HOT ISOSTATIC PRESSING (HIP)

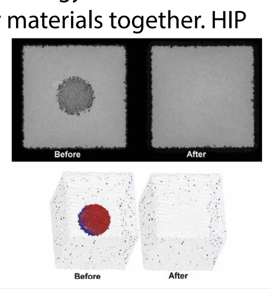
Author: Benjamin Ruttert

aalberts surface technologies

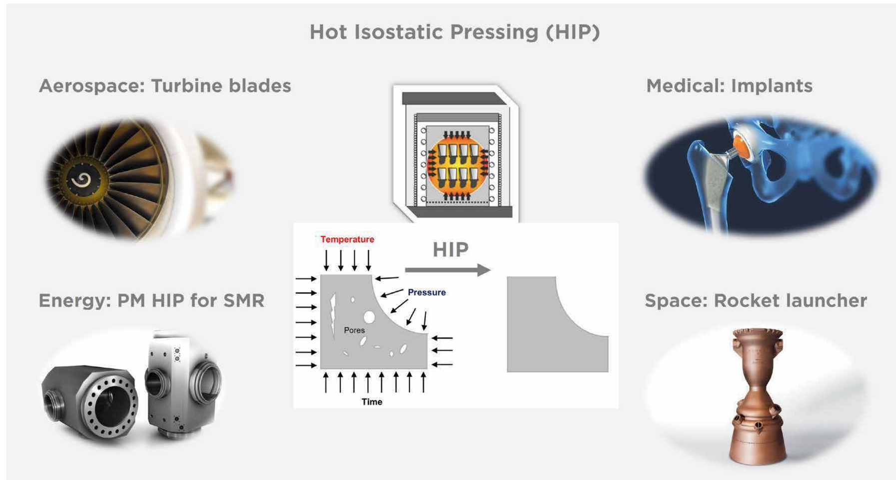
Principle

HIP involves the simultaneous application of a high-pressure inert gas (up to 207 MPa) and an elevated temperature (up to 1400°C) in a specially constructed vessel.

The pressure applied is isostatic because it is developed with a gas. Under these conditions of heat and pressure, internal pores or defects collapse and weld up. HIP can be applied to castings and additively manufactured parts, to consolidate powder metallurgy materials into fully dense components and to bond dissimilar materials together. HIP gives improved mechanical properties and a reduction in the scatter band of properties.



X-ray tomography reveals pore closure. The same cube with an artificially designed spherical cavity imaged before and after HIP, showing how metal powder is consolidated and no pores remain after HIP in the centre of the cube. Source: A. du Plessis et al. Addit. Manuf. Vol. 34, 2020.



Advantages

HIP allows developers to optimize component design and manufacture, whilst simultaneously improving microstructural homogeneity and material properties.

Improved properties: The HIP process gives improved mechanical properties, a general reduction in scatter of these properties, as well as the possibility to polish also cast, welded or powder metal parts, to the highest surface finish offering more predictive properties.

Steering the HIP cycle: The controllability of the HIP system is versatile. Set-up specific heating, densification and cooling regimes to ensure repeatable performance. This enables the design of desired microstructures whilst ensuring densification of products. Heat treatment (stress relief, solution annealing) and HIP can be done in one tailored HIP process step.

Clean HIP operations: High purity Argon as process gas together with special equipment programming and hardware allows to achieve clean processing results reducing discoloration.

Efficient production: HIP not only improves products through densification, but also leads to reduced quality costs. High speed production of components (e.g. fast printing in AM) in combination with defect removal and heat-treatment using HIP, can reduce energy significantly whilst reducing overall cost.

Disadvantages

- High initial investment costs for the HIP equipment.
- Slow (natural) cooling rates in older HIP equipment resulting in longer cycle times.
- Low production quantities: Smaller production runs of less than around 10,000 per annum.
- Loading and unloading a HIP cycle can be time consuming.

Examples

Additively manufactured turbine parts for HIP treatment.

Production boundaries and limits

- HIP is still a niche process for many people, so less is known about its potential.
- Larger production equipment has limited heating and cooling rates.
- Pre-preparation of parts can be complex: Canning / Encapsulation of metallic powders.

Cost

- HIP is an expensive investment.
- HIP cycle costs are higher than in a conventional vacuum furnace.

Modern Quintus HIP units at Aalberts Surface Technologies

www.KSCConference.nl