IFUM
Institut für Umformtechnik
und Umformmaschinen
Prof. Dr.-Ing. Bernd-Arno Behrens

On the Tailored Forming of Massive Components: A Hybrid Shaft Example

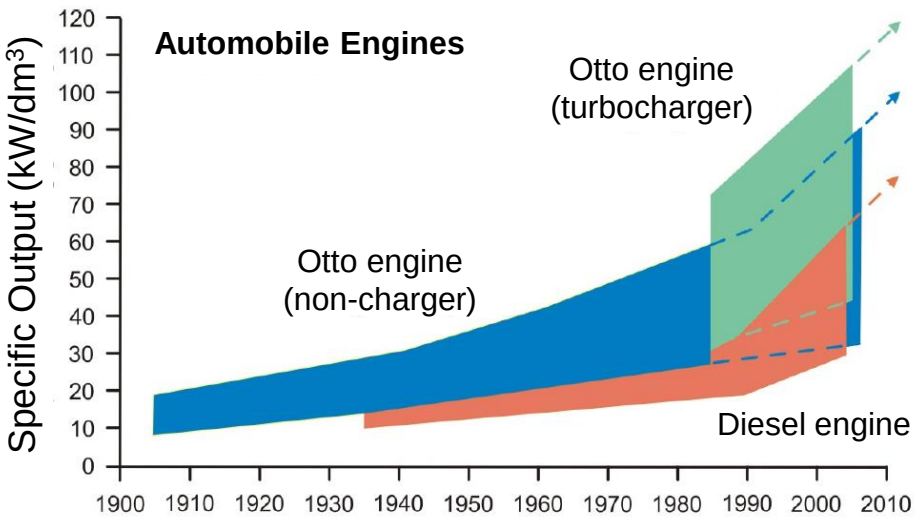
Deniz Duran

International Conference on Design and Production Engineering
Berlin, July 2016

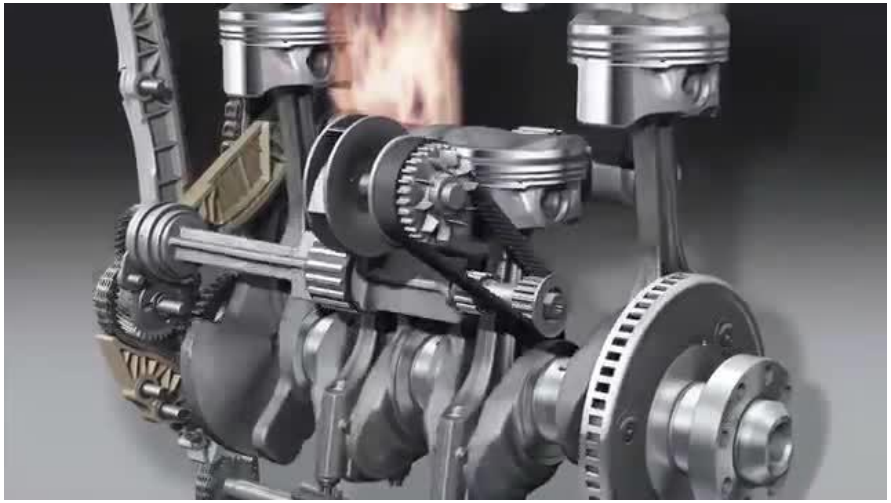
26.07.2016

Leibniz Universität Hannover
Produktionstechnisches Zentrum Hannover

Motivation



Source: Golloch, 2005
Downsizing bei Verbrennungsmotorren



Source: Audi AG 1.8 TFSI Engine

Current Trends

- Rising power density
- Locally varying loads

- Conservation of resources
- Energy efficiency

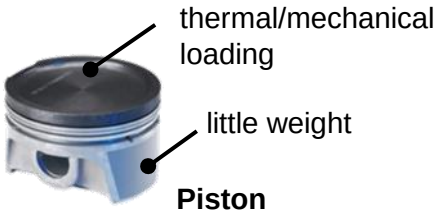
Motivation

- Integrate different materials into one single **hybrid** component
- Lightweight construction
- Take advantage of specific characteristics of different materials

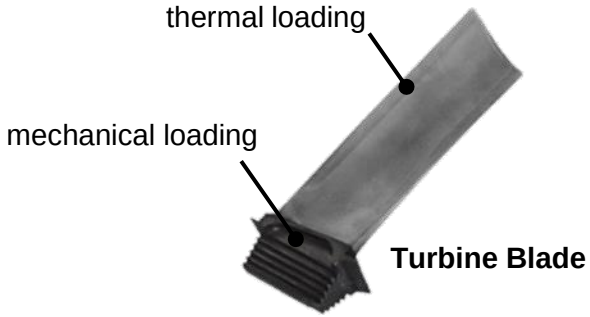
Introduction (1)

Appropriate Material at the Appropriate Location

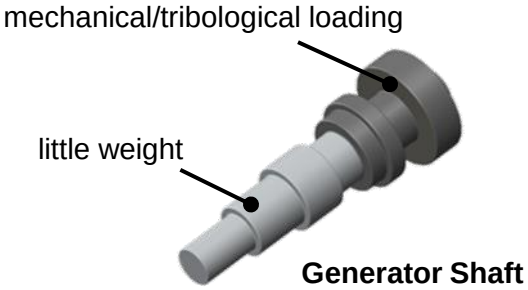
- Function-adapted hybrid construction
- Extended functionality of components
- Novel process chains



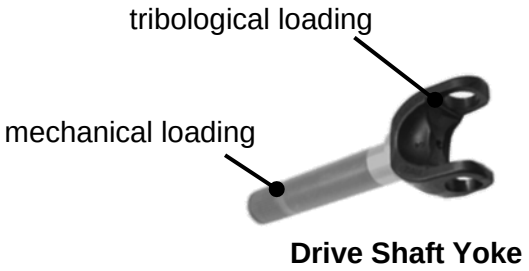
Automative Engineering



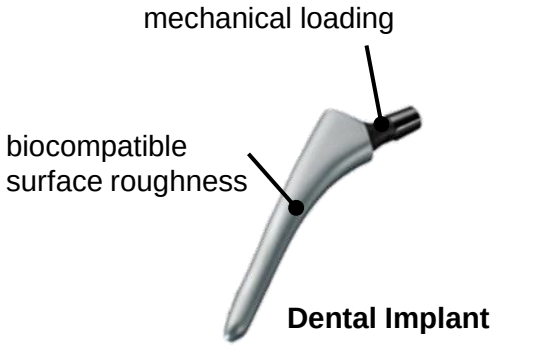
Aerospace Engineering



Energy Technology



Automative Engineering



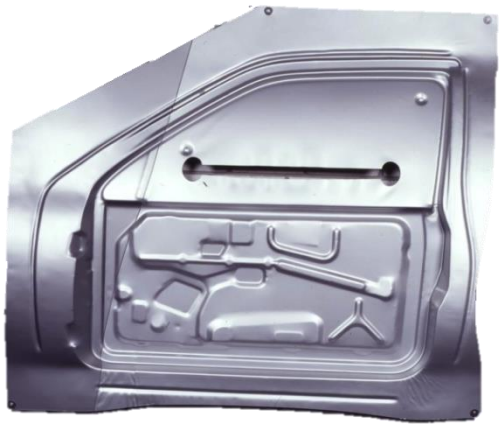
Medical Engineering

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Introduction (2)

Sheet Metal Forming → Tailored Blanks

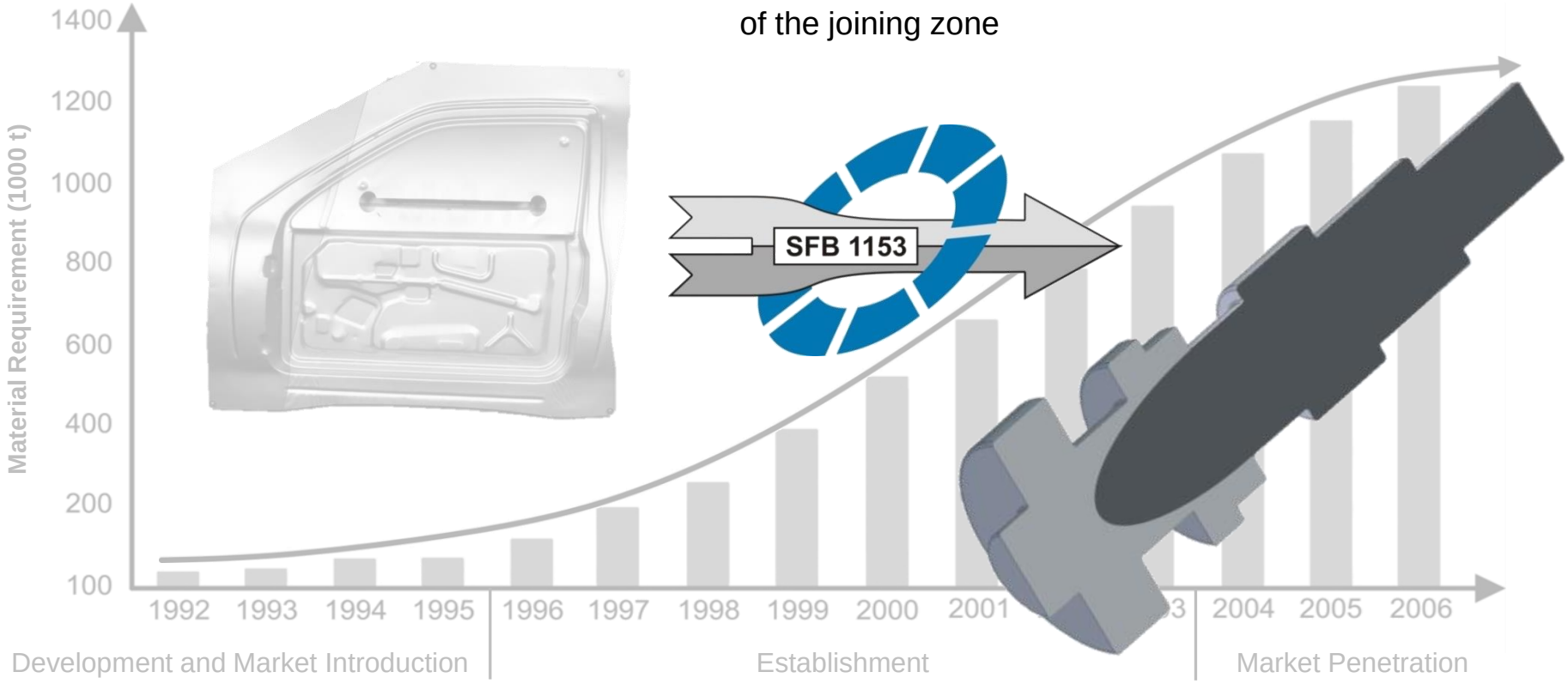
- Laser-welded blanks
- Variable sheet thicknesses
- Different material types



Introduction (3)

Bulk Metal Forming → Tailored Forming

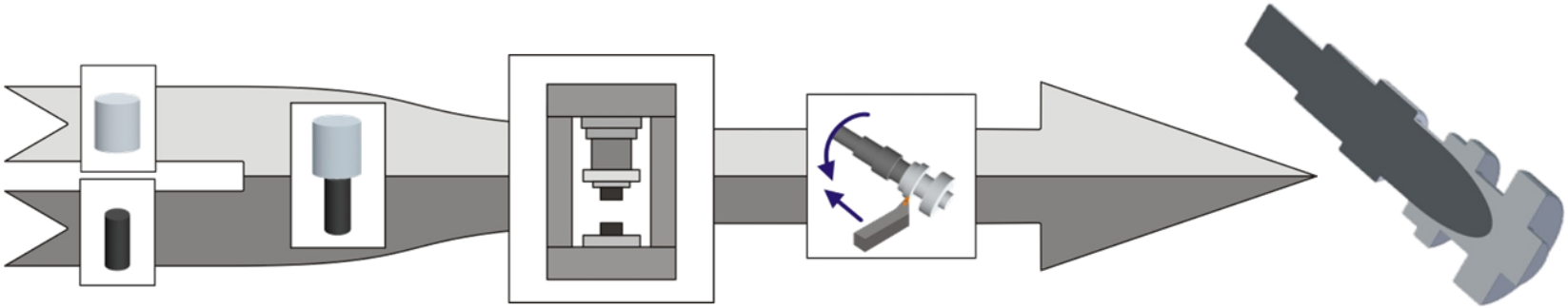
- 3 Dimensional multi-materials
- Different joining processes
- Geometrical and thermo-mechanical treatment of the joining zone



Introduction (4)

Outline of the Collaborative Research Centre "**CRC 1153**"

Use of **combined semi-finished workpieces** and **thermo-mechanical manufacturing processes** to produce hybrid components with locally-adapted properties



Joining

- Laser welding
- Friction welding
- Joining by metal forming

Forming

- Die forging
- Impact extrusion
- Cross wedge rolling

Finishing

- Machining
- Heat treatment
- Finishing

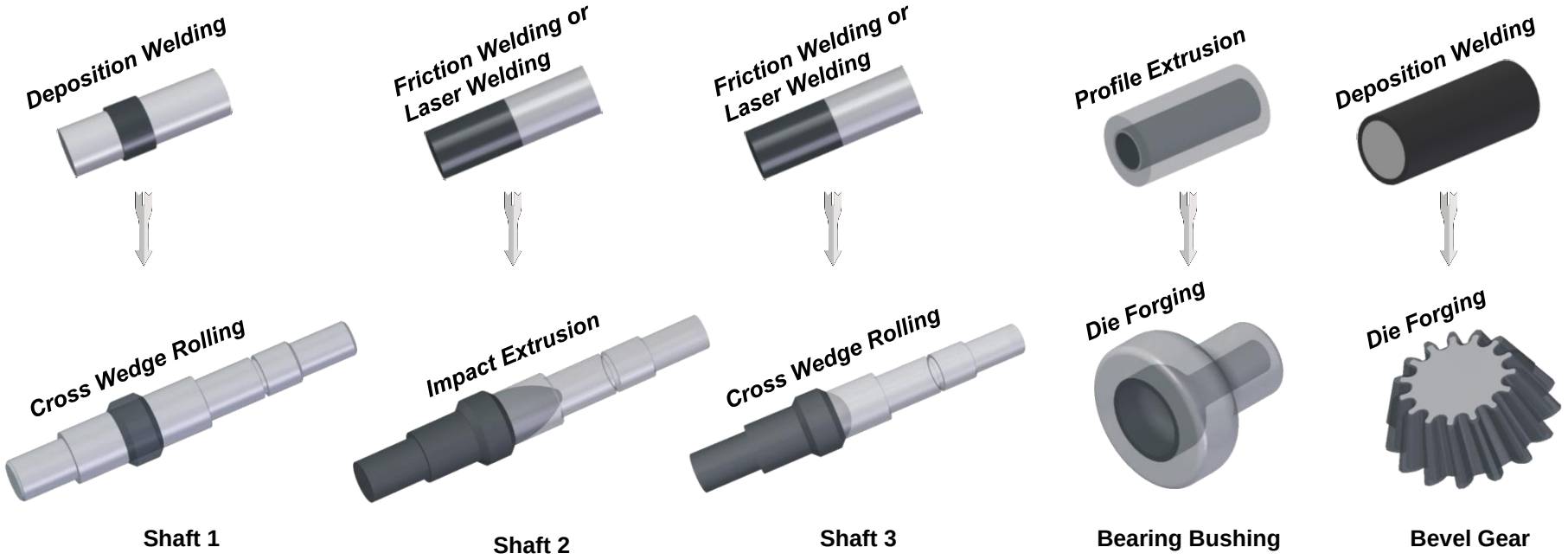
High-performance components with locally-adapted properties

- Service life evaluation
- Geometrical inspection
- Damage prediction
- Multiscale modelling

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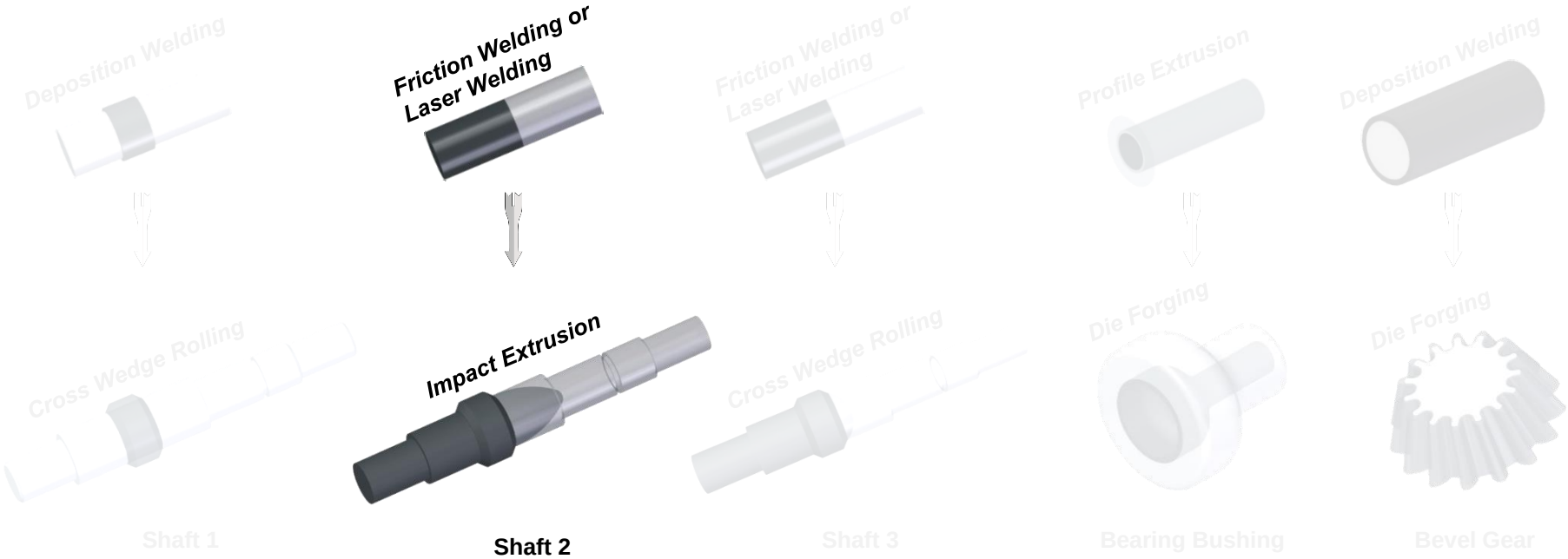
Introduction (5)

Demonstrators of the CRC 1153



Introduction (6)

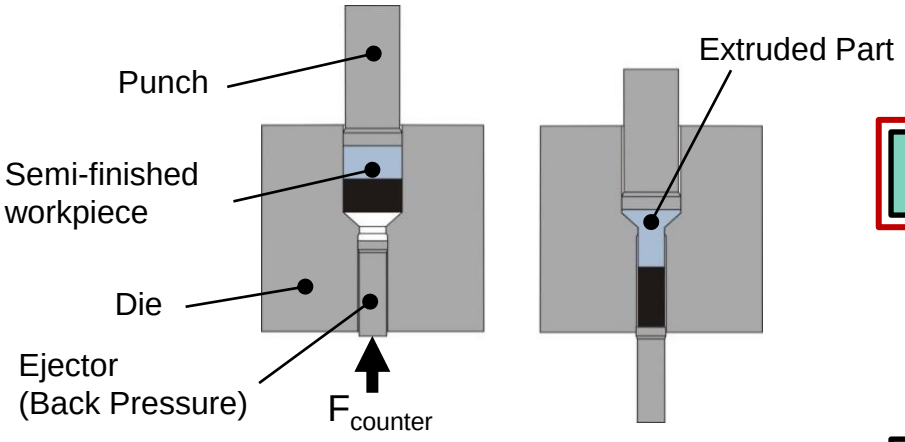
Demonstrators of the CRC 1153

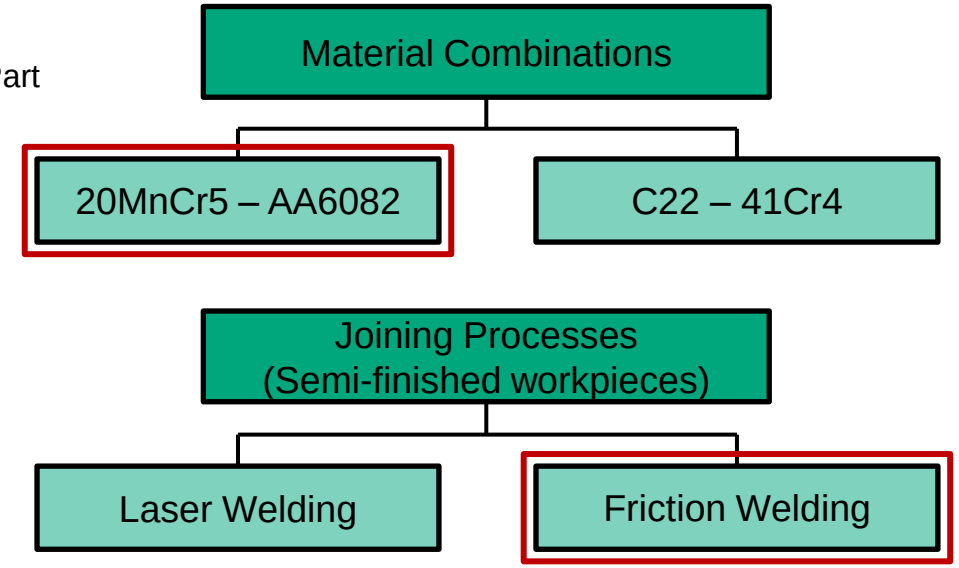


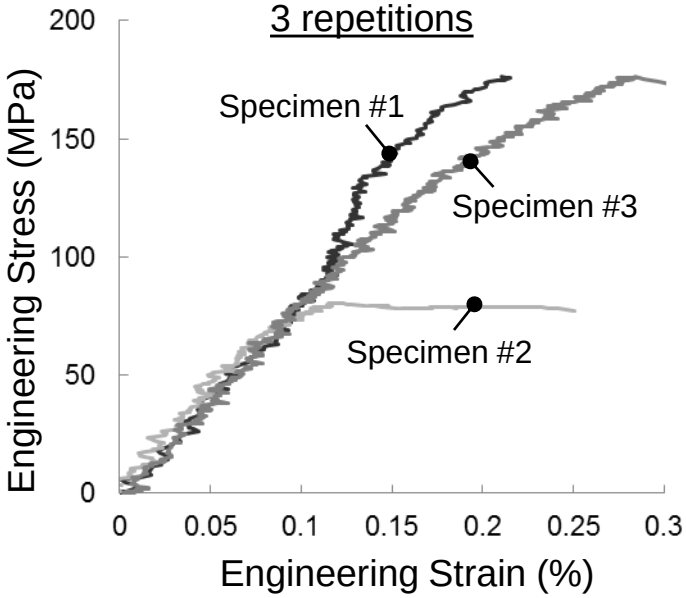
SFB 1153

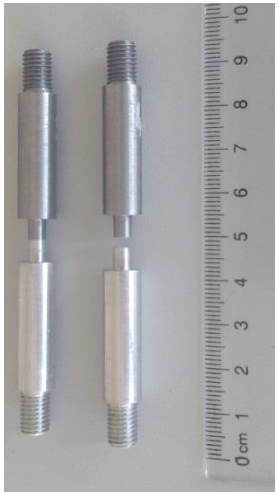
www.sfb1153.uni-hannover.de

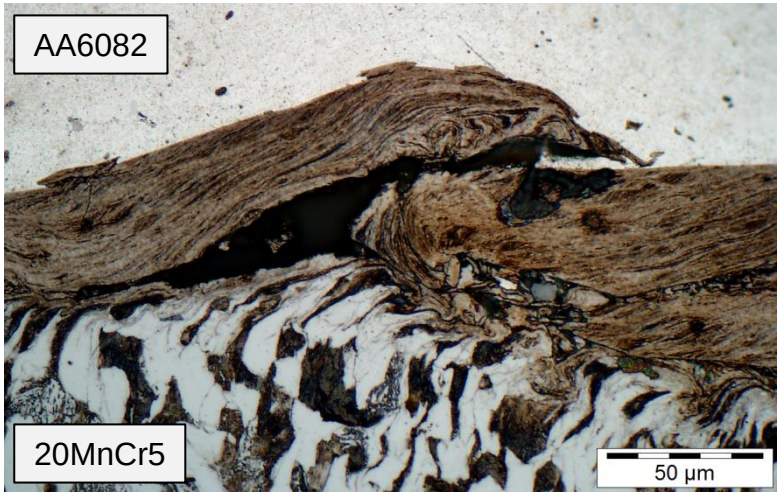
Material and Method (1)





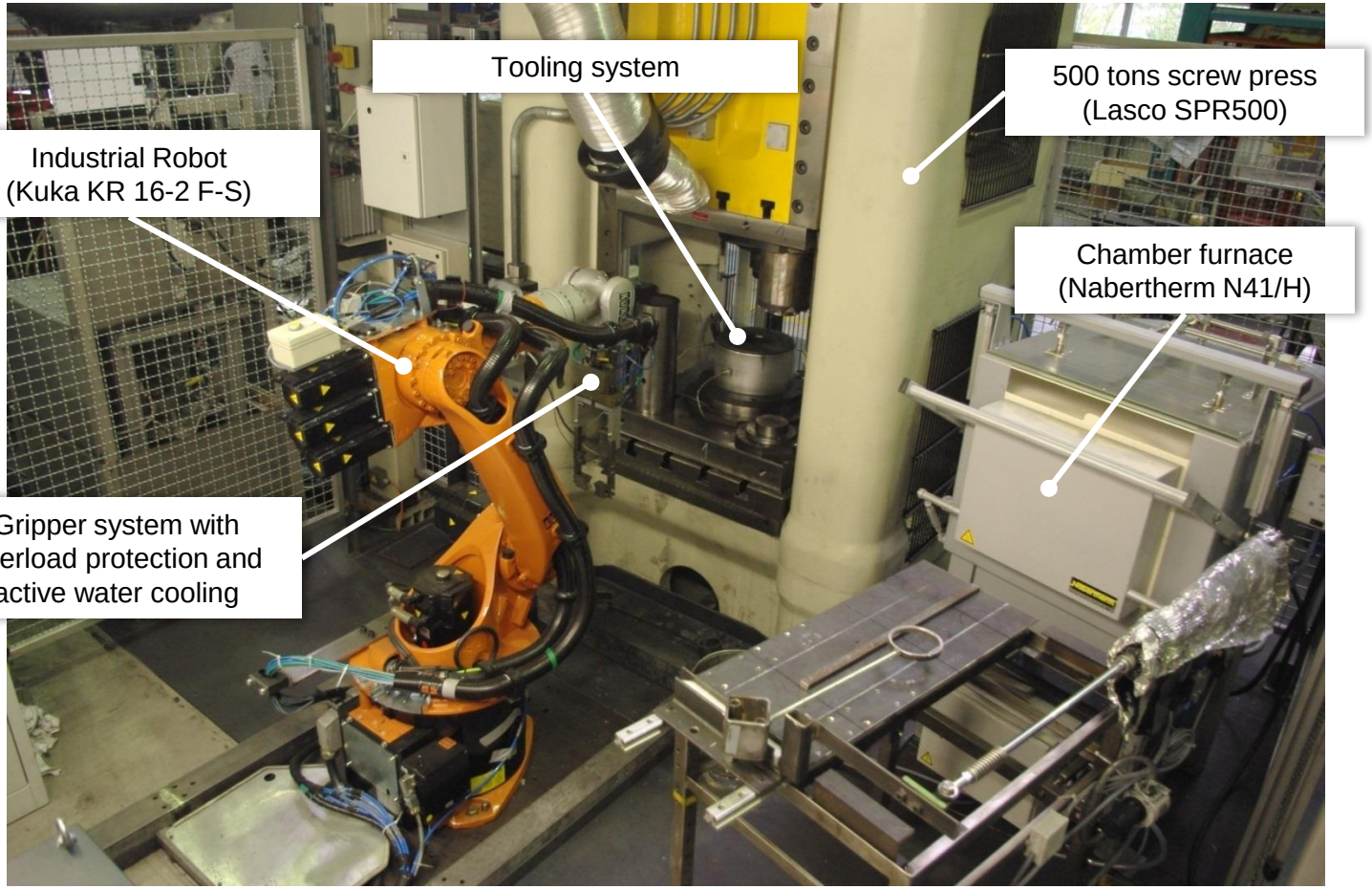






Material and Method (2)

Fully Automated Forging Cell



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Material and Method (3)

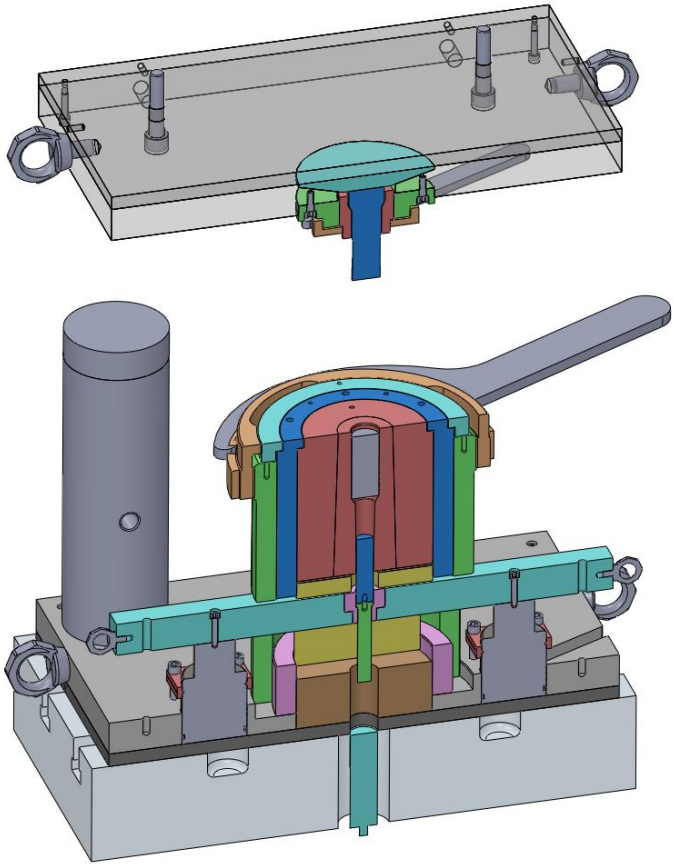
Fully Automated Forging Cell

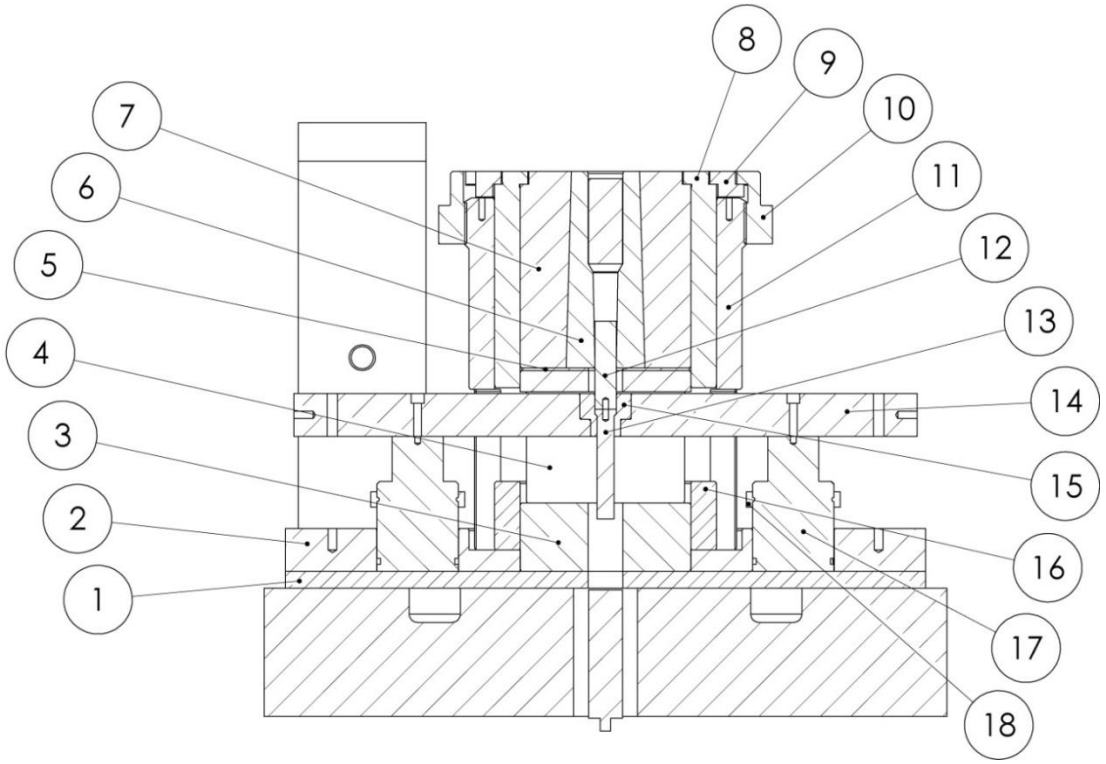


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Material and Method (4)

Tooling System for Back Pressure Superimposed Impact Extrusion



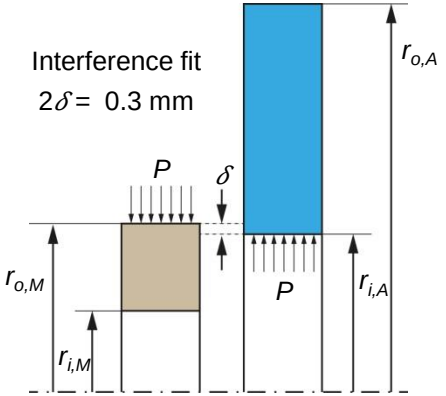


1	Bottom Base Plate	4	Intermediate Plate	7	Shrink Ring	10	Clamping Ring	13	Lower Ejector	16	Centring Ring
2	Top Base Plate	5	Isolating Plate	8	Die Adapter	11	Case	14	Transverse Beam	17	Gas Spring
3	Pressure Plate	6	Die Insert	9	Fixing Ring	12	Upper Ejector	15	Beam Insert	18	Clamping Flange

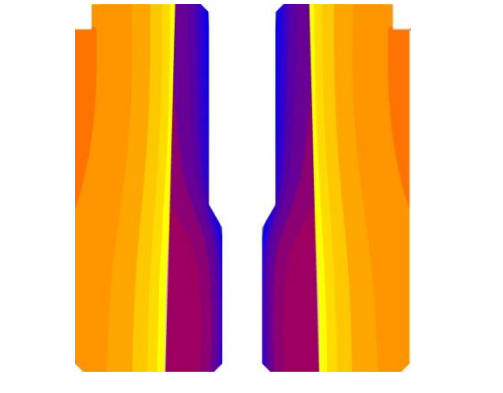
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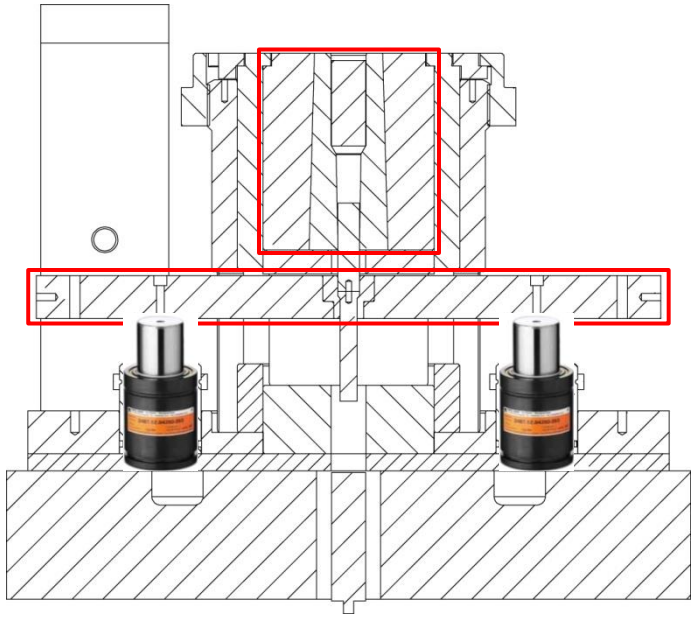
Material and Method (5)

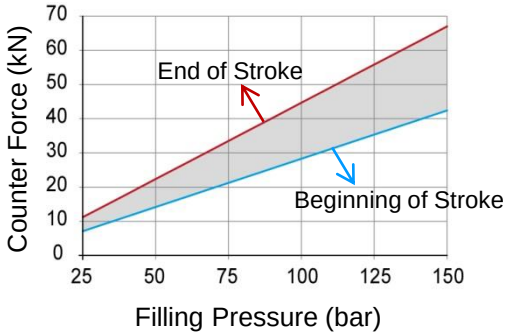
Tooling System for Back Pressure Superimposed Impact Extrusion

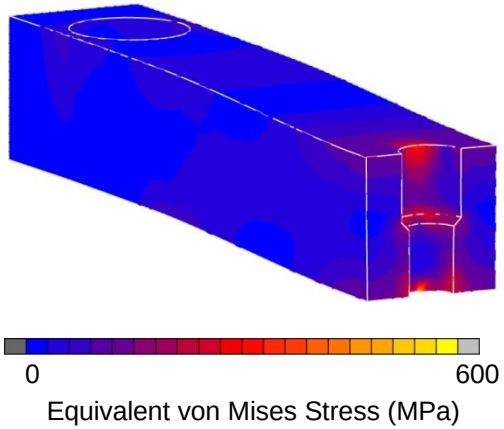


$\frac{r_{o,M}}{r_{i,M}} = 2$ $\frac{r_{o,A}}{r_{o,M}} = 2{,}5$

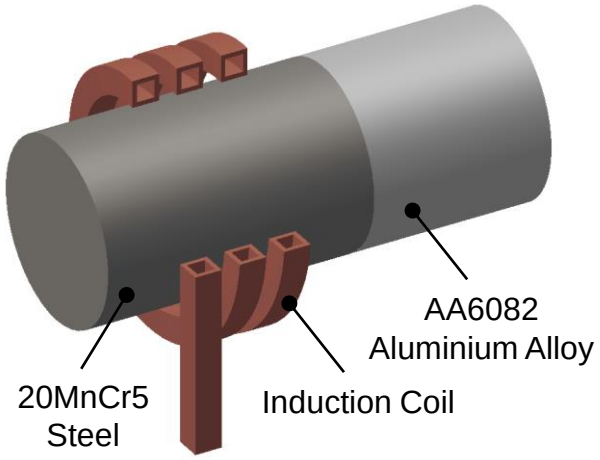






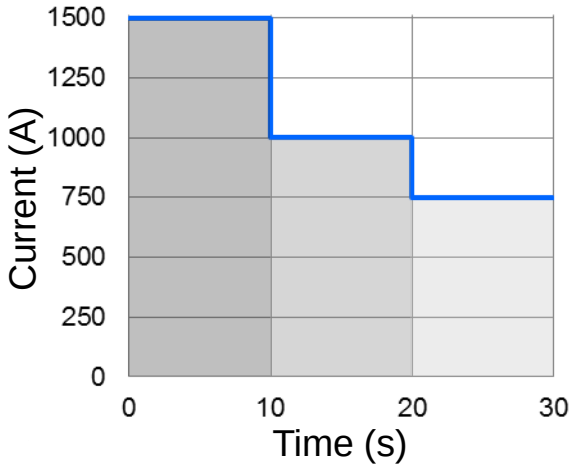


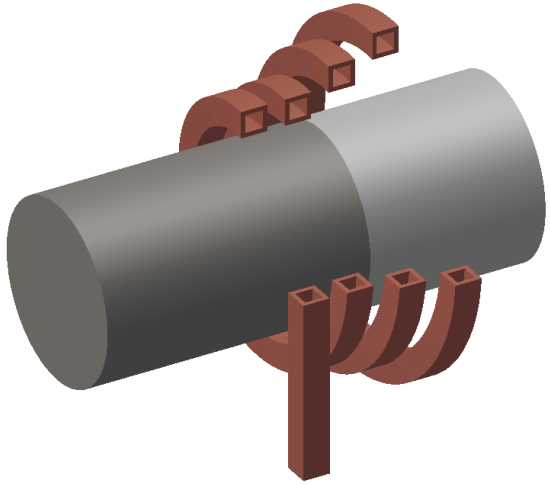
Induction Heating (1)
Introduction of the Strategies



Strategy #1

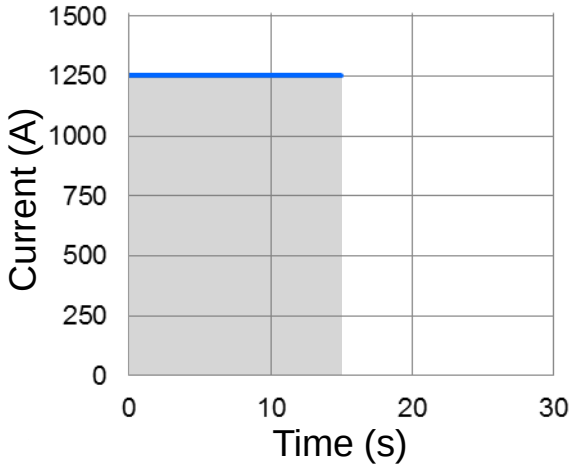
- 10 kHz operating frequency
- Coil with three windings and of constant cross section
- Only steel is induced
- Heating in three steps





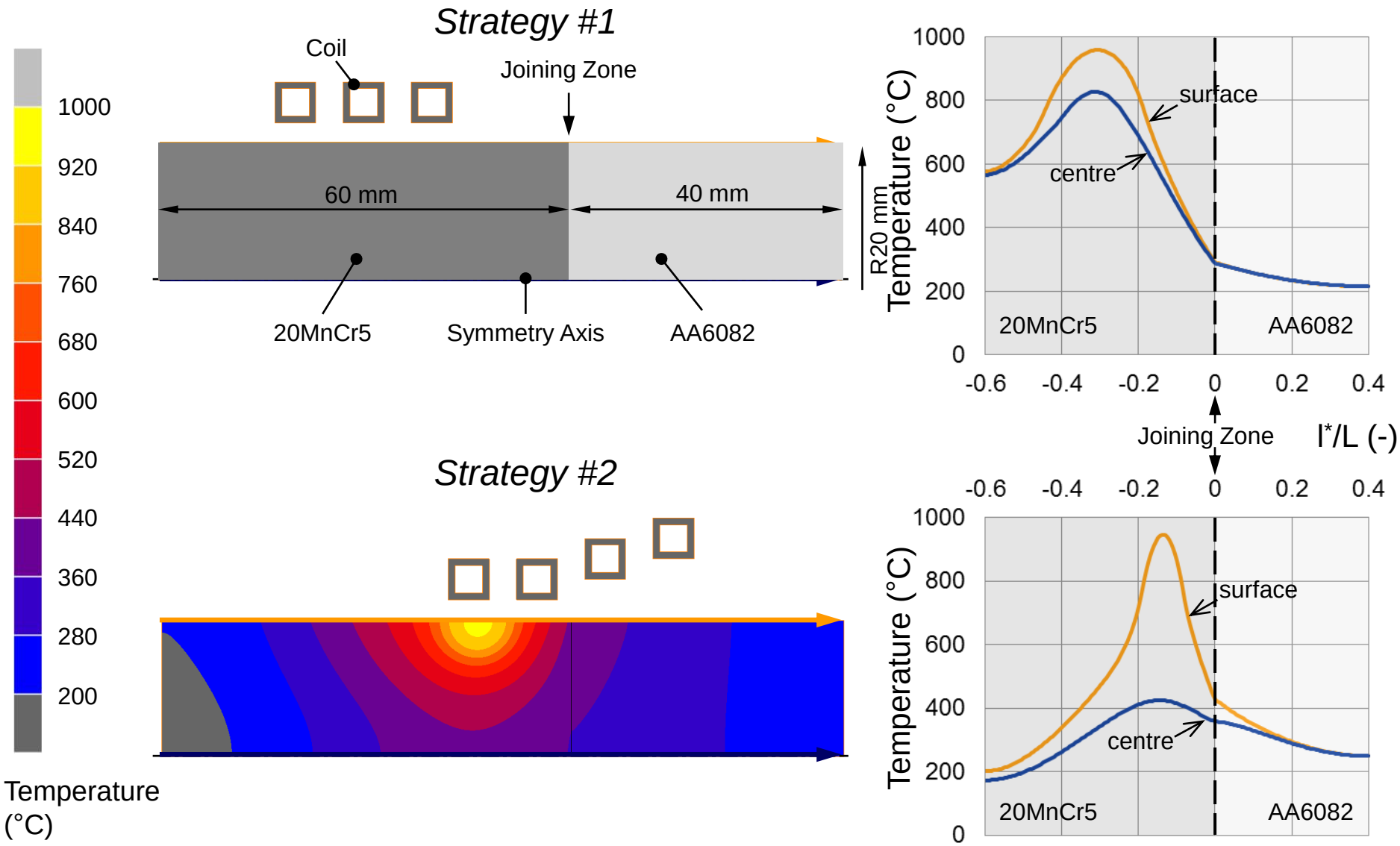
Strategy #2

- 10 kHz operating frequency
- Coil with four windings and variable in cross section
- Positioned around the joining zone
- Single step heating

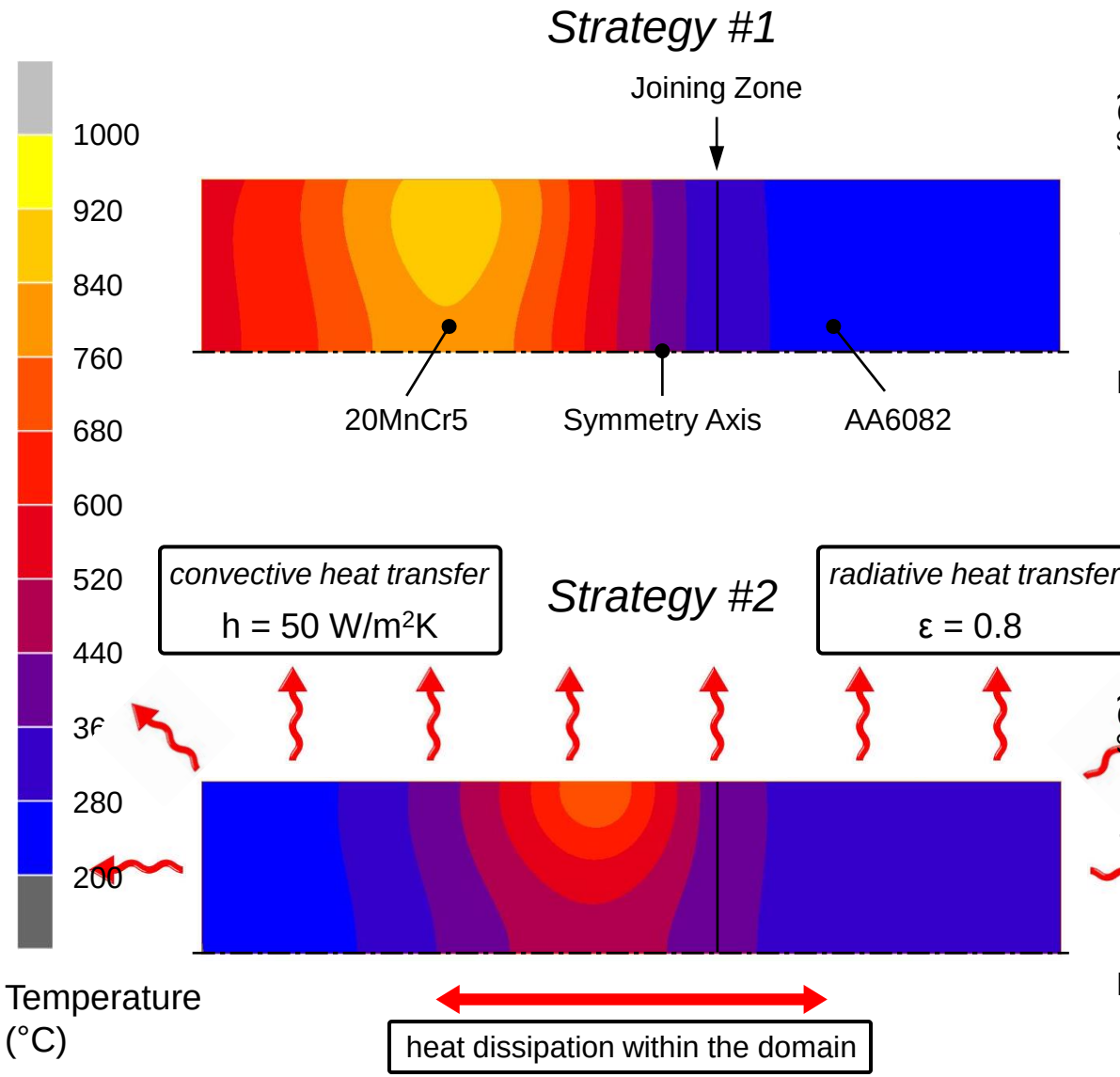


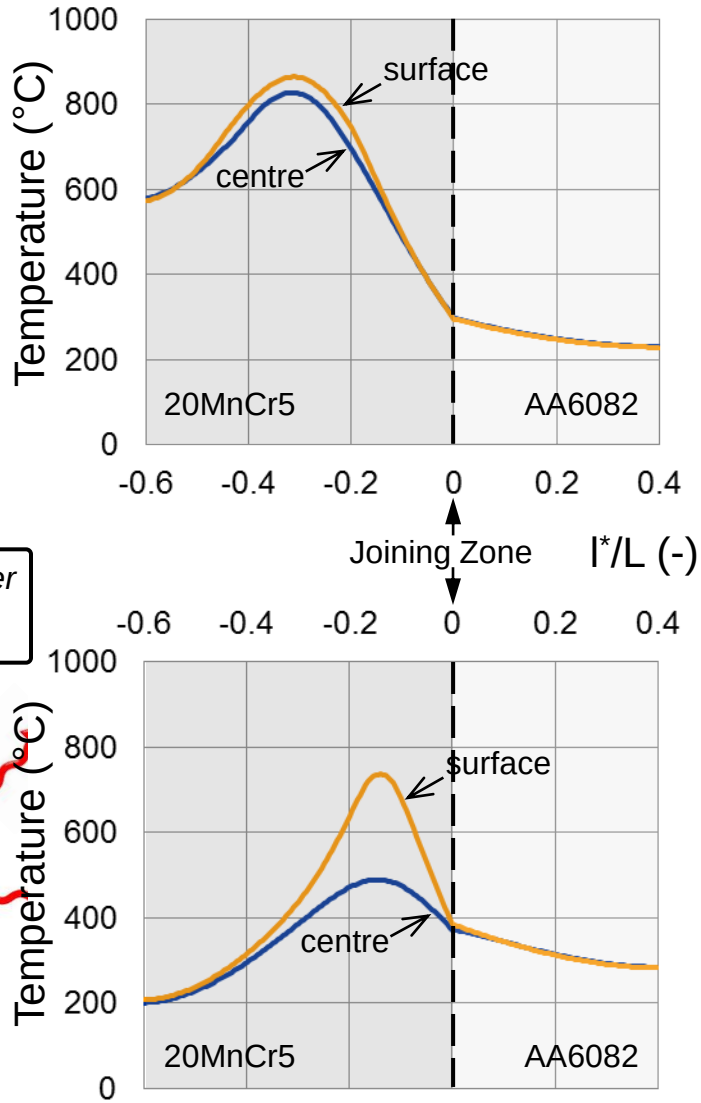
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Induction Heating (2)
Temperature Distribution After Heating

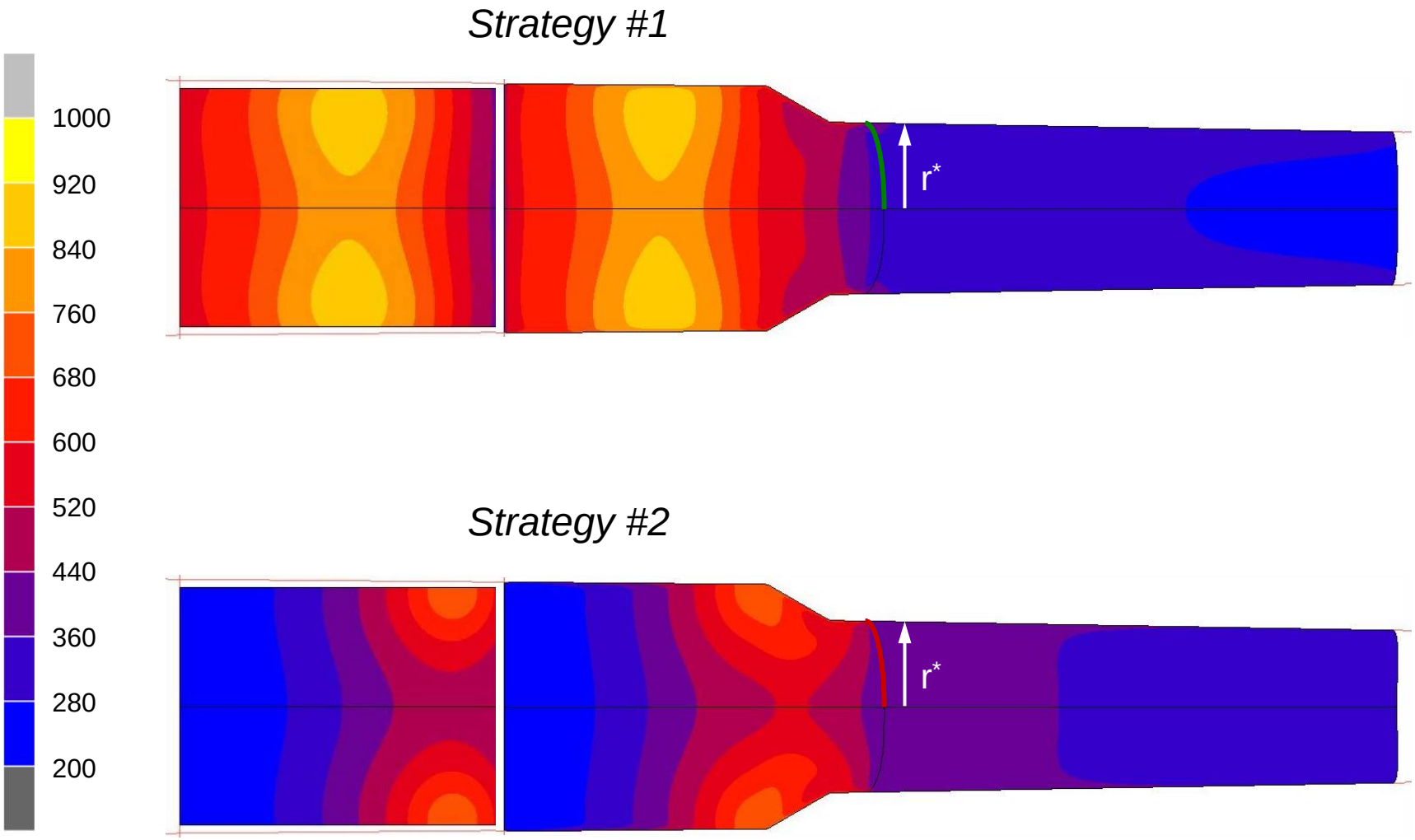


Induction Heating (3)
Temperature Distribution After 3 s Transfer Time

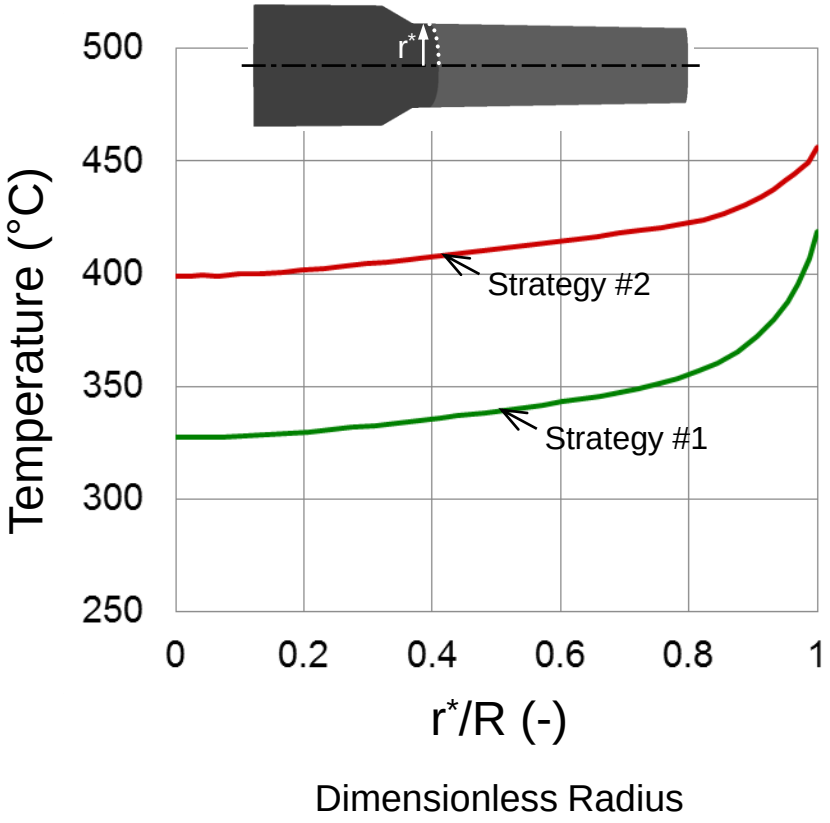




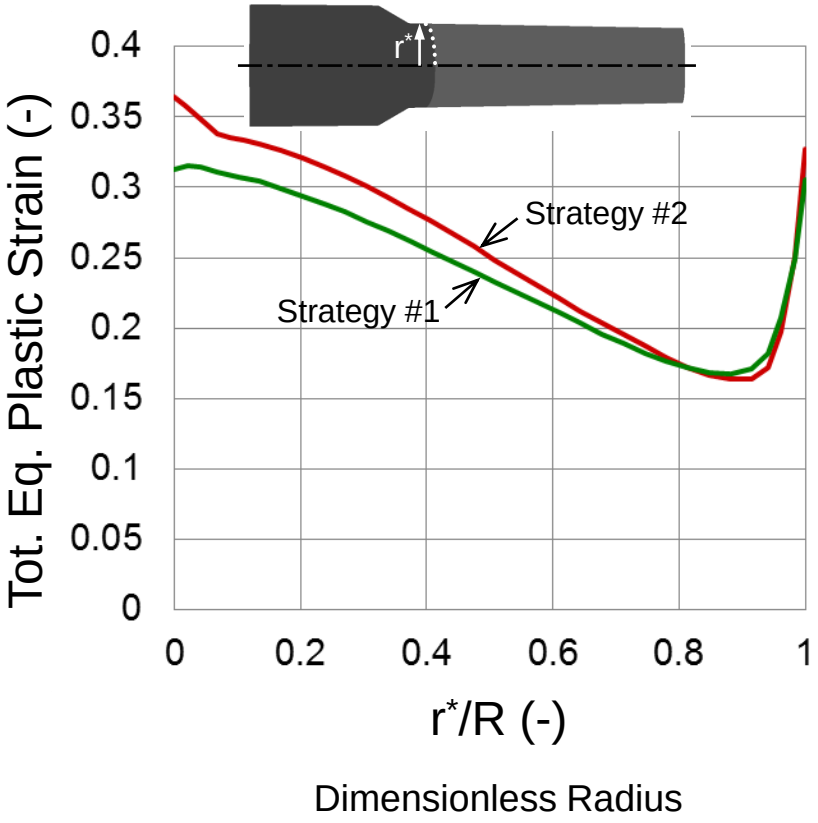
Forming Simulation (1)
Temperature Distribution During Extrusion



Forming Simulation (2)
Temperature and Plastic Strain Profiles of the Joining Zone



Dimensionless Radius



Dimensionless Radius

Thank you for your attention!

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SFB 1153 www.sfb1153.uni-hannover.de

The results presented in this paper were obtained within the Collaborative Research Centre 1153 ‘‘Process chain to produce hybrid high performance components by Tailored Forming’’ in the subproject B3. The speaker would like to thank German Research Foundation (DFG) for the financial and organisational support of this project.

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