Manufacturing of structural parts by HPDC Technology

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IK4-AZTERLAN

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- **Aluminium content in automotive → Experience in Structural Components**
- **Conventional High Pressure Die Casting.**
- **Problems with Conventional HPDC.**
- **Successful factors for structural HPDC**
- **Democratization opportunities of Structural parts by HPDC**

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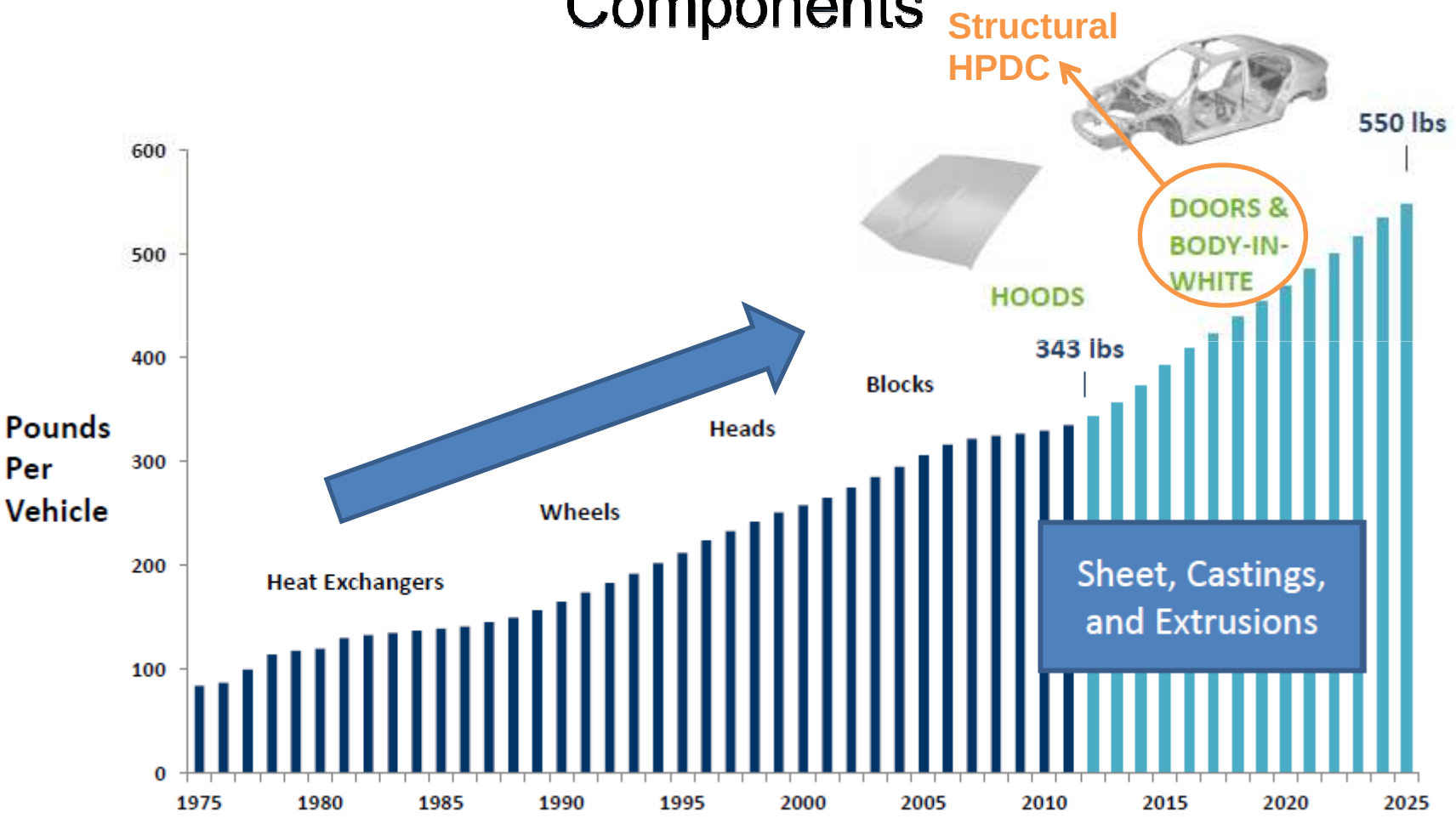
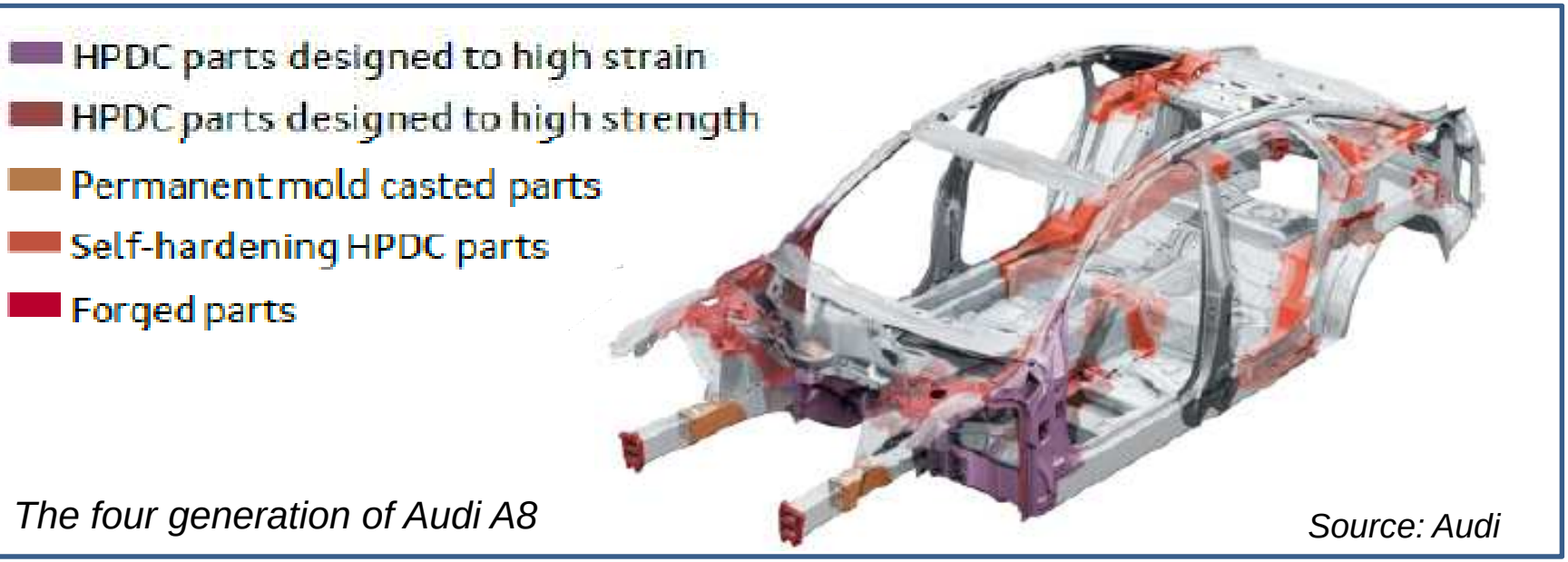
Al content in automotive → Experience in Structural Components



Source: Ducker Worlwide 2011

Al content in automotive → Experience in Structural Components

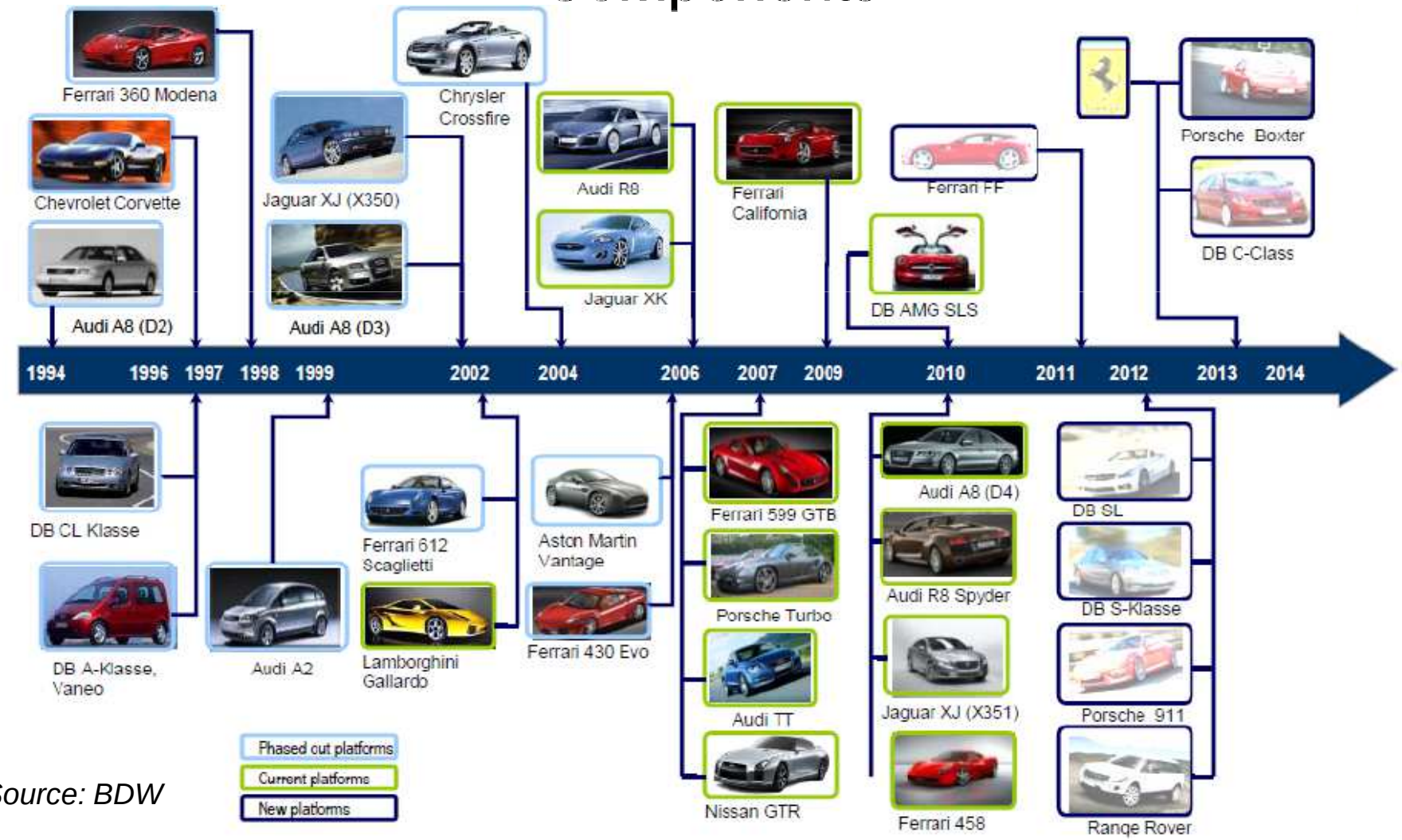
- Audi A8 was the first car in incorporating structural HPDC in 1994.
- The four generation of Audi A8 has an special Tailor-made cast part design in the Spaceframe architecture.
- The new structural HPDC manufacturing technology takes the key role within the lightweight strategy of Audi for 2020.



The four generation of Audi A8

Source: Audi

Al content in automotive → Experience in Structural Components

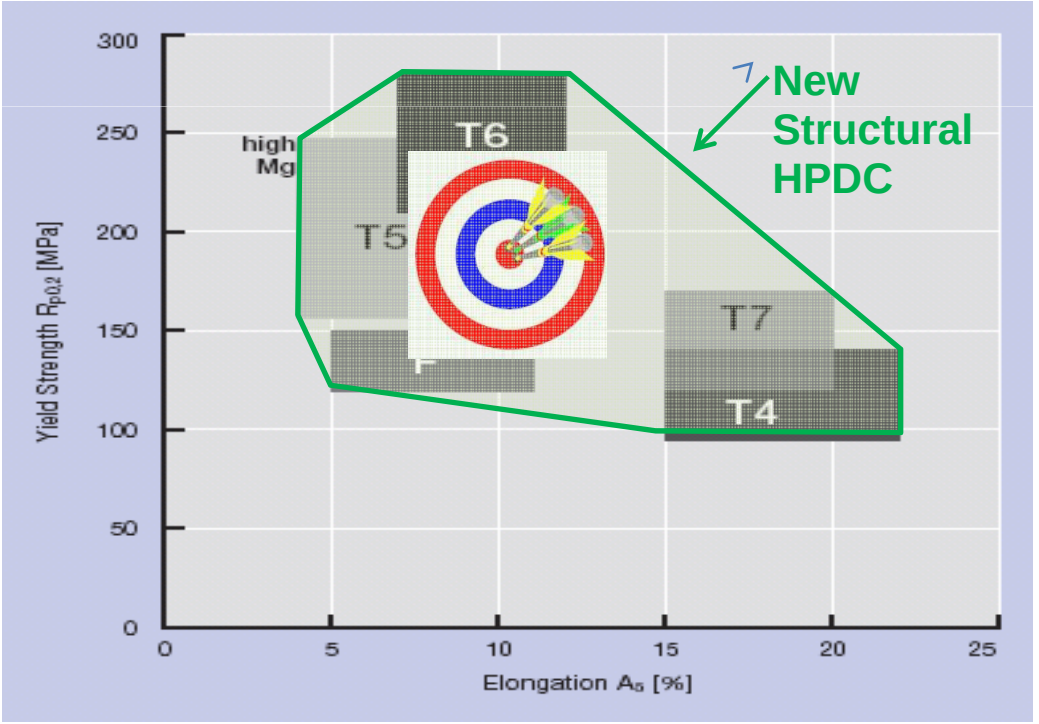


Source: BDW

Al content in automotive → Experience in Structural Components

The needs of Structural parts are:

- High elongation to withstand impacts
- High yield Strength and/or ultimate Strength
- Heat Treatability
- Weldability



Source: Structural HPDC: Rheinfelden catalogue AlSi10MnMg alloy

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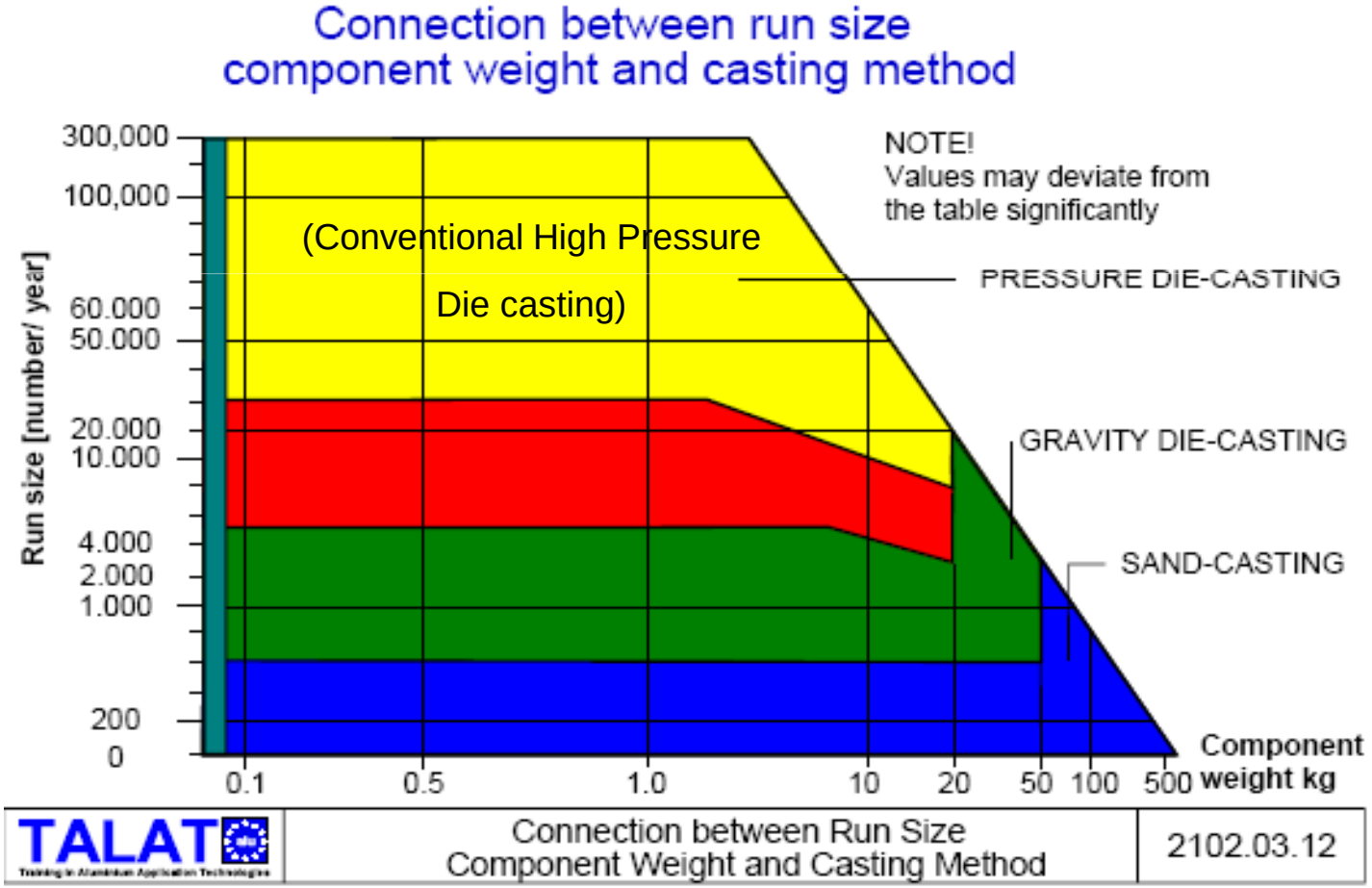
Conventional High Pressure Die Casting (HPDC)

- High rates of production at low cost
- Net – shape manufacturing process. Little or no machining.
- Production of complex shapes with close tolerances
- Thin walls (typical 1 – 5 mm)
- Excellent surface finish
- Integrated fastening elements → **Significant cost and labor reduction.**
- Quick, efficient and economical process.
- “Skin” effect can give very good fatigue performance
- Traditionally, it is not used to produce very large products like car door frame.

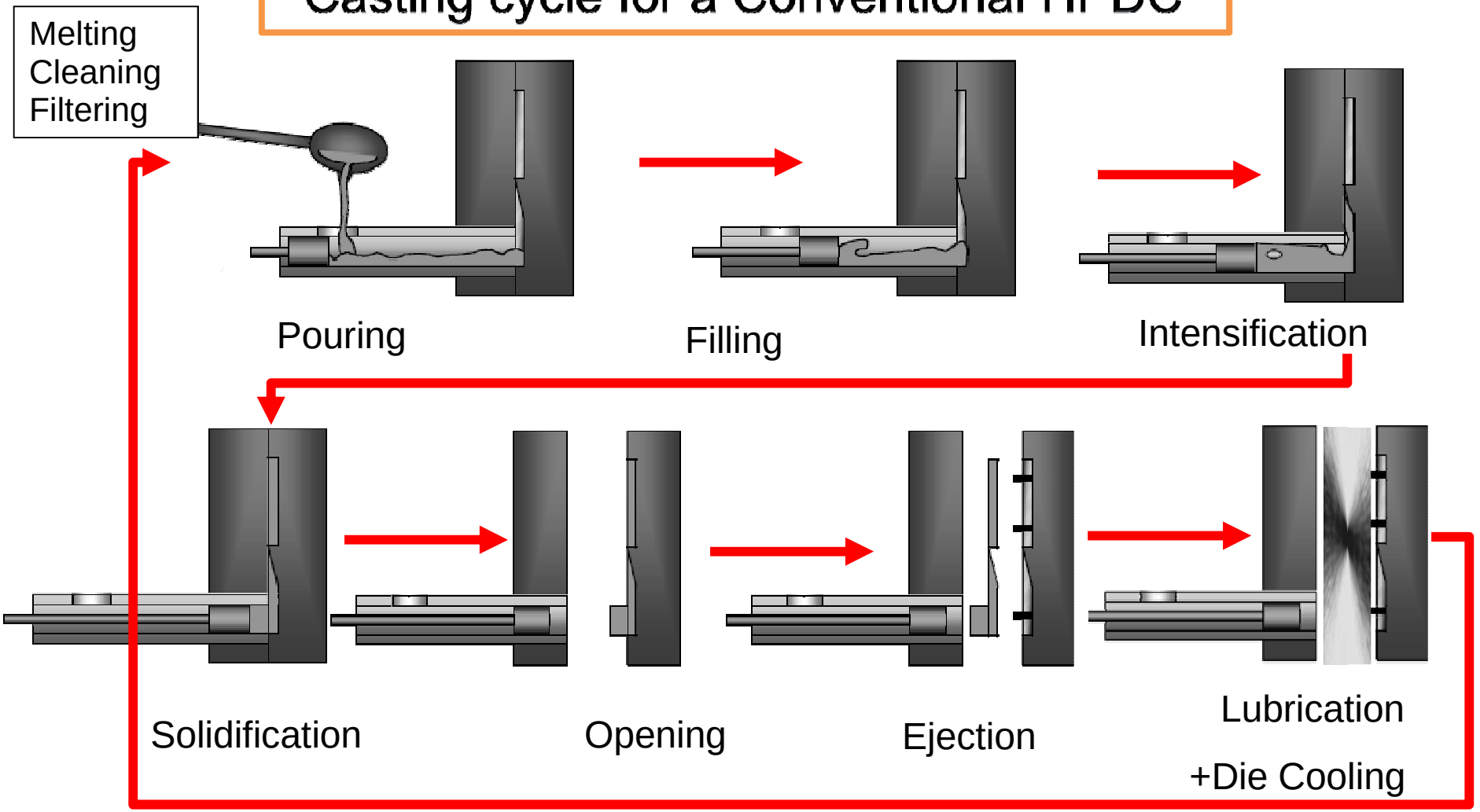
Conventional High Pressure Die Casting (HPDC)



Source: TALAT. Internet available.

Conventional High Pressure Die Casting (HPDC)

Casting cycle for a Conventional HPDC



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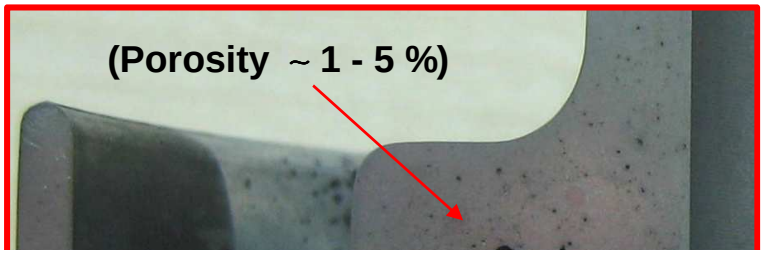
Problems of Conventionnal High Pressure Die Casting

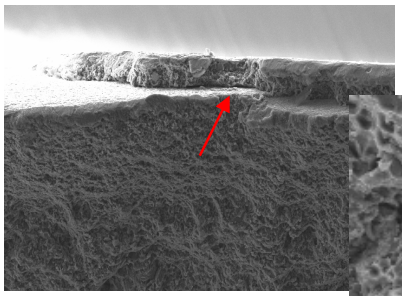
Main limitation
POROSITY



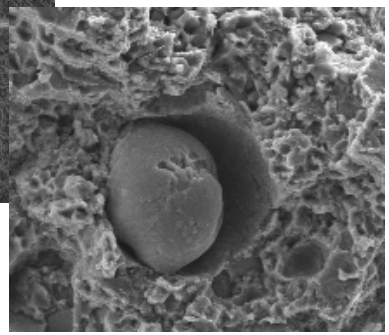
Problems of Conventionnal High Pressure Die Casting

Other limitations

Microstructural Defects Inherent to HPDC

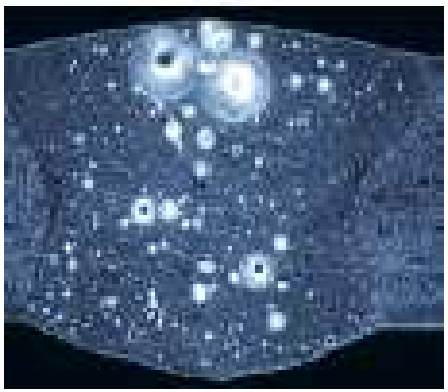


Delamination



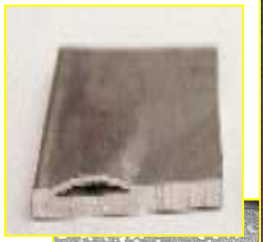
Cold drop

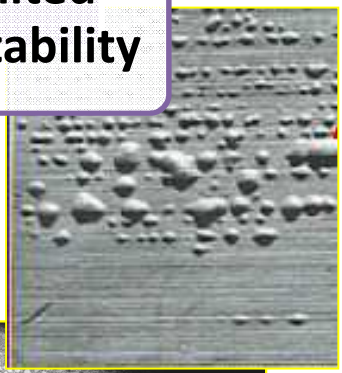
Very limited weldability



Internal porosity appears when welding

Very limited heat treatability





Blister

Problems of Conventionnal High Pressure Die Casting

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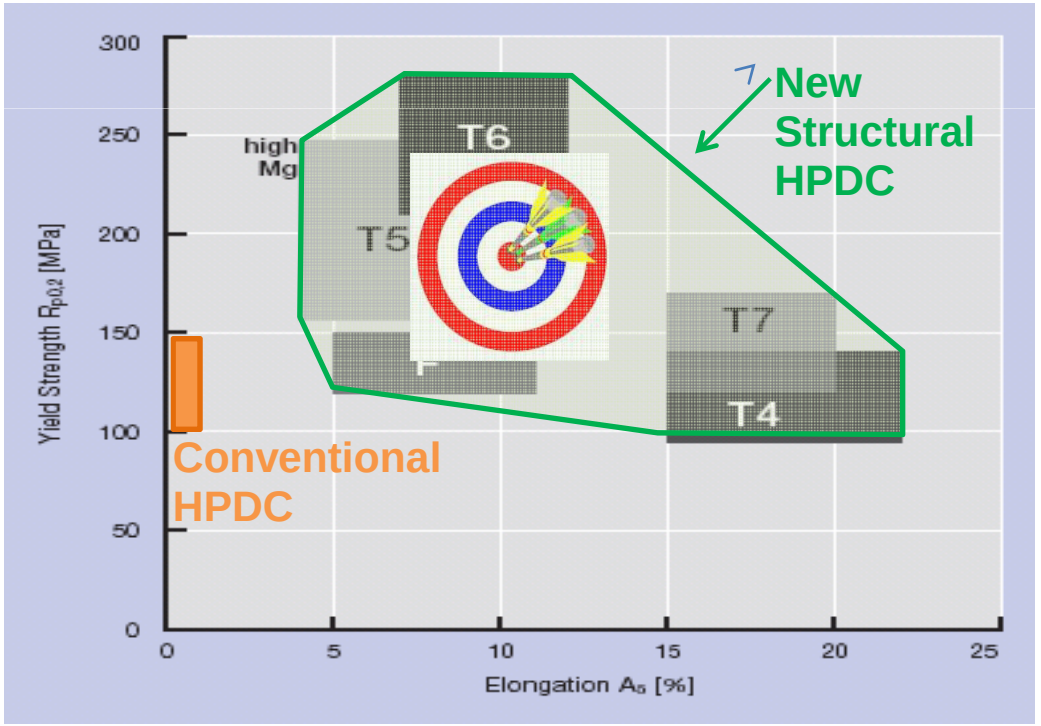
- High yield Strength and/or ultimate Strength
- Heat Treatability
- Weldability



Source: Conventional HPDC properties: European Norm 1706
Structural HPDC: Rheinfelden catalogue AlSi10MnMg alloy

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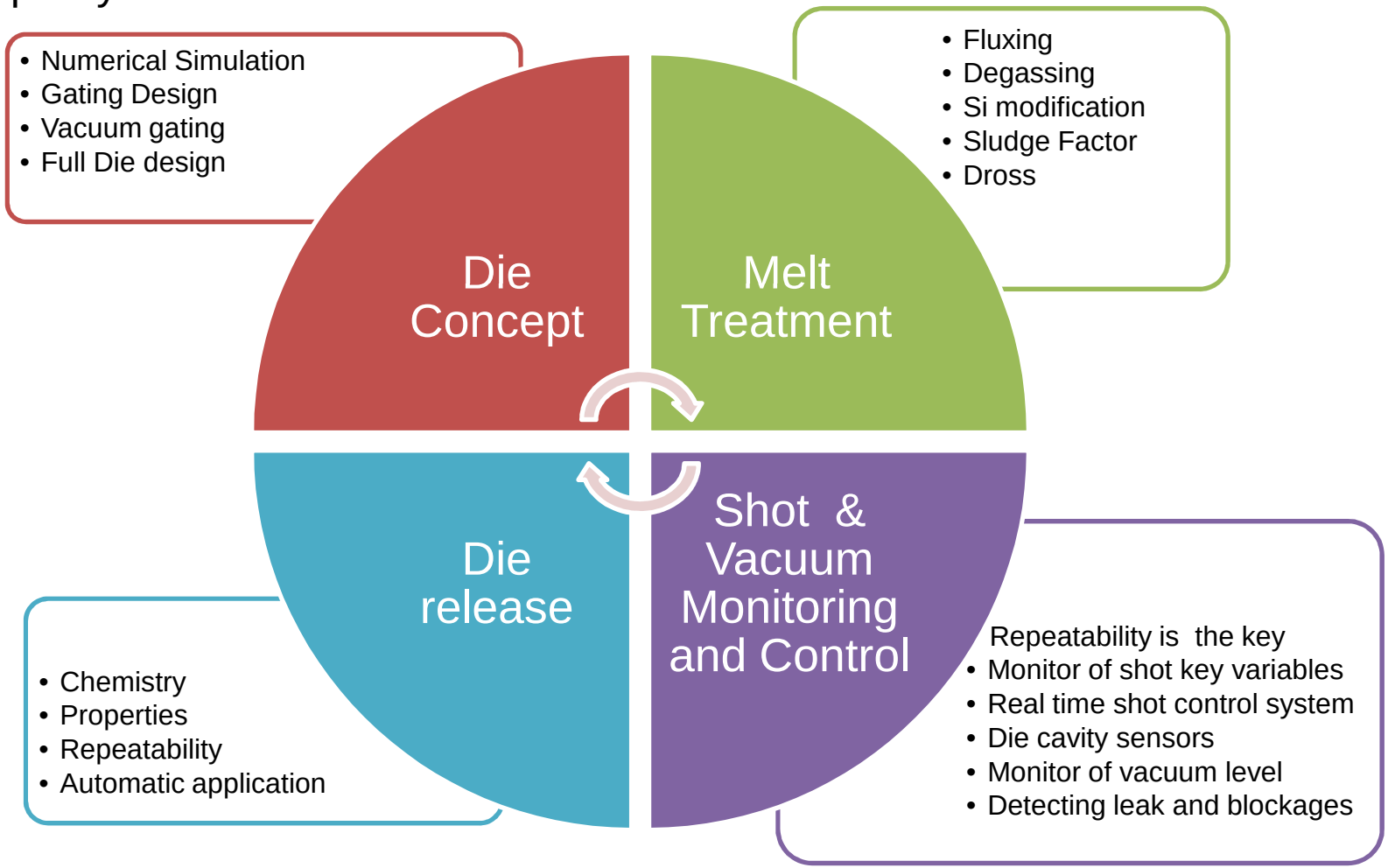
Successful factors for structural HPDC

It is not just to apply vacuum: it is a combination of technologies, know-hows and quality checks.



Successful factors for structural HPDC

- Numerical Simulation
- Gating Design
- Vacuum gating
- Full Die design

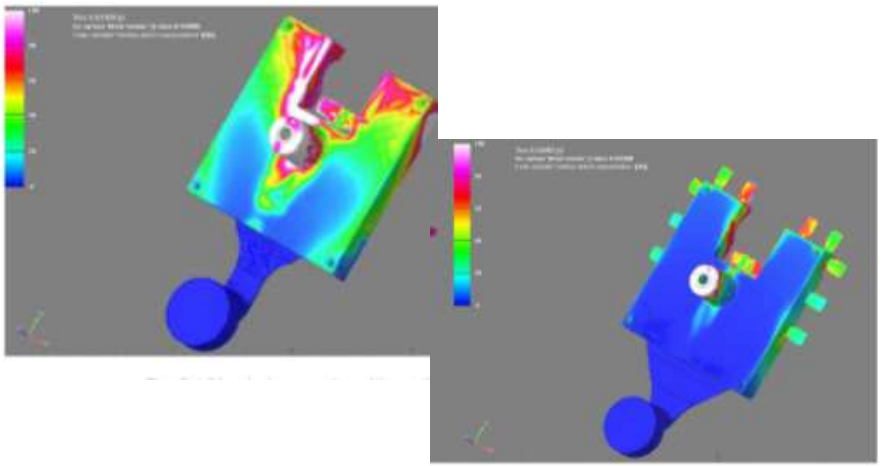
Die Concept

Improves

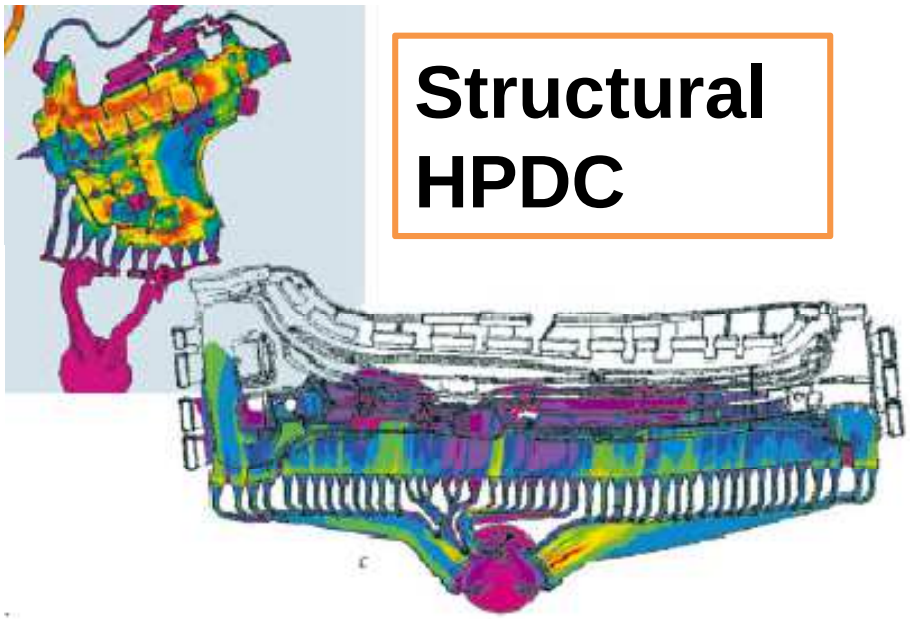
Porosity: Solidification shrinkage

Porosity: Air entrapment

Conventional HPDC



Structural HPDC



Successful factors for structural HPDC

Melt Treatment

- Fluxing
- Degassing
- Si modification
- Sludge Factor
- Dross

Improves

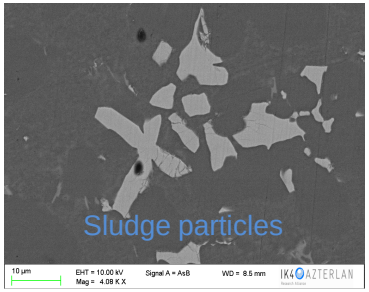
Porosity: Gas dissolved in the alloy

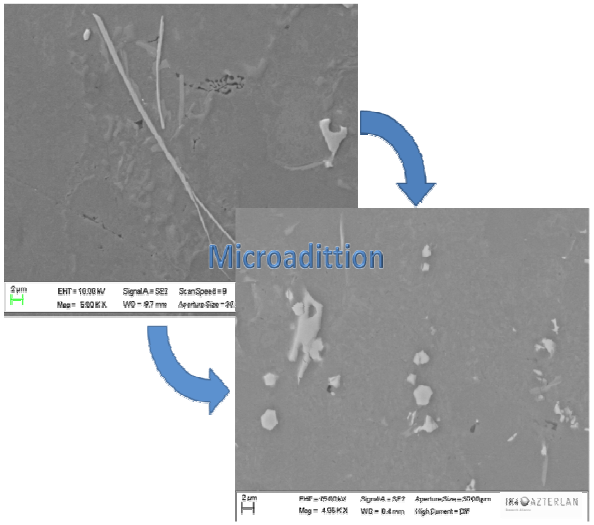
Microstructural Defects Inherent to HPDC

Very similar to that of good quality permanent mold or sand cast part, except that TiB_2 grain refinement is not necessary due to the high solidification rate.

- Degassing (H_2 removal from the melt). Fluxing.
- Primary alloy (AlSi9MnMg alloy) + Sr modification.
- Die soldering criteria %Fe + %Mn > 0.7
- Sludge Factor criteria

  SF = %Fe + 2·%Mn+ 3·%Cr < 2.2





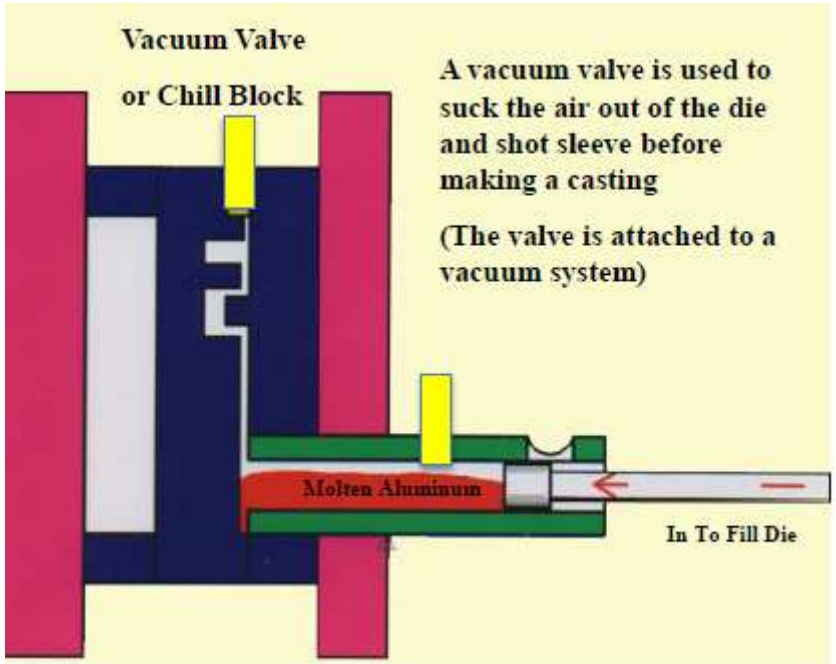
Successful factors for structural HPDC

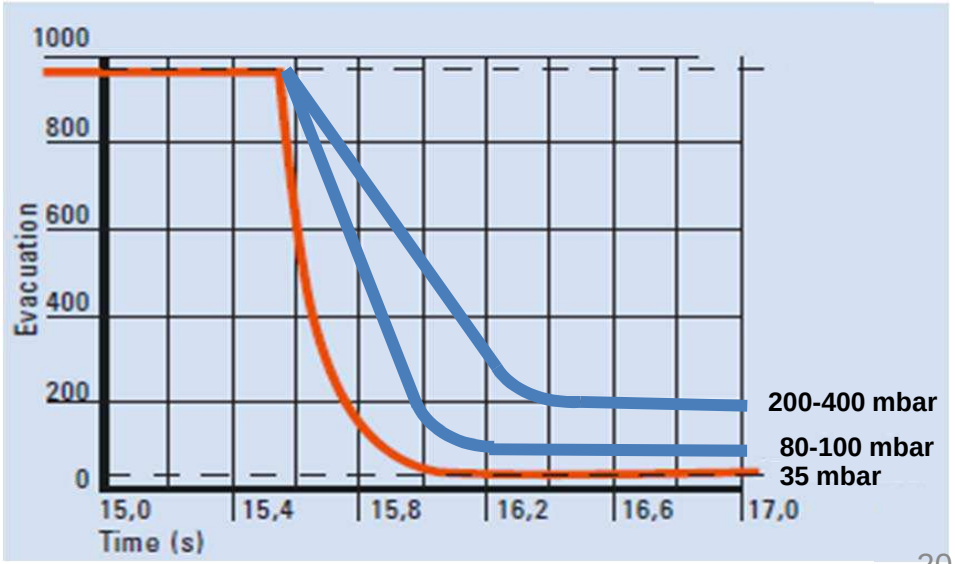
Shot & Vacuum Monitoring and Control

- Repeatability is the key
- Monitor of shot key variables
- Real time shot control system
- Die cavity sensors
- Monitor of vacuum level
- Detecting leak and blockages

Reduces

- **Porosity: Solidification shrinkage**
- **Porosity: Air entrapment**





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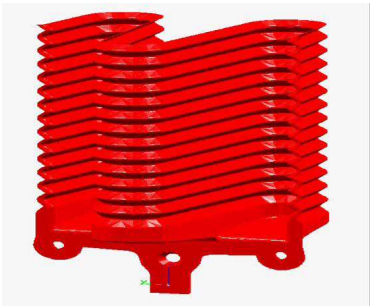
Chill Vent

Conventional Vacuum

Vacuum exhaust valve

Metal activated or shot controlled valve

3D Chill Vent



Higher flow rate without increasing locking force

Successful factors for structural HPDC

Shot & Vacuum Monitoring and Control

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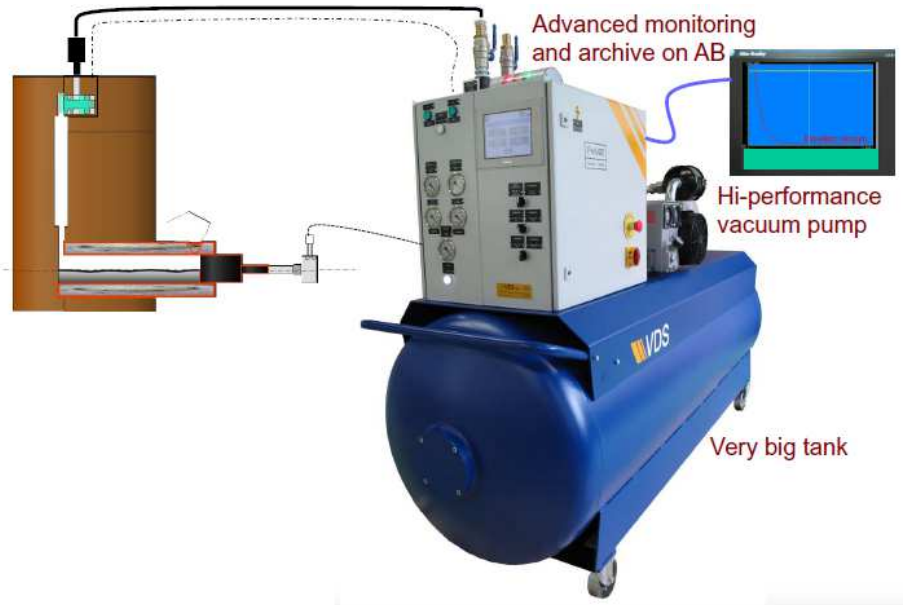
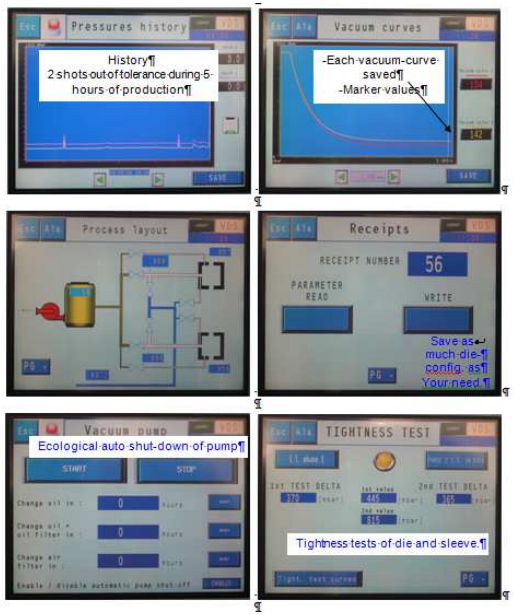
Reduces

Porosity: Solidification shrinkage

Porosity: Air entrapment





Source: VDS

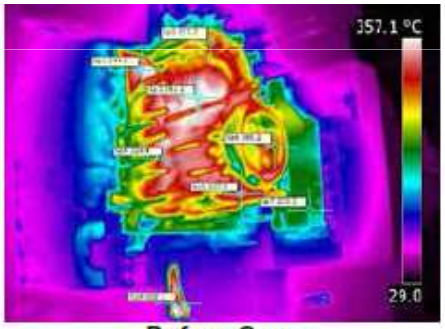
Successful factors for structural HPDC

Die release

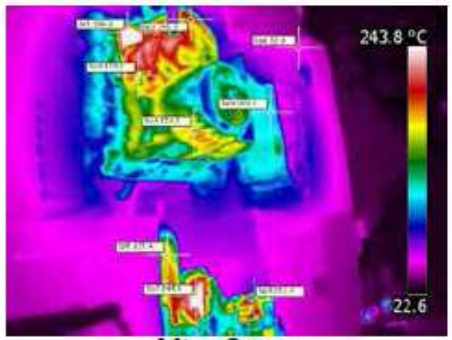
- Chemistry
- Properties
- Repeatability
- Automatic application

Improves

Porosity: Gas from lubricant decomposition



Before Spray



After Spray

There is a clear HOT SPOT

The HOT SPOT is cooled

Source: Chem-Trend

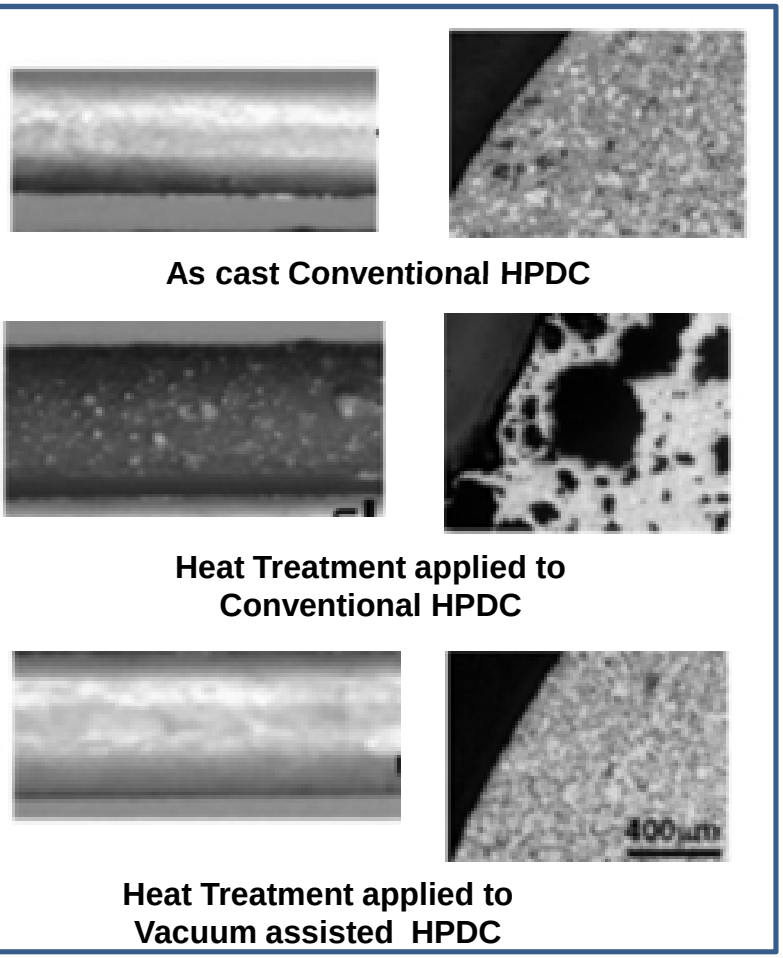
First lubrication

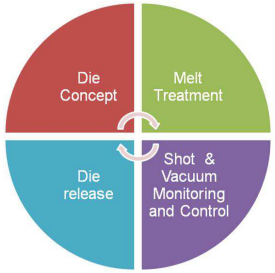
4th lubrication

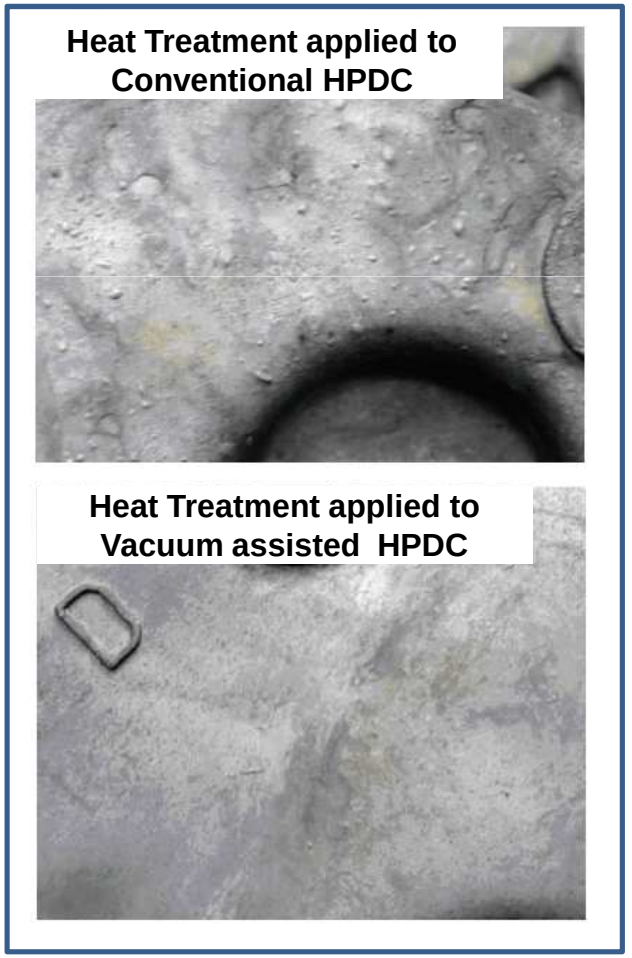
Photographic comparison of three die lubricants during spraying onto die steel for a initial temperature of the die steel of 180 °C.

Successful factors for structural HPDC

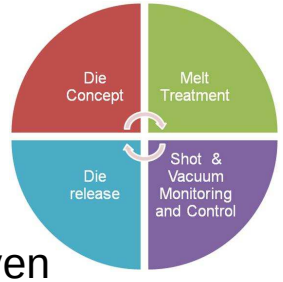
Effect of the heat treatment







Successful factors for structural HPDC

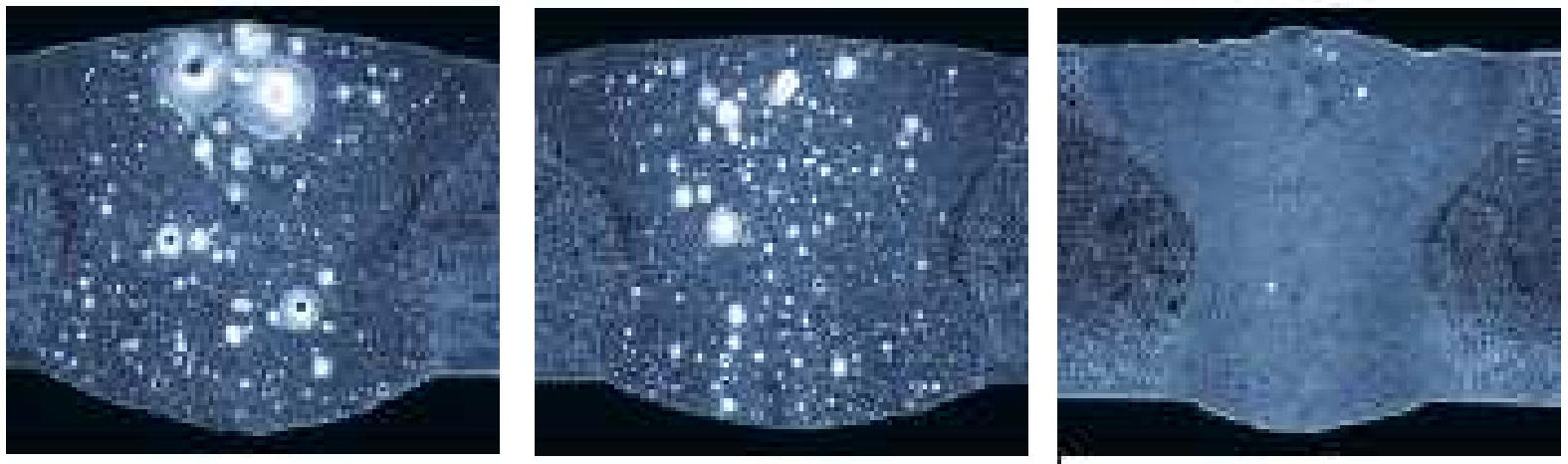


Effect on weldability:

TIG and MIG Welding are generally possible in T6 & T7 heat treated parts.

Laser Welding is the most exigent technology in terms of casting quality, even more than T6 & T7 solutionizing. Very low gas contents (from the melt, from the filling process and from the lubricants) can be tolerated.

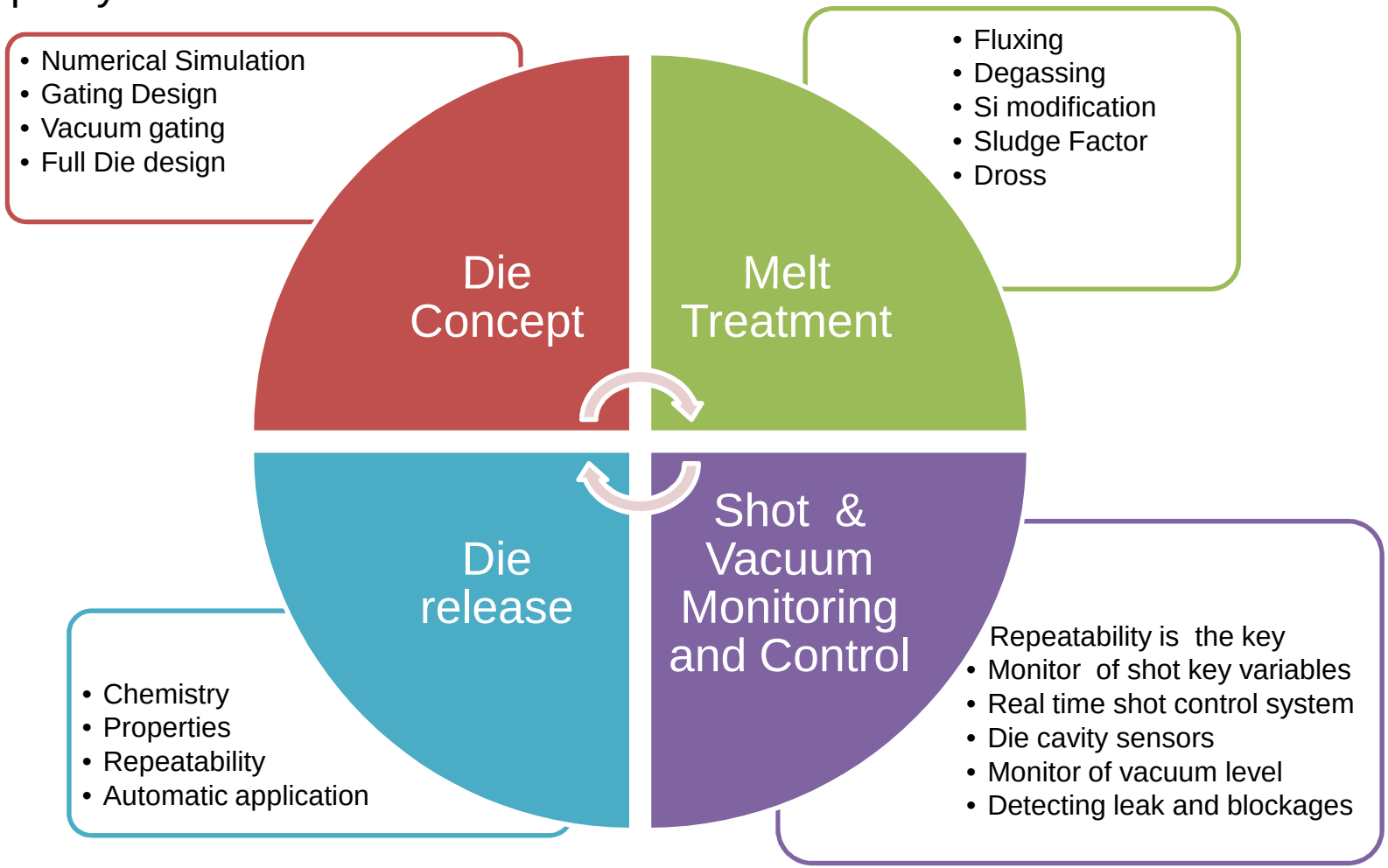
Friction Stir Welding is an attractive alternative



Without Vacuum | **Conventional vacuum** | **With high vacuum**

Successful factors for structural HPDC

It is not just to apply vacuum: it is a combination of technologies, know-hows and quality checks.



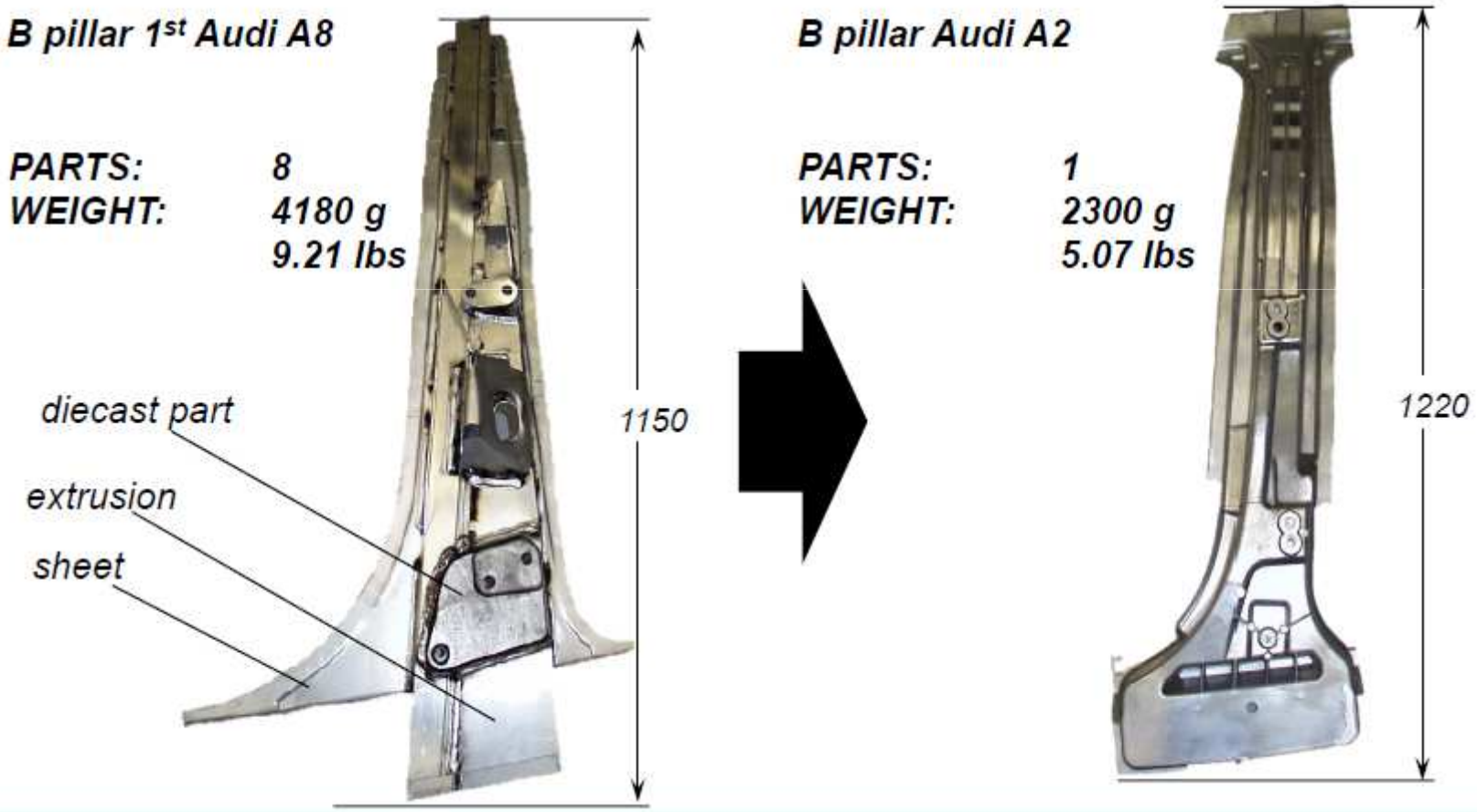
Successful factors for structural HPDC

Structural aluminum high pressure diecastings are being used for

- Replacing
  - Heavier materials
  - Steel/Al assemblies and stampings
  - Higher cost materials and processes
- Welded asemblies
- Lower weight (thin walls)
  - Increased fuel economy
- Performance increases
- Pressure tight hydraulics
- Significant machining cost reduction

Successful factors for structural HPDC

Successful case I: Pillar B



First: *Pillar B required 8 welded parts with only small HPDC part*

Next generation: *Only One HPDC part.*

Source: Audi

Successful factors for structural HPDC

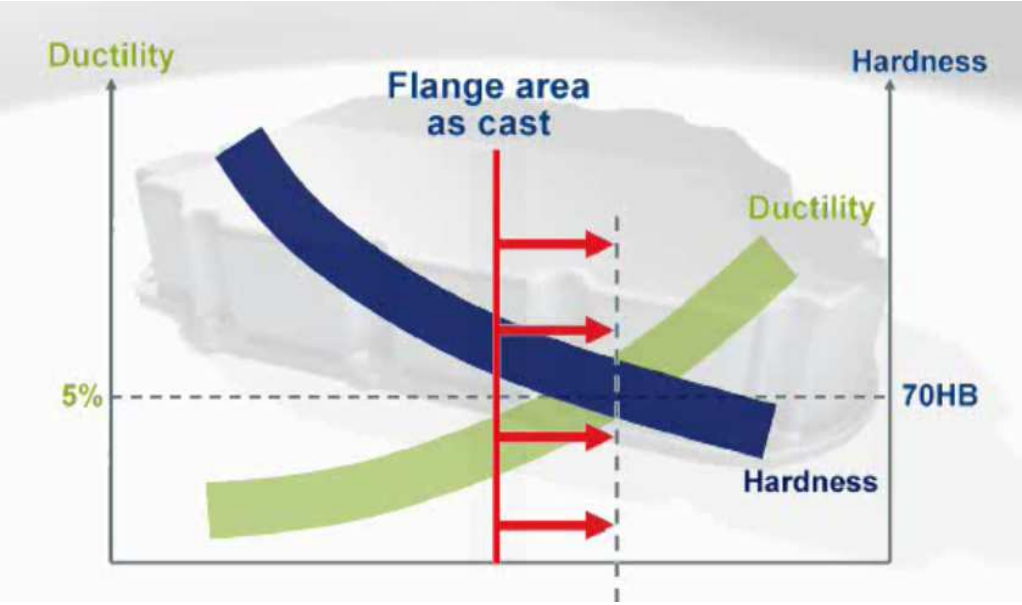
Successful case II: Oil pan

- **Ductility on the bottom** part to support the stones impact (ductility > 5 %)
- Stiffness in the flange area (hardness > 70 HB)

Conventional Solution: Partial heat treatment in bottom area

New Vacuum HPDC solution: As-cast quality is enough. No Heat treatment.

The whole casting fulfils both requirements in as-cast state .



Conventional secondary AlSi9Cu3Mg alloy

High ductile alloy: Primary AlSi9MnMg alloy

Source: BDW

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Democratization opportunities of Structural parts by HPDC

As every OEM has the need to reduce weight.

Is it possible to democratize this new technology for medium size car?

Yes, it is. The democratization of structural HPDC is the main objective of the FP7-Soundcast Project, by using:

- Medium-good vacuum 80-100 mbars, achieved with a vacuum pump adaptable to conventional HPDC machines.
- Secondary alloy (cost reduction) with similar mechanical properties to primary high ductile AlSi9MnMg alloy.
- New laser welding procedure able to weld this new secondary alloy.

Source: "FP7-SME-315506 – SOUNDCAST": Vacuum-assisted high pressure die casting with reduced porosity at low cost.

PARTNERS

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Technische Universität Braunschweig

Thanks for your attention