Lightweight Design – Cooperative research to improve the car body structure

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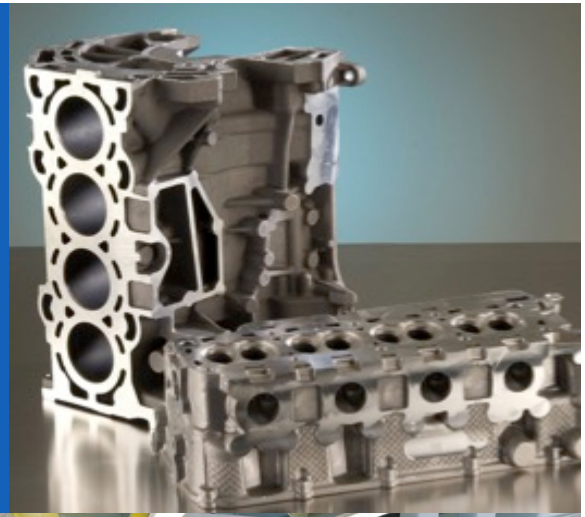
AMAP 3rd Anniversary

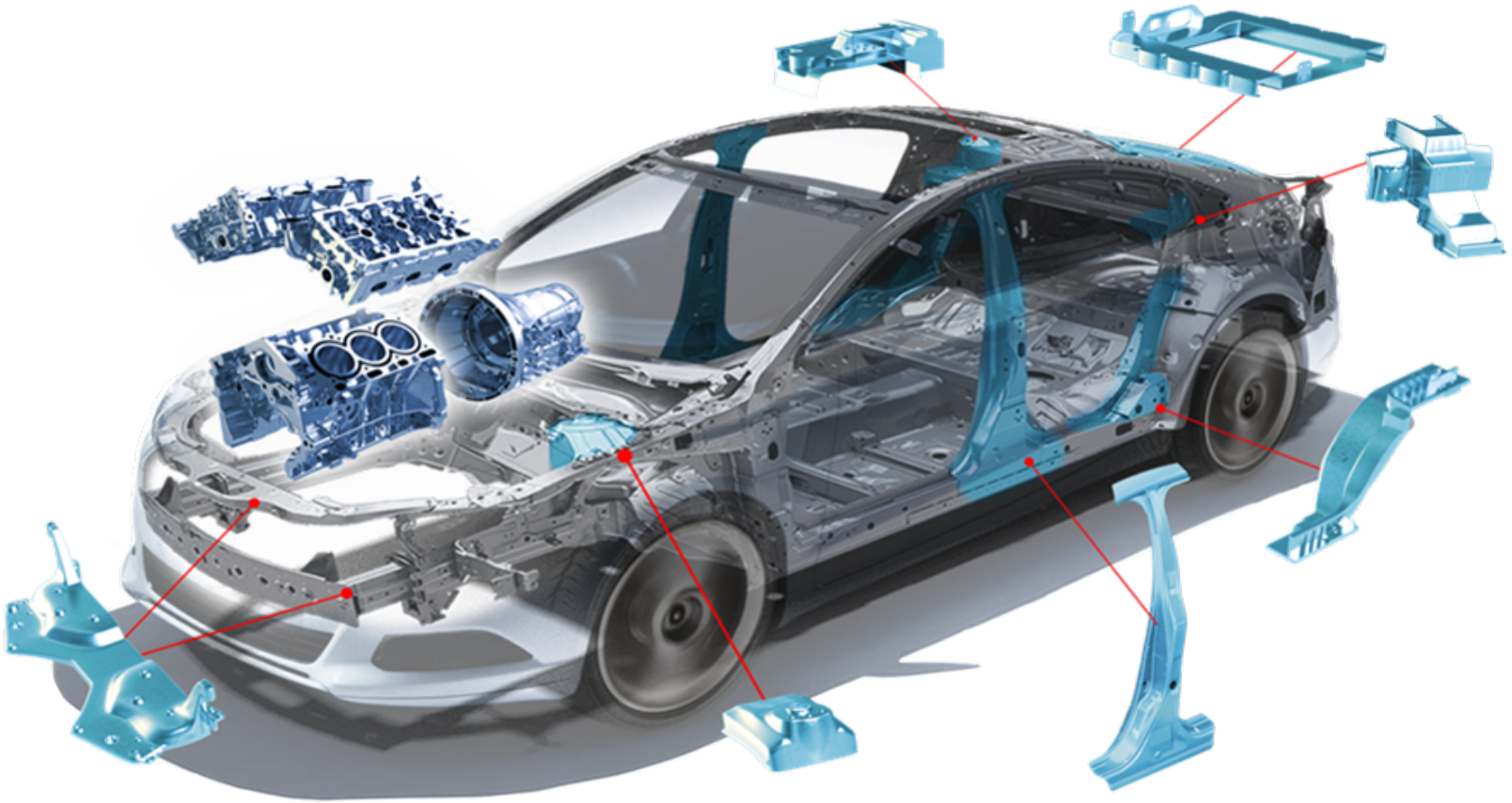
Agenda

- Introduction
- Hollow Structural Components in High Pressure Die Casting
  - Motivation
  - Current Status of Market and Technology
  - Potential Parts
  - Structure and Work

Innovation in complex aluminium automotive components



Our products enhance drive and structure



Nemak Global Footprint …

… with 9 product development centers

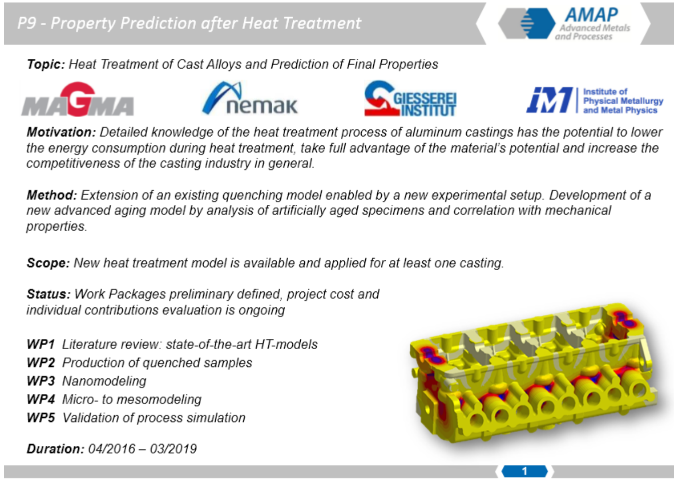
Nemak @ AMAP

Core Distortion : 1/2013 - 3/2016

Melt Cleanliness: 1/2013 - 12/2016

Property Prediction: 4/2016 - 3/2019

Hollow Structural Components: 1/2016 - 12/2018



P9 - Property Prediction after Heat Treatment

AMAP Advanced Metals and Processes

Topic: *Heat Treatment of Cast Alloys and Prediction of Final Properties*

MAGMA | nemak | GIESSEREI INSTITUT | IMM Institute of Physical Metallurgy and Metal Physics

Motivation: *Detailed knowledge of the heat treatment process of aluminum castings has the potential to lower the energy consumption during heat treatment, take full advantage of the material's potential and increase the competitiveness of the casting industry in general.*

Method: *Extension of an existing quenching model enabled by a new experimental setup. Development of a new advanced aging model by analysis of artificially aged specimens and correlation with mechanical properties.*

Scope: *New heat treatment model is available and applied for at least one casting.*

Status: *Work Packages preliminary defined, project cost and individual contributions evaluation is ongoing*

WP1 *Literature review: state-of-the-art HT-models*
WP2 *Production of quenched samples*
WP3 *Nanomodeling*
WP4 *Micro- to mesomodeling*
WP5 *Validation of process simulation*

Duration: *04/2016 – 03/2019*

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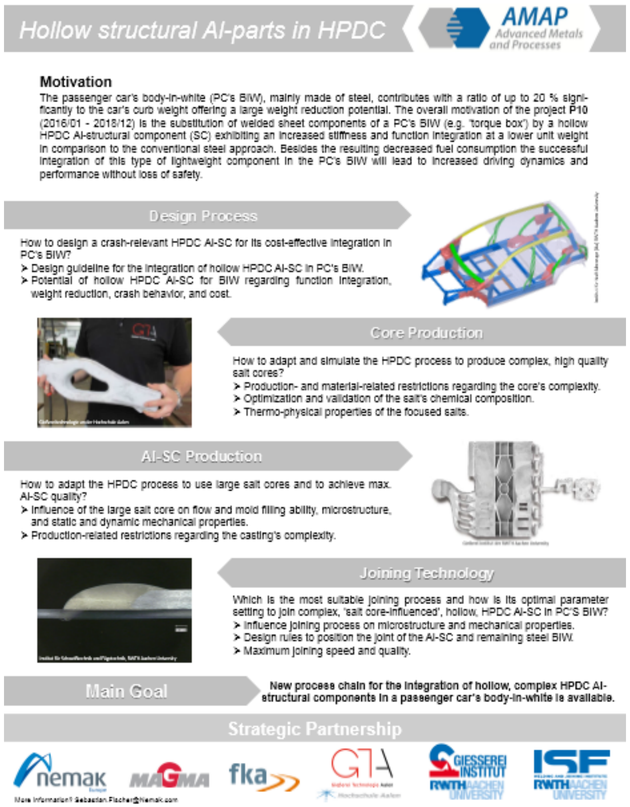

Hollow structural Al-parts in HPDC

AMAP Advanced Metals and Processes

Motivation

The passenger car's body-in-white (PC's BIW), mainly made of steel, contributes with a ratio of up to 20 % significantly to the car's curb weight offering a large weight reduction potential. The overall motivation of the project **P10** (2016/01 - 2018/12) is the substitution of welded sheet components of a PC's BIW (e.g. 'torque box') by a hollow HPDC Al-structural component (SC) exhibiting an increased stiffness and function integration at a lower unit weight in comparison to the conventional steel approach. Besides the resulting decreased fuel consumption the successful integration of this type of lightweight component in the PC's BIW will lead to increased driving dynamics and performance without loss of safety.

Design Process

How to design a crash-relevant HPDC Al-SC for its cost-effective integration in PC's BIW?
- Design guideline for the integration of hollow HPDC Al-SC in PC's BIW.
- Potential of hollow HPDC Al-SC for BIW regarding function integration, weight reduction, crash behavior, and cost.

Core Production

How to adapt and simulate the HPDC process to produce complex, high quality salt cores?
- Production- and material-related restrictions regarding the core's complexity.
- Optimization and validation of the salt's chemical composition.
- Thermo-physical properties of the focused salts.

Al-SC Production

How to adapt the HPDC process to use large salt cores and to achieve max. Al-SC quality?
- Influence of the large salt core on flow and mold filling ability, microstructure, and static and dynamic mechanical properties.
- Production-related restrictions regarding the casting's complexity.

Joining Technology

Which is the most suitable joining process and how is its optimal parameter setting to join complex, 'salt core-influenced', hollow, HPDC Al-SC in PC'S BIW?
- Influence joining process on microstructure and mechanical properties.
- Design rules to position the joint of the Al-SC and remaining steel BIW.
- Maximum joining speed and quality.

Main Goal **New process chain for the integration of hollow, complex HPDC Al-structural components in a passenger car's body-in-white is available.**

Strategic Partnership

nemak | MAGMA | fka | GTA | GIESSEREI INSTITUT RWTH AACHEN UNIVERSITY | ISF RWTH AACHEN UNIVERSITY

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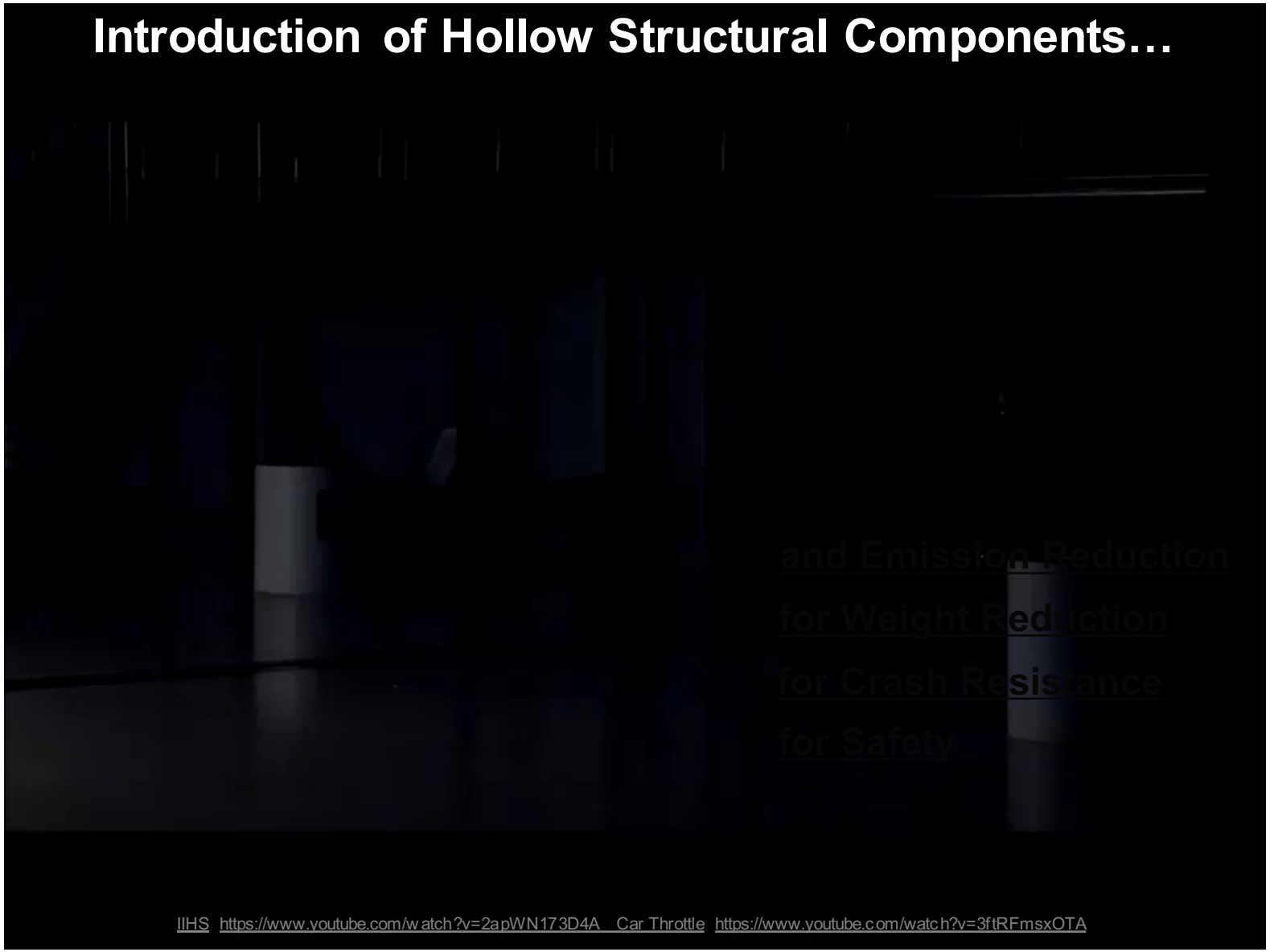
nemak

Hollow Structural Components in HPDC (AMAP P10)

Motivation


Introduction of Hollow Structural Components…
and Emission Reduction
for Weight Reduction
for Crash Resistance
for Safety
IIHS https://www.youtube.com/watch?v=2apWN173D4A Car Throttle https://www.youtube.com/watch?v=3ftRFmsxOTA

Hollow Structural Components in HPDC – Market Situation

- Steel body structure represents > **20 %** of the vehicle weight
  → high **weight-saving** potential of Al-components

- Safety: **Aluminum tube**-shaped HPDC parts are **equal stiff or even stiffer** in bending than steel tubes*

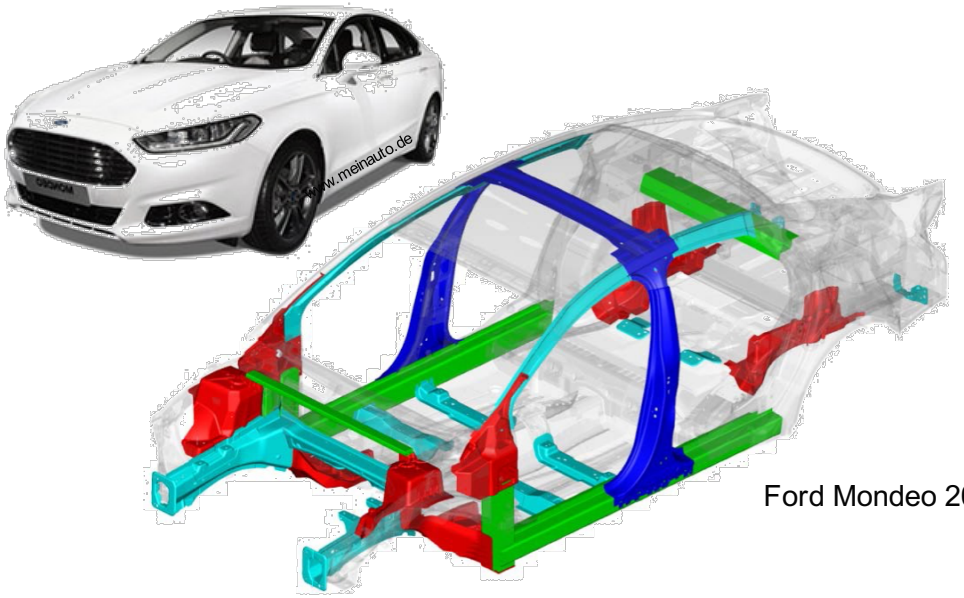
- Development of hollow HPDC Al-castings for passenger car BIW targets for*:
  - significant weight reduction
  - reduced manufacturing steps
  - higher design flexibility
  - enhanced performance, handling and NVH of the vehicle
  - lower cost

Ford Fusion 2013

Source: Randy Beals, Jeff Conklin, Tim Skszek, Matt Zaluzec, David Wagner (Magna, Ford): Aluminum High Pressure Vacuum Die Casting Applications for the Multi Material Lightweight Vehicle Program Body Structure, **Light Metals 2015**, Eds: Margaret Hyland, pp. 215-221

Potential HPDC Car Body Structural Parts

- In red:
  - Front shock tower*
  - Front kick-down*
  - Door hinge pillar*
  - Rear mid rail*
- In blue:
  - B-pillar assembly
- Doors & closures

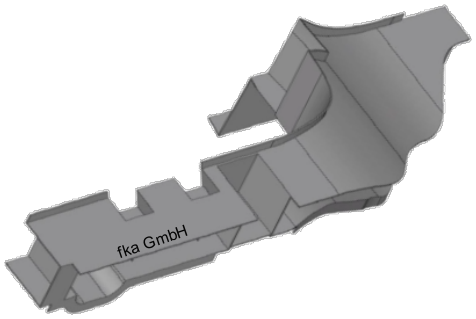


Ford Mondeo 2013*

Front ‘torque box‘*

Door hinge pillar*

Rear mid rail*



Rear ‘torque box‘

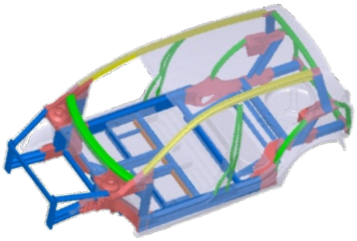
*__Source__: Randy Beals, Jeff Conklin, Tim Skszek, Matt Zaluzec, David Wagner (Magna, Ford): Aluminum High Pressure Vacuum Die Casting Applications for the Multi Material Lightweight Vehicle Program Body Structure, **Light Metals 2015**, Eds: Margaret Hyland, pp. 215-221

Current Status for Production and Application of Hollow Cast Components

- Design rules for hollow cast Al-componets for application in BIW parts need to be developed
- Joining techniques for the integration of Aluminium and steel components to be evaluated
- For producing hollow, complex HPDC Al-components pressed + sintered or cast cores may be used
  - Drawbacks of pressed/ sintered salt cores
    - Manufacturing process
    - Stability
    - Surface quality
  - Cast salt cores have potential for
    - Higher bending strength
    - Smooth surfaces
    - High design flexibility
  - Manufacturing of large cast salt cores (Ø > 85 mm) is very challenging/ know-how is missing

Open points addressed to AMAP Consortium

How to design a crash-relevant hollow HPDC Al-SC for its cost-effective integration in car body structure?

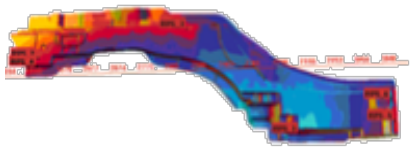


Institut für Kraftfahrzeuge (ika) RWTH Aachen University

How to adapt the HPDC process to produce complex, high quality salt cores?

Gießereitechnologie an der Hochschule Aalen

How can the production of salt cores by HPDC be simulated to optimize the core's quality?



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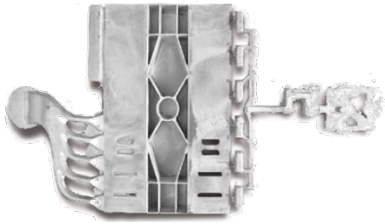
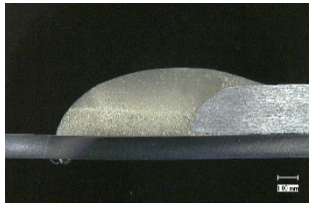
How to adapt the HPDC process to use large salt cores and to achieve max. Al-SC quality?



Gießerei-Institut der RWTH Aachen University

Which is the most suitable joining process and its optimal parameter BIW?



Institut für Schweißtechnik und Fügetechnik, RWTH Aachen University

Project Structure and Work

- **Structural part's design** and validation are conducted by the Institute for Automotive Engineering (fka GmbH), RWTH Aachen.
- The Institute for Welding and Joining (ISF), RWTH Aachen, selects the suitable **joining process** and develops process parameters, and evaluates process cost for joining.
- The Foundry-Institute (GI), RWTH Aachen, will develop the **HPDC process for hollow components** and will evaluate the SC's properties.
- Institute for Foundry Technology of the University of Aalen (GTA) as subcontractor will produce, characterize and **optimize salt cores** and will deliver the cores to the GI.
- MAGMA will **model the salt core production** and optimization. In addition HPDC quality criteria for the production of SC will be further developed.

AMAP P10 – Facts and Figures

- 5 Project partners
- 8 Subcontractors
- 7 Main work packages
- 36 Milestones
- 13 Quality/ decision gates
- 3 years duration
- 1.0 M€ budget

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The consortium started to work right now …