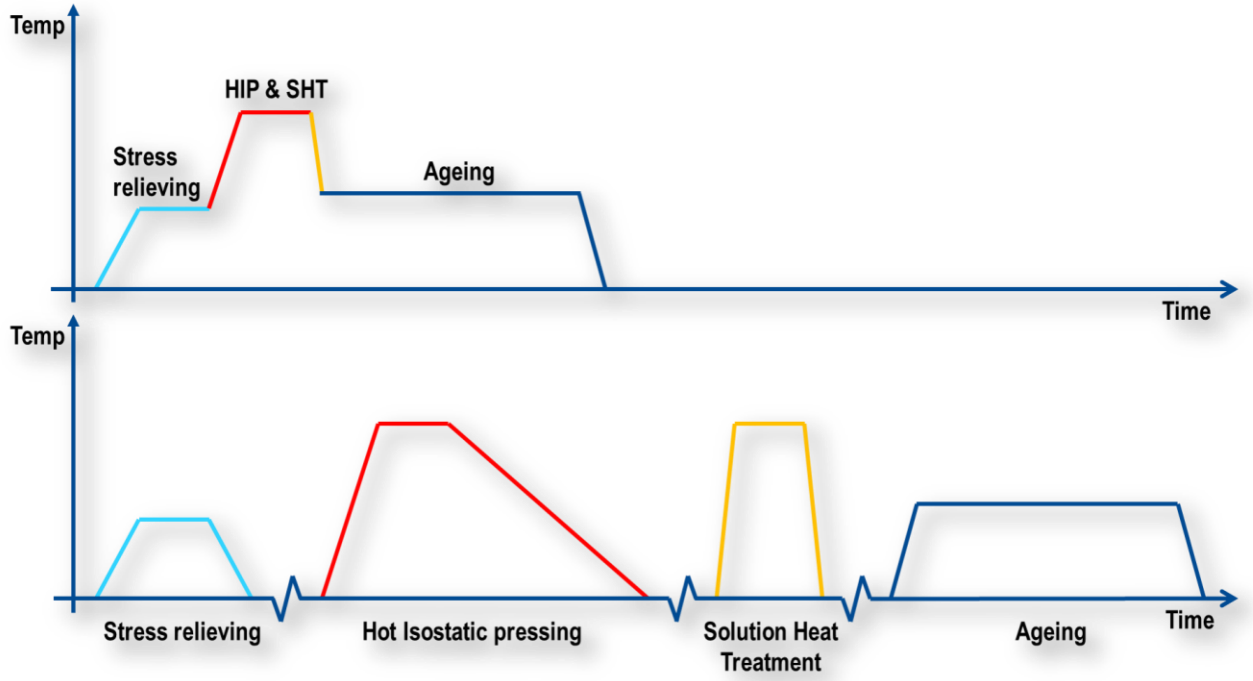


[Tammas-Williams, 2016]

- Regrowth above the ß-anneal heat treatment
- The diffusion of argon out of the material did not occur
- HIPing + heat treatment in the same cycle can be a solution

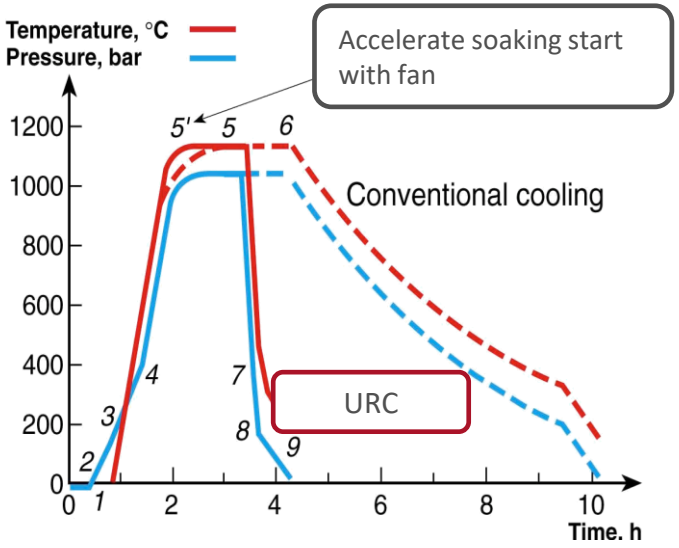
Integrating heat treaments together with HIP

- High Pressure Heat Treatment (HPHT) gives:
  - reduced number of process steps
  - reduced total cycle time, down time & lead time
  - improved process and quality control
  - less time at elevated temperature
- savings in:
  - lead time
  - reduction in working capital
  - energy consumption
  - material performance

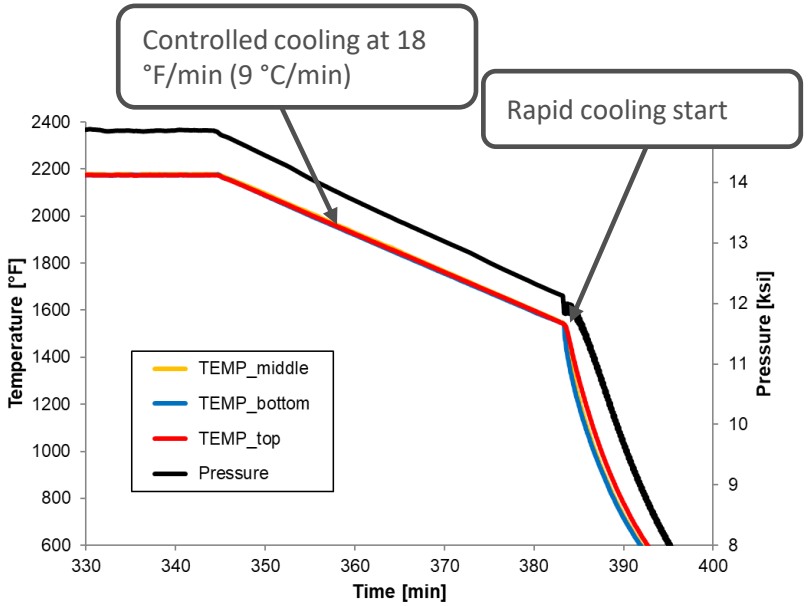


HIP system flexibility

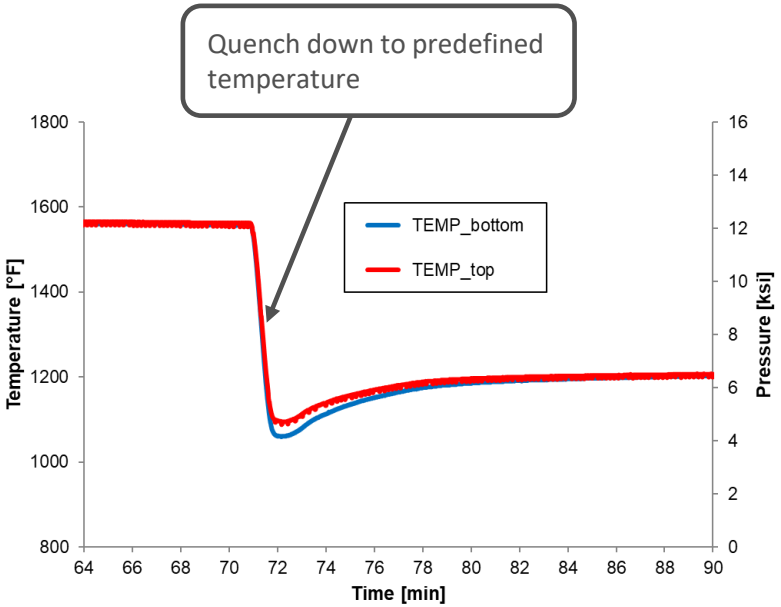
reduction in cycle time with fan/URC®



mix between controlled cooling and rapid cooling



stop cooling/quenching at a predefined temperature



HIP at Aalberts US

- equipment: 2, Quintus QIH122 M URC® units
  - hot zone size:
    - diameter 660 mm (24.5”)
    - height 1750 mm (69”)
  - max. pressure: 207 MPa (30 000 psi)
  - max. temperature: 1250 °C (2282 °F)
  - max pay load weight: ~ 2600 kg (5730 lbs)
  - temp. uniformity: ± 7 °C (12.6 °F) (guaranteed)
    ± 3 °C (5.4 °F) (typical)
    - high pressure argon (high conductivity), natural and/or forced convection, and multiple heating zone
  - integrated gas chromatograph to analyze and track gas purity
  - Nadcap certified for HIP
  - uniform rapid cooling (URC®) with fan beyond 200°C/min (390°F/min) in the gas
    - Max. cooling rate will depend on total load weight, material, temperature interval

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thank you!