# Hot Isostatic Pressing of Near Net Shaped Parts

a service offered by the Hempel Special Metals Group

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# Introduction

- What is hot isostatic pressing of near net shaped parts?
- Which are the technologies needed?
- What are the alternatives?
- Which are the comparative advantages?
- For which alloys and geometries is HIP an option?

# What is hot isostatic pressing of near net shaped parts?

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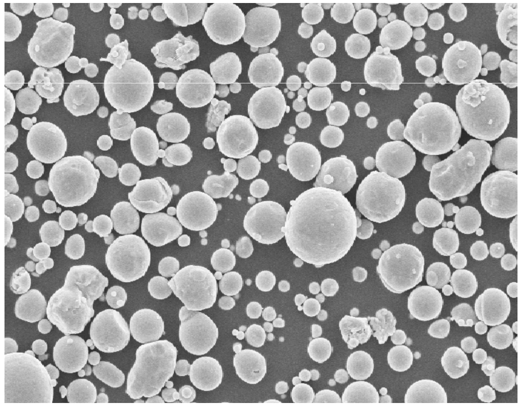
It is a modern manufacturing method for shaped parts with a weight in the range between 10 kg and 15 tons. The method bases on powder metallurgy and combines some of the advantages of casting technology with those of forging technology.

# Which are the technologies needed?

manufacturing
of alloy powder by
**gas atomisation**



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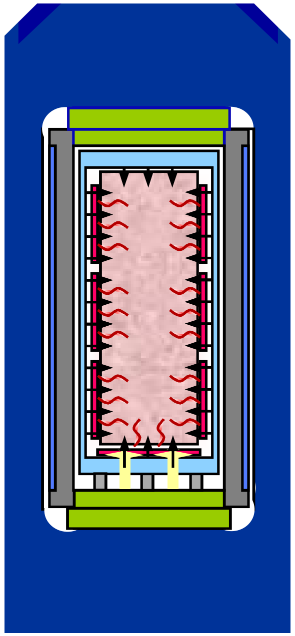
powder consolidation by
**hot isostatic pressing**



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**near net shaped product**

# What are the alternatives?

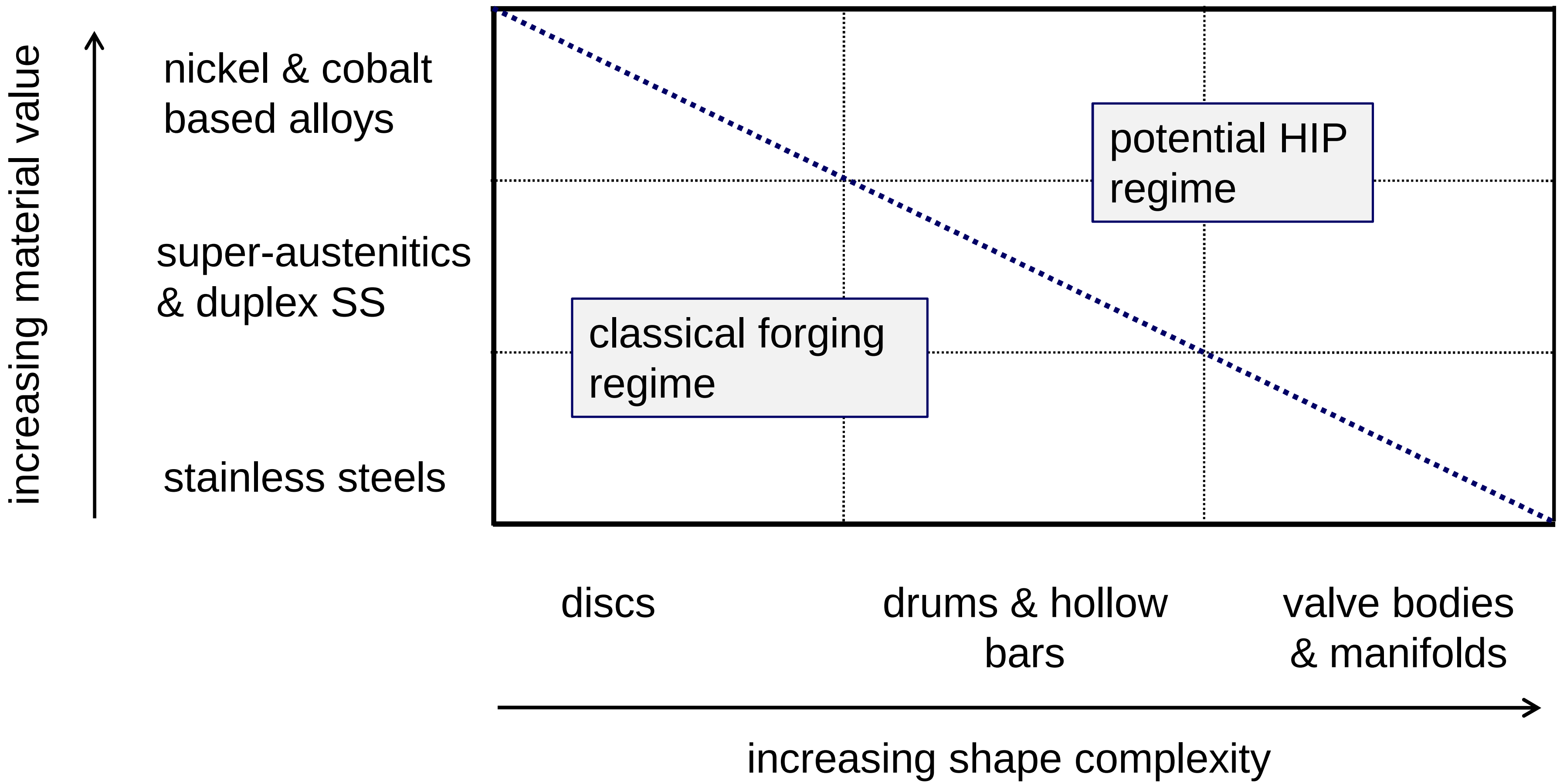
| raw material | master-alloys | metal powder | billets | plates bars |
|---|---|---|---|---|
| MANUFACTURING METHOD | CASTING | COMPACTION (SINTERING) | FORGING | MACHINING / JOINING |

# Which are the comparative advantages?

| | casting | HIP | forging / machining |
|---|---|---|---|
| metallurgical quality | bad | good | good |
| material losses | low | low | low / high* |
| processing effort | low | low | low / high** |

* for complex shaped parts (i.e. valve bodies…)
** for complex shaped and / or big parts

# For which alloys and geometries is HIP an option?




- HIP is favoured where material costs & metallurgical requirements are high and/or where the total processing effort is high

# Description of Method

- How does hot isostatic pressing work?
- How is a HIP - part produced?
- How is the container manufactured?
- How does a HIP - furnace function?
- How does a HIP'd part look like and how is it finished?

# How does hot isostatic pressing work?

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HIP is a method for the densification of metallic or ceramic material by application of a high isotropic pressure at temperatures below the melting point of the material

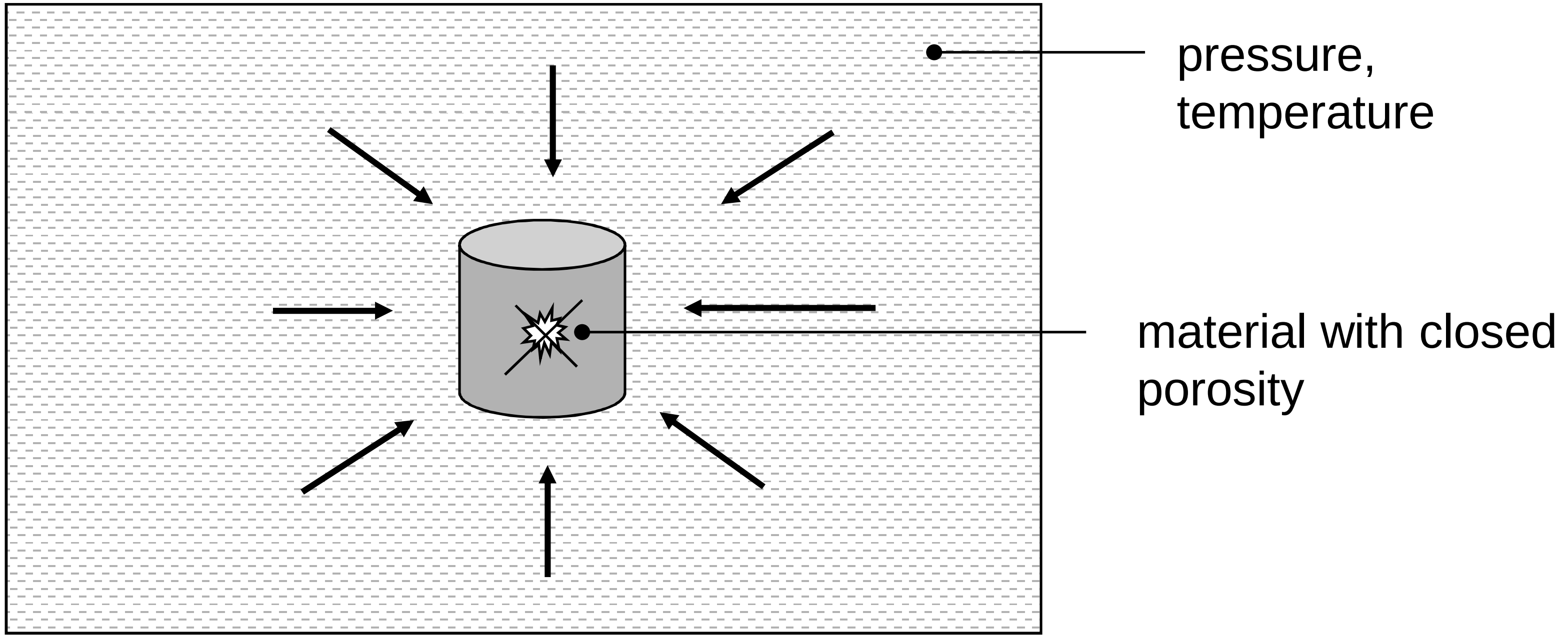
HIP can be used for

(1) elimination of closed porosities in castings or sintered parts

(2) consolidation of a metal powder within a closed and evacuated metal container

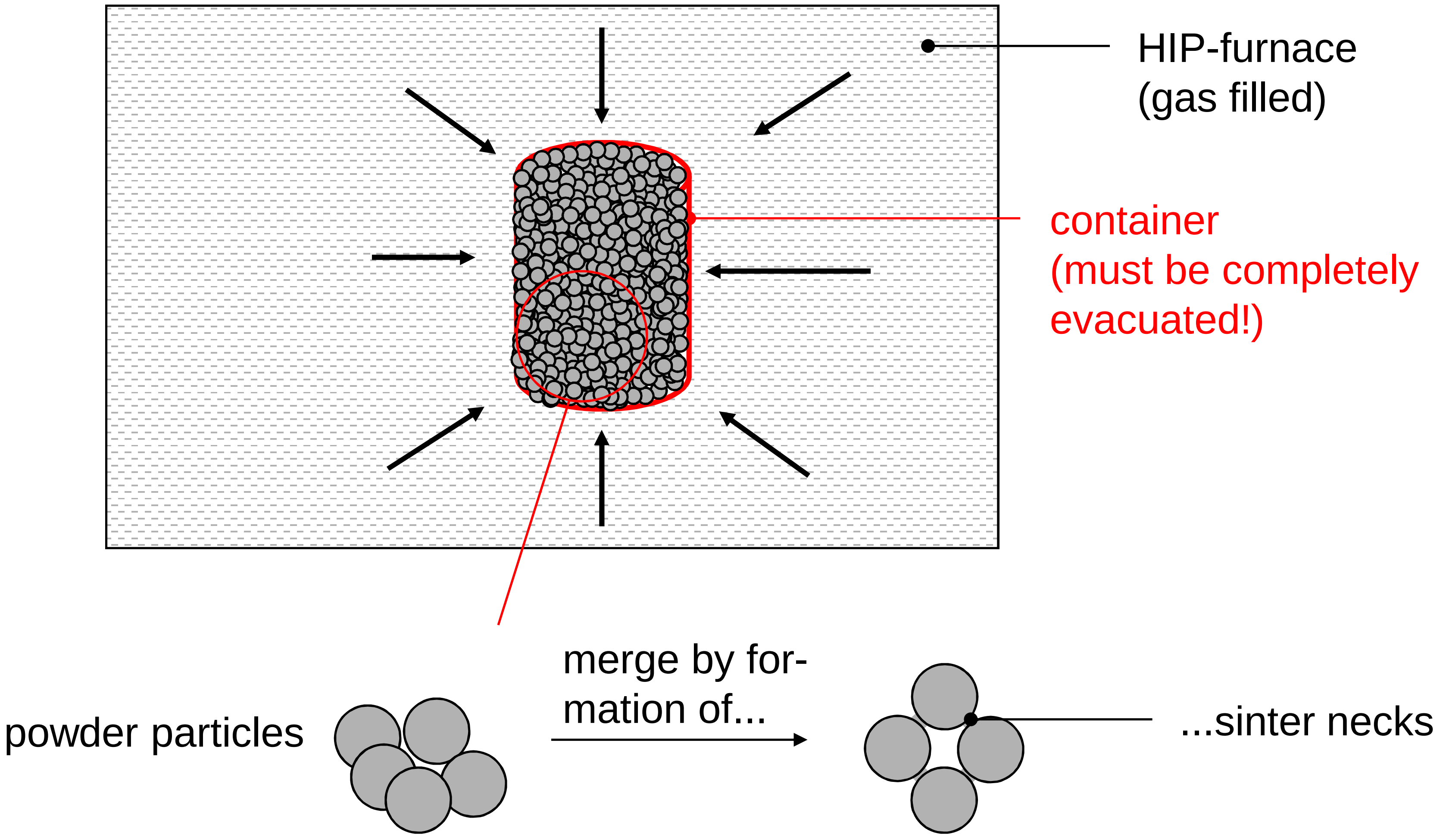
# How does hot isostatic pressing work?

1) densification of materials containing closed porosities



# How does hot isostatic pressing work?

2) consolidation of metal powders



# How is a HIP - part produced (next slide)?

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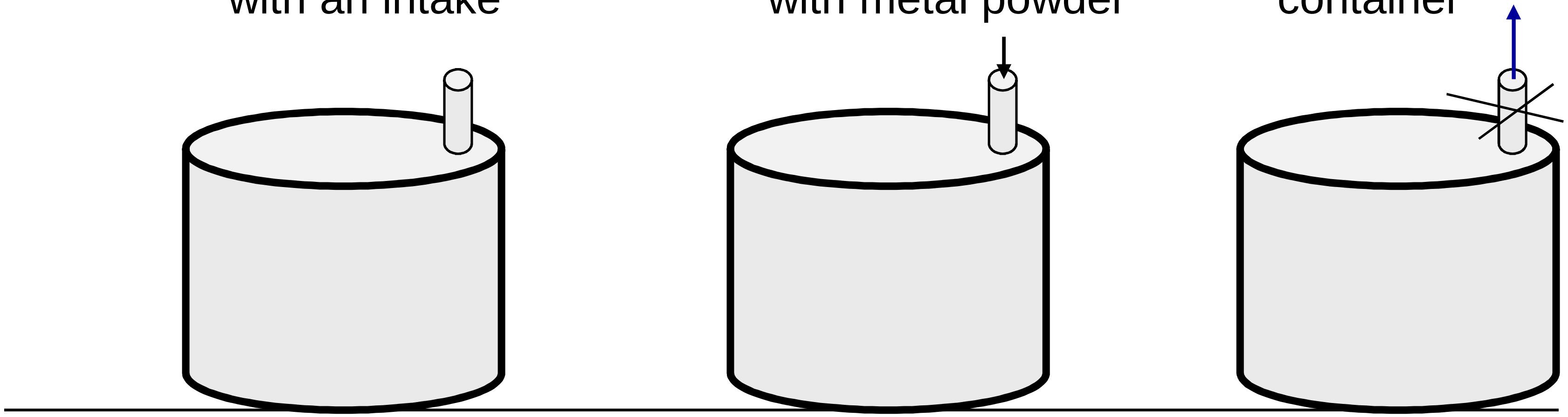
(1) a container with the shape of the desired product is designed and produced
(2) the container is filled with a powder of the desired alloy
(3) filled container is evacuated
(4) the container is put into a hot isostatic press
(5) the alloy powder is consolidated at elevated temperatures with the help of a big pressure by a sintering mechanism
(6) pressed canister is cooled down
(7) container material on the surface is removed by machining

# processing sequence

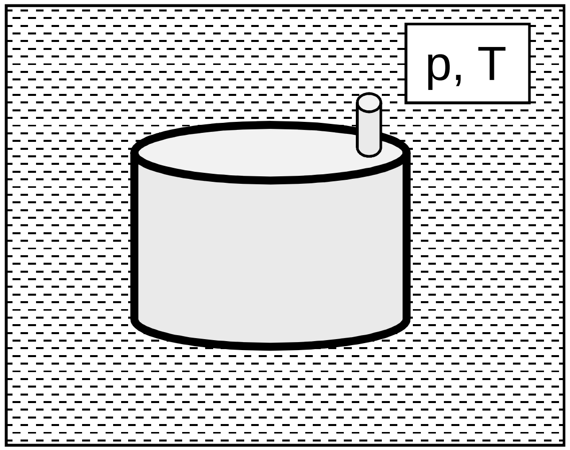
1) weld a container with an intake

2) fill container with metal powder

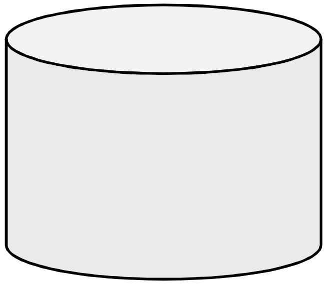
3) evacuate and close container



4) press container in a HIP




5) remove container material by machining



# How is the container produced?

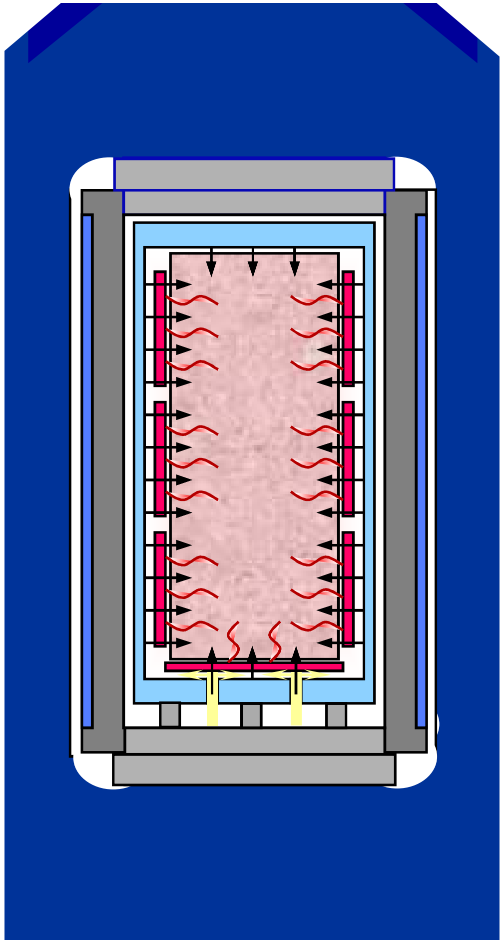
- container is manufactured by welding of steel sheets, tubes and pipes

- weld design and integrity is critical

- weld seam can be examined with respect to leakages using He detectors

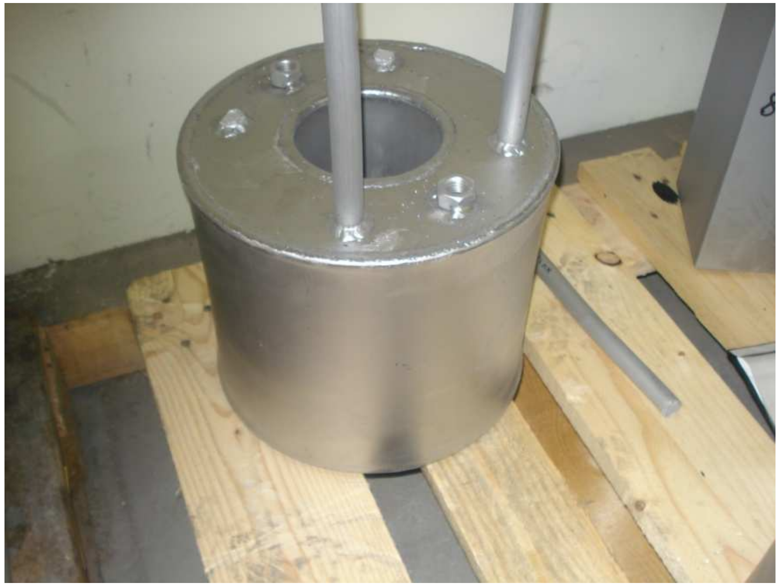
# How does a HIP - furnace function?

- HIP is filled with an inert gas (Ar) at room temperature
- closed HIP is heated up and gas expands
- at high temperatures the powder within the canister consolidates by a sintering mechanism with the help of argon pressure all-round



# How does a HIP'd part look like and how is it finished?

- as-hipped part with canister & with fill tubes
- machined & annealed drum



Canister material is perfectly bound to the base material by diffusion bonding. It can be removed by machining (simple shape) or by acid leaching (complex shape).

# Supply Chain Aspects and Quality Management

- How does the overall value chain looks like?
- Which are the main quality drivers within the value chain?
- How is the part certified?

# How does the overall value chain looks like?

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## P/M route

1. alloy melting and atomisation
2. design and fabrication of a container
3. HIP and heat treatment of part
4. container removal & finishing to tolerance
5. validation & certification of product

P/M - HIP can also be used for manufacturing of forging billets

## forging route

1. alloy melting and casting
2. forging a billet
3. forging and heat treatment of part
4. finishing to tolerance
5. validation & certification of product

# What are the main quality drivers in the value chain?

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| alloy melting and atomisation | design and fabrication of container | HIP and heat treatment of part | finishing to tolerance | validation & certification of product |
|---|---|---|---|---|
| **control measures** | | | | |
| chemical composition | weld compactness | shrinkage | dimensions | yield-strength |
| oxygen content | (leakage testing) | density | tolerances | tensile-strength |
| inclusion content | | porosities | | elongation |
| | | grain size | | impact energy |
| | | homogeneity | | |

# How is the material certified?

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- for any part a certificate according to EN 10 204 3.1 can be issued
- this certificate gives information about alloy composition, (annealing) condition & mechanical properties
- further information like grain size, purity content and ultrasonic examination results can be added on demand
- for applications with special requirements, as for example pressure vessel applications, the parts can be released by means of a expert's (TüV) report

# Applications

- Where is HIP already being used for critical applications?
- Which questions have to be raised when considering HIP?

# Where is HIP already being used for critical applications?

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- **off-shore industry**
  - shaped parts made of nickel based alloys and duplex stainless steels
- **aero industry**
  - gas turbine discs made of high temperature nickel based alloys
- **medical industry**
  - billets for forged and hot-rolled bars made of a cobalt based alloy are currently being produced by powder metallurgy; these bars are used for the manufacturing of implants by forging or machining

# Which questions have to be asked when considering HIP?

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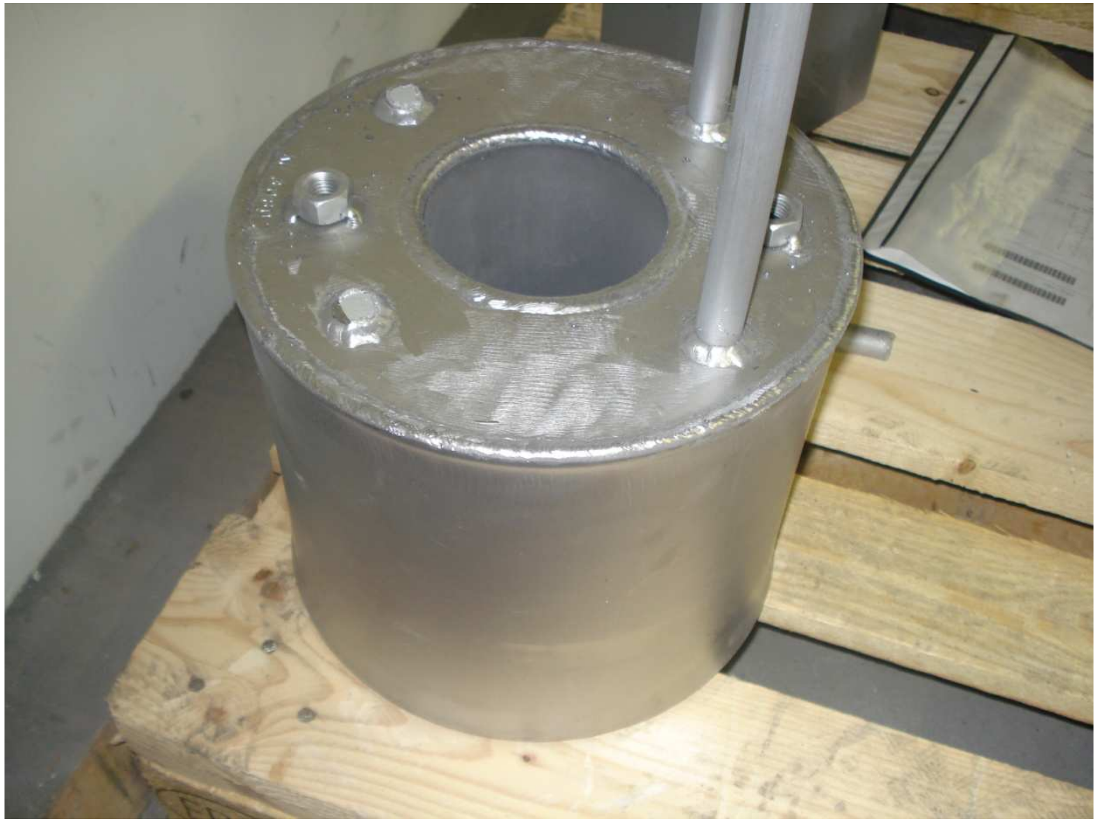
- are there economic gains by using powder metallurgy (P/M) and hot isostatic pressing (HIP) instead of forging: **costs, quality, raw material availability, through put time...**

- can we select alloys that are difficult or even impossible to forge or cast: **fine grained complex alloys / structures, alloys with enhanced precipitation hardenability, oxide dispersion strengthened alloys...**

- are there possible quality gains provided by HIP alone: **densification of casting porosities, densification of MIM - parts, densification of sintered ceramics...**

- are there new opportunities for the design of high temperature components: **bimetallic compounds,  internal cooling systems....**

# near net shape manufacturing of valuable alloys



manufacturing of a HIP'd drum from a nickel alloy to **save material and machining costs**

# use of powder metallurgy for customisation of alloys

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manufacturing of a HIP’d disc for an impeller made of a **customer specific nickel based alloy**, which is not available on the raw material market

# improved material performance realised by PM & HIP

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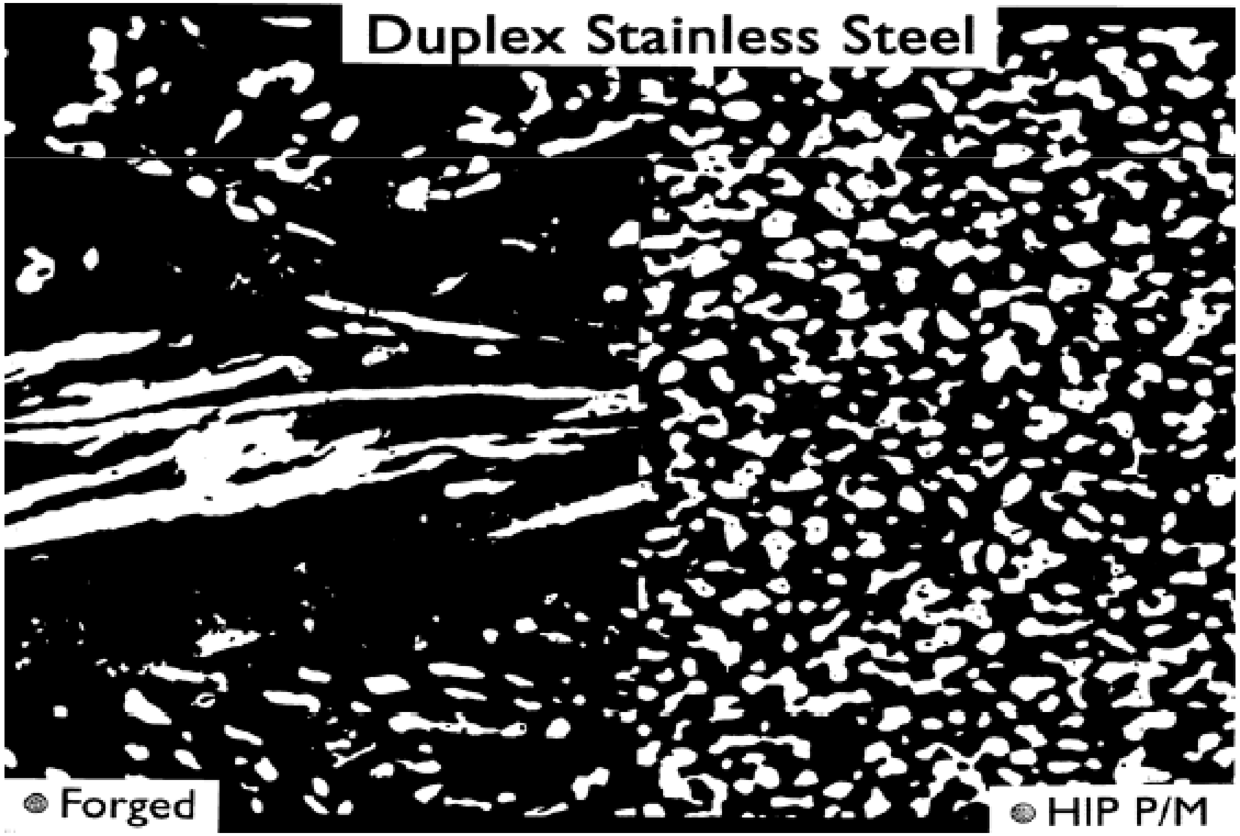
HIP enables to adjust fine, isotropic microstructures in duplex stainless steels, which is fundamental to attain **high strength - high toughness combinations**



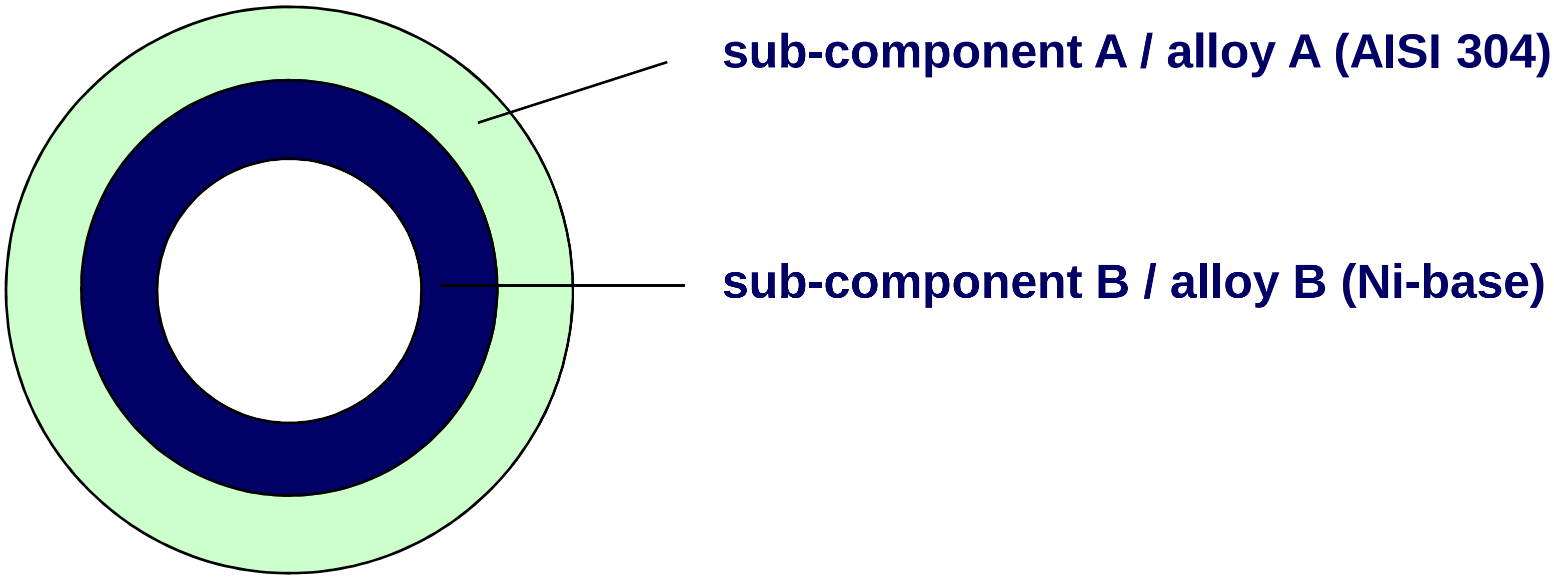
# increased flexibility in design and material selection

**Valve bodies and manifolds** for oilfield uses can be produced by hot isostatic pressing of **duplex stainless steel powder**

**MPIF – HIP council**
**John C. Hebeisen**

# bi-metallic components manufactured by HIP

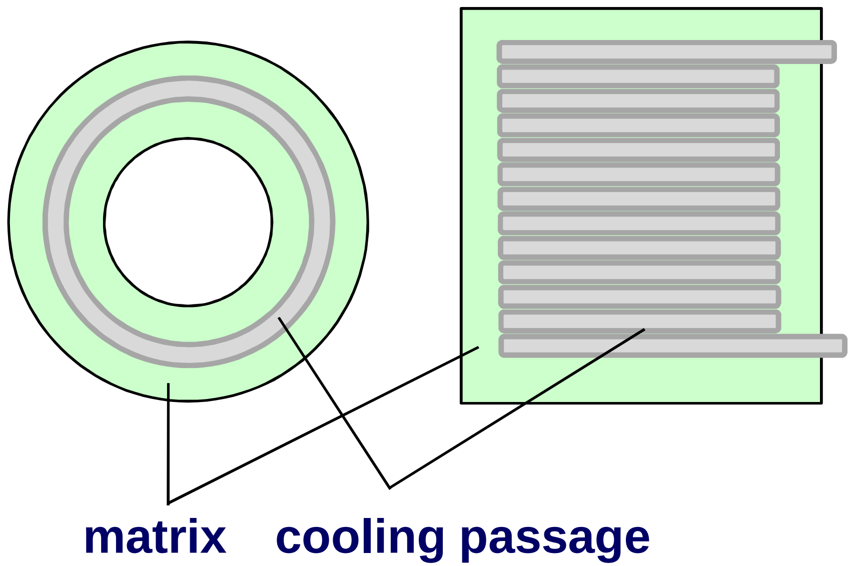
Hot isostatic pressing enables to produce bi-metallic compounds by powder-powder or by powder-solid body bonding.




The method is successfully applied for **cladding of more ore less complex shaped parts like valve bodies**.

# realisation of internal cooling passages by diffusion bonding

Hot isostatic pressing enables to produce **hollow structures** by HIP'ing of a pipe or tube system with a metal powder. The realisation of internal cooling passages is a typical example.



# Interested ?

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