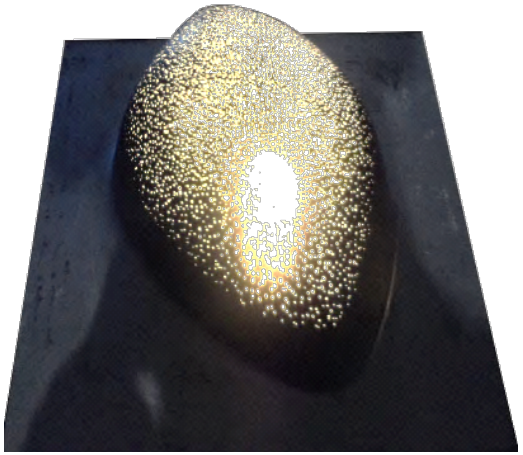
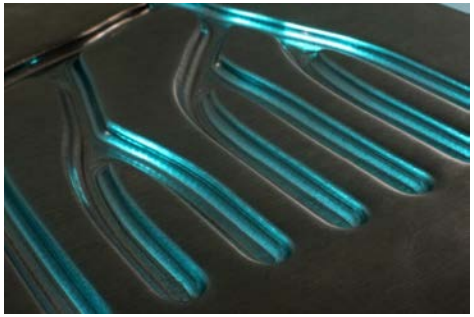
DEVELOPMENT OF A NEW VARIANT OF INCREMENTAL SHEET METAL FORMING USING HEATED AIR

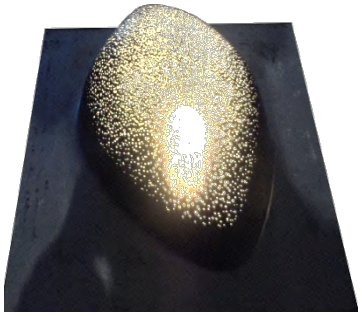
Dr.-Ing. R. Müller, Dipl.-Ing. D. Weise, Prof. Dr.-Ing. D. Landgrebe

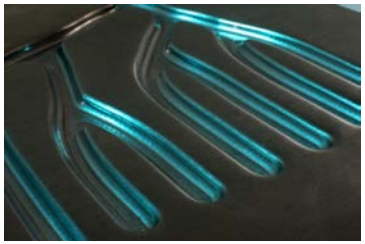




AGENDA

1. Introduction
2. ISF at Fraunhofer IWU
3. ISF using heated air
4. Conclusions





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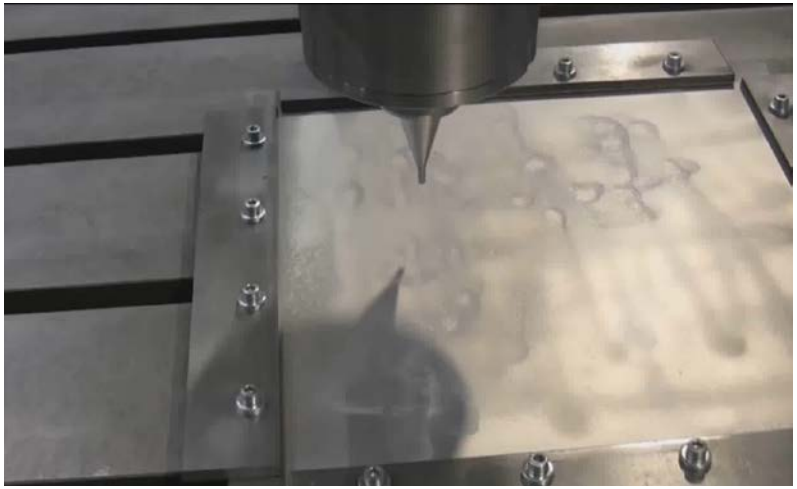
ISF at Fraunhofer IWU
Introduction

- gradual kinematic shape generation
- several successive tool movements
- very small proportion: deformation zone to component volume
- tools with a low shape memory degree
- examples:
  - pressure forming
  - swaging
  - peening
- incremental sheet metal forming:
  - mandrel forms metal sheets by moving along predetermined lines



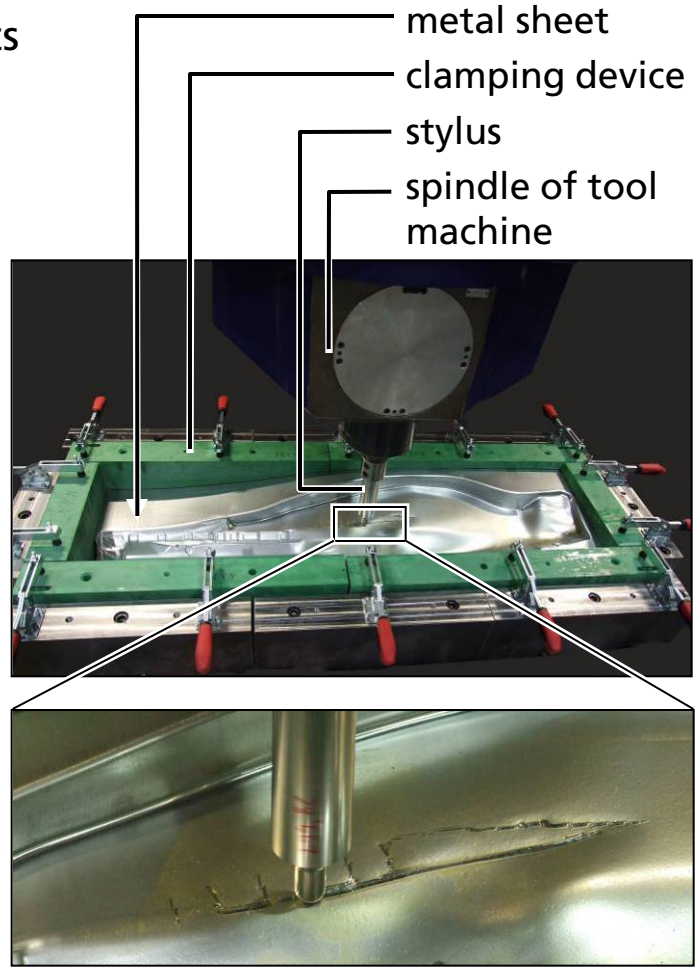
incremental sheet metal forming at IWU

Fraunhofer IWU

ISF at Fraunhofer IWU
General process

- tool machines and robots for mandrel movements
- use of different stylus alternatives
- predominantly rotating stylus
- use of various blank holder
- use of partial or full dies

universal machining centre Dynapod at IWU



incremental sheet metal forming at IWU

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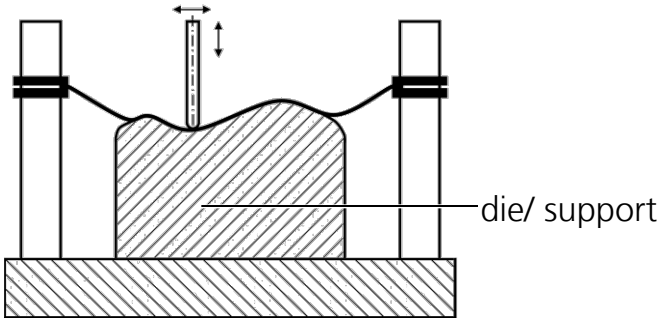
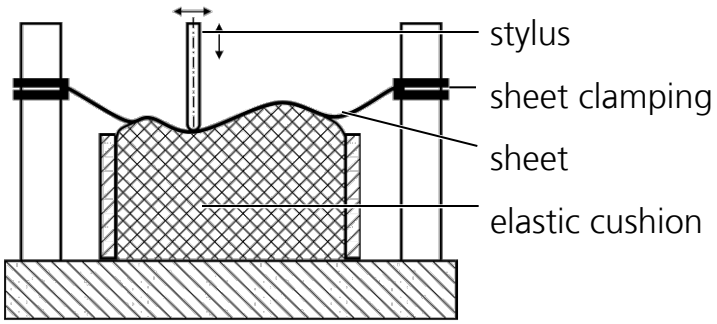
ISF at Fraunhofer IWU

Process Variants of IFS

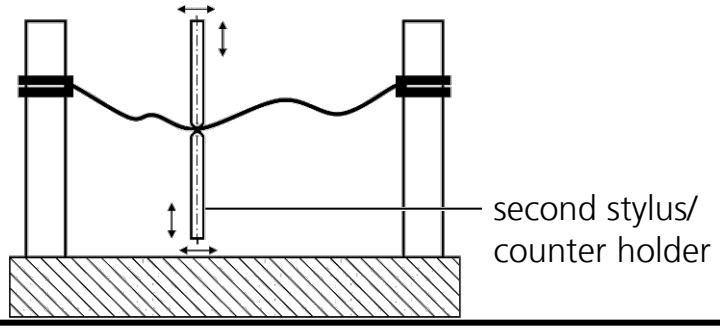
Use of a (partial) die/ support



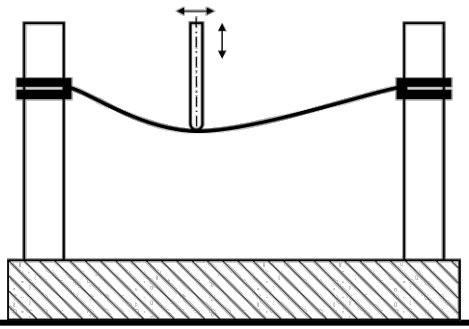
Use of an elastic cushion



Use of a counter holder or second stylus



Use of no support



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Process Variants of IFS

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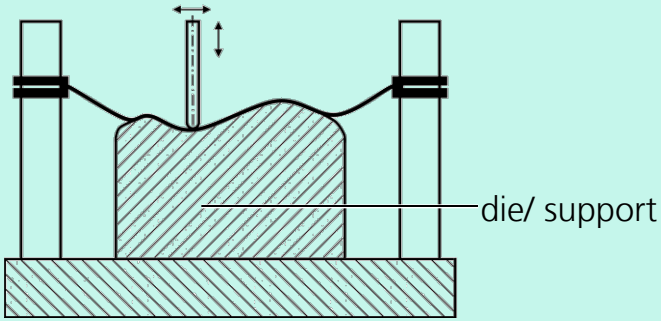
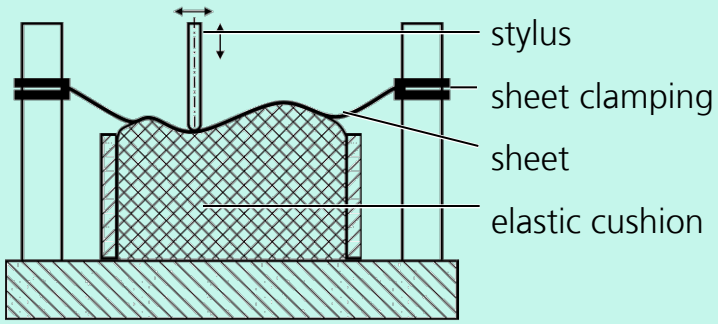


Use of an elastic cushion



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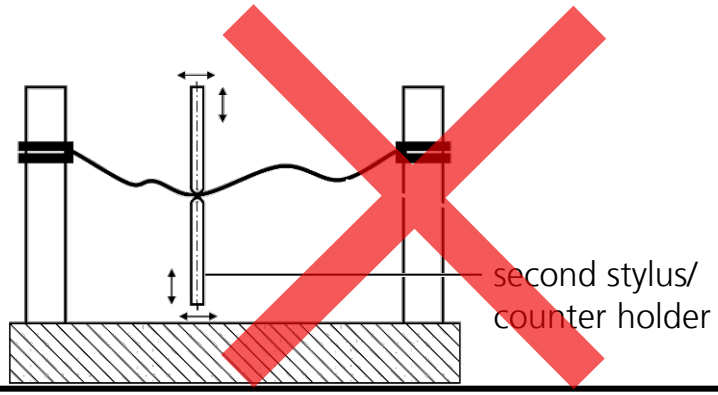
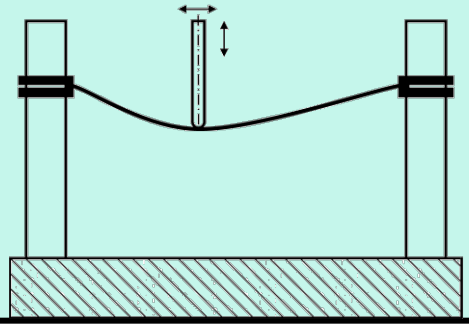


Use of no support



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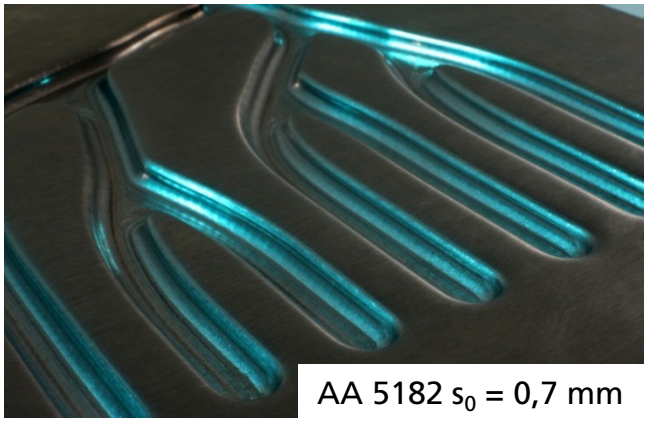
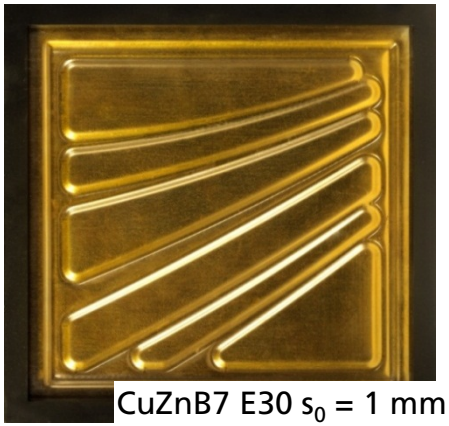
Spectrum of parts I



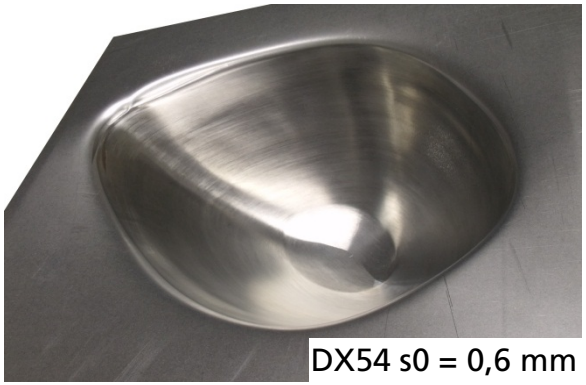
AA 5182 s_0 = 0,7 mm

„channel structure ‘



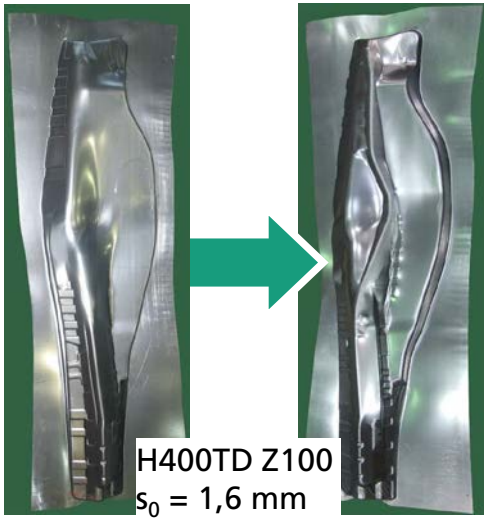
CuZnB7 E30 s_0 = 1 mm

„FhG logo“



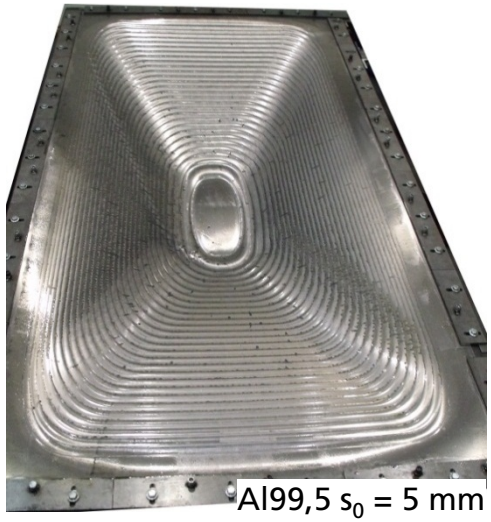
DX54 s0 = 0,6 mm

„Schale“



H400TD Z100
s_0 = 1,6 mm

„transmission bracket“



Al99,5 s_0 = 5 mm

„casing “

conventional

incremental

AA5182 s_0 = 1 mm

„bowl“

DC04 s_0 = 0,7 mm

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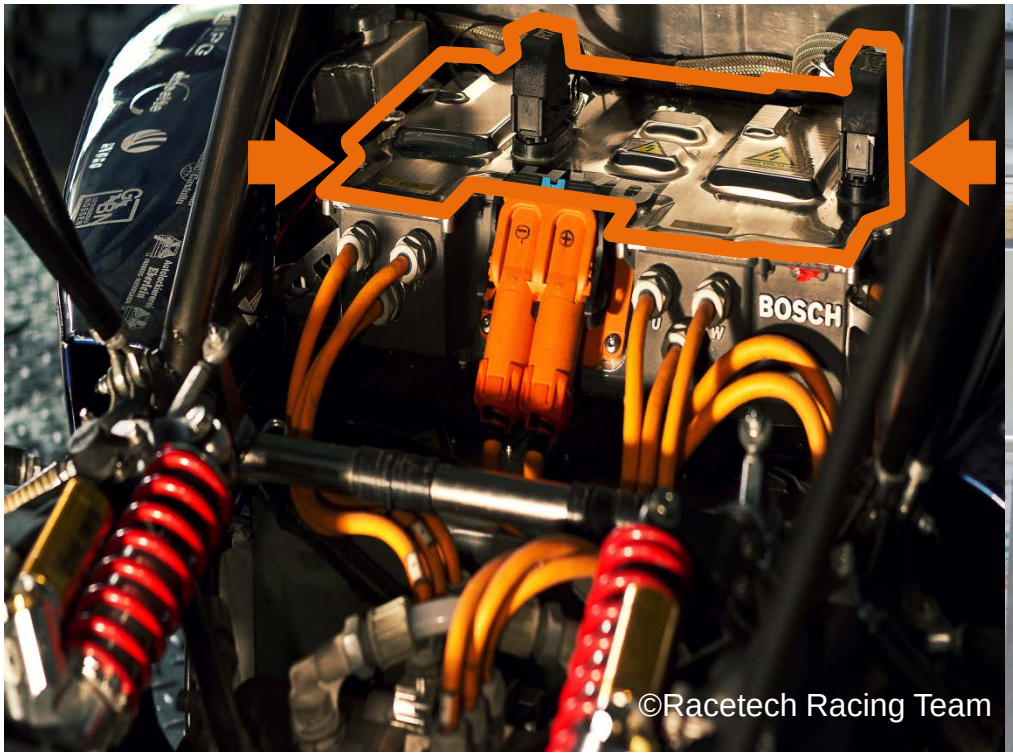
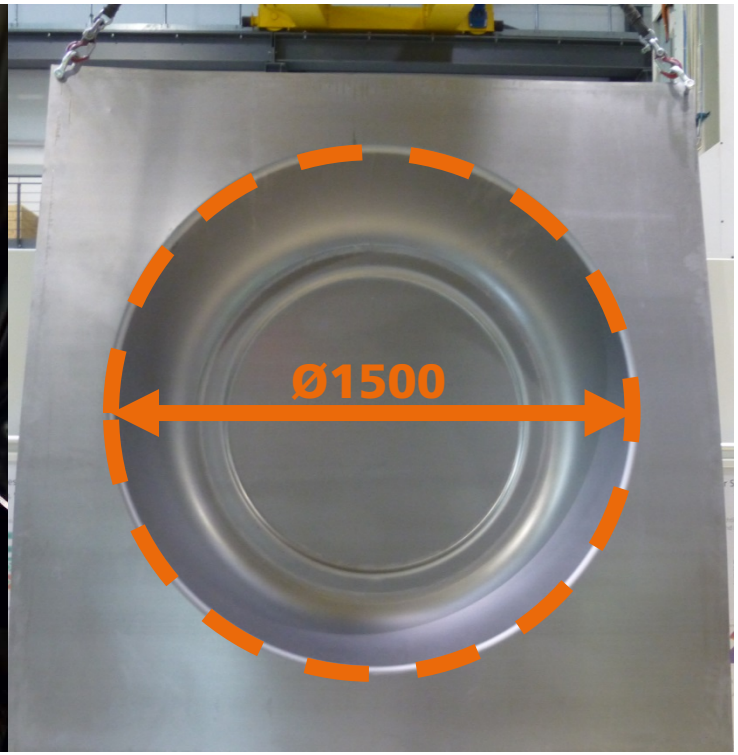
Spectrum of parts II



battery hood (A6016 s_0 = 0,6 mm)



Windmill housing element (DC04 s_0 = 1,5 mm)

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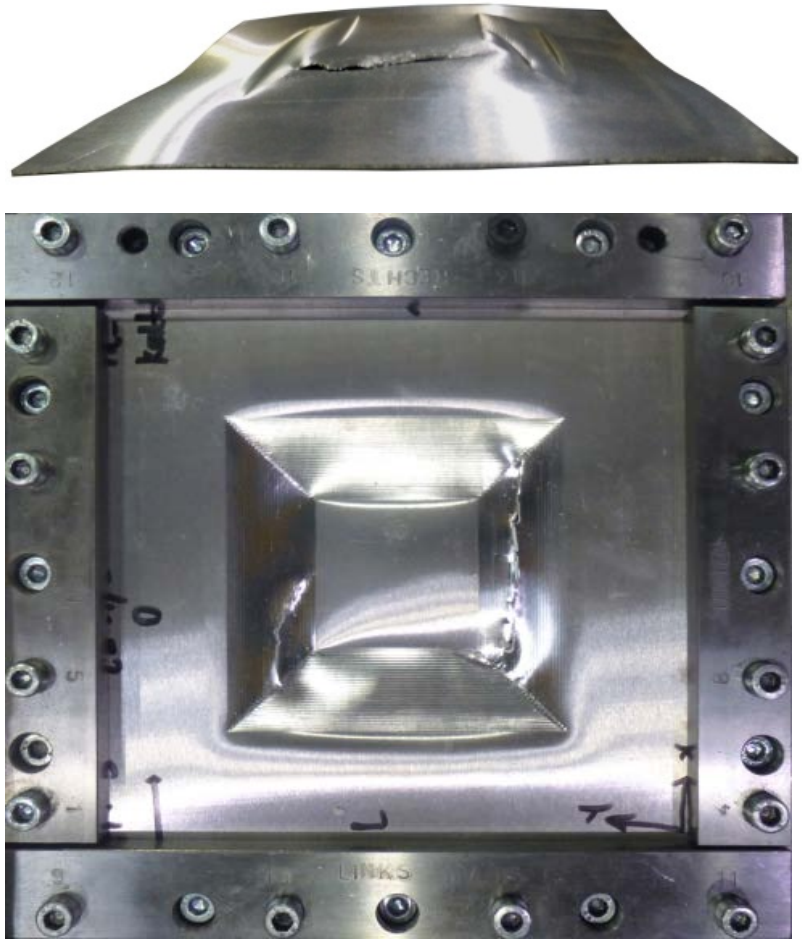
ISF using heated air
Challenge



test components truncated pyramids at 20 °C

- challenge: high risk of failures in cold forming
- new method of temperature-assisted incremental sheet metal forming (ISF) of lightweight materials was developed at Fraunhofer IWU
- basic idea: combination of conventional single-point incremental forming (SPIF) with evenly distributed heated air flow under the sheet
- result of heated air: whole sheet receives approximately same temperature
- part quality significantly better in comparison to conventional ISF

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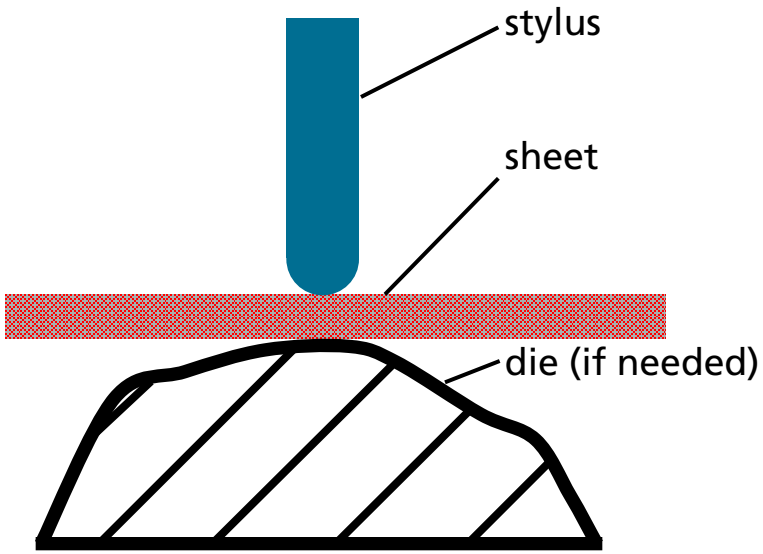
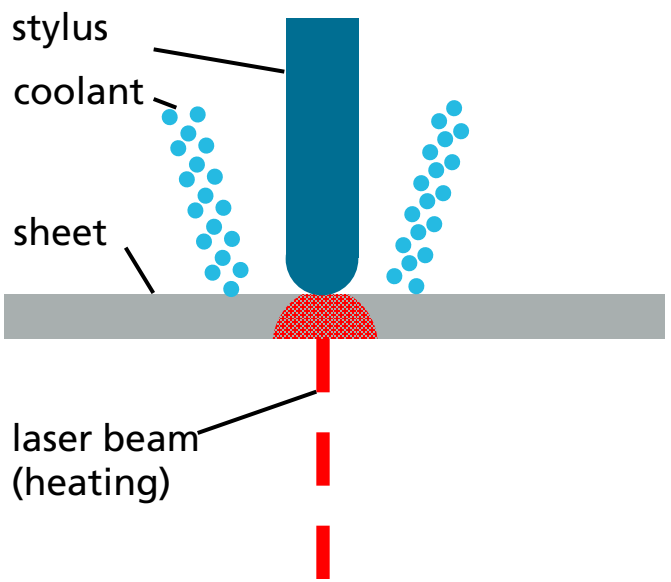
ISF using heated air
Heating strategy

- two different strategies:
  - global heating (IWU)
  - local heating (Sirris/KUL)



global heating



local heating

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ISF using heated air
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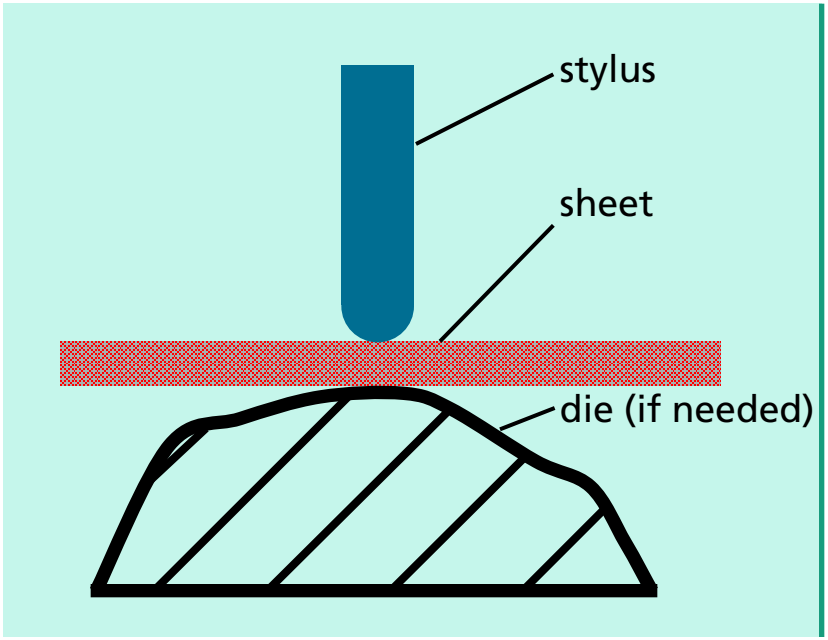
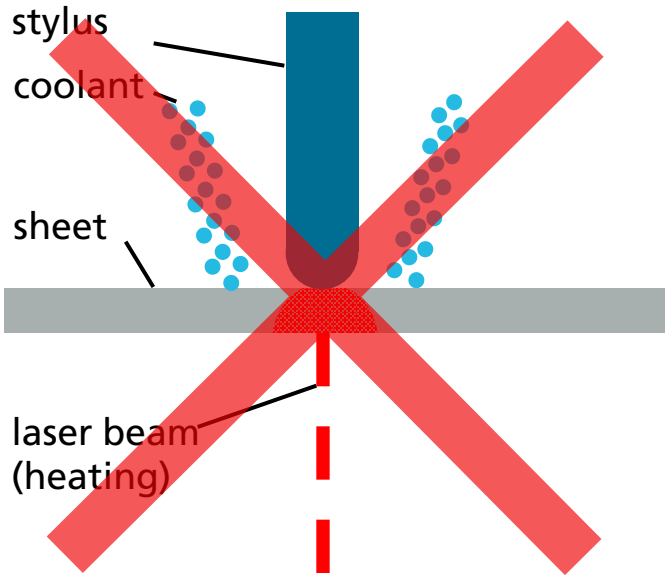


global heating



local heating

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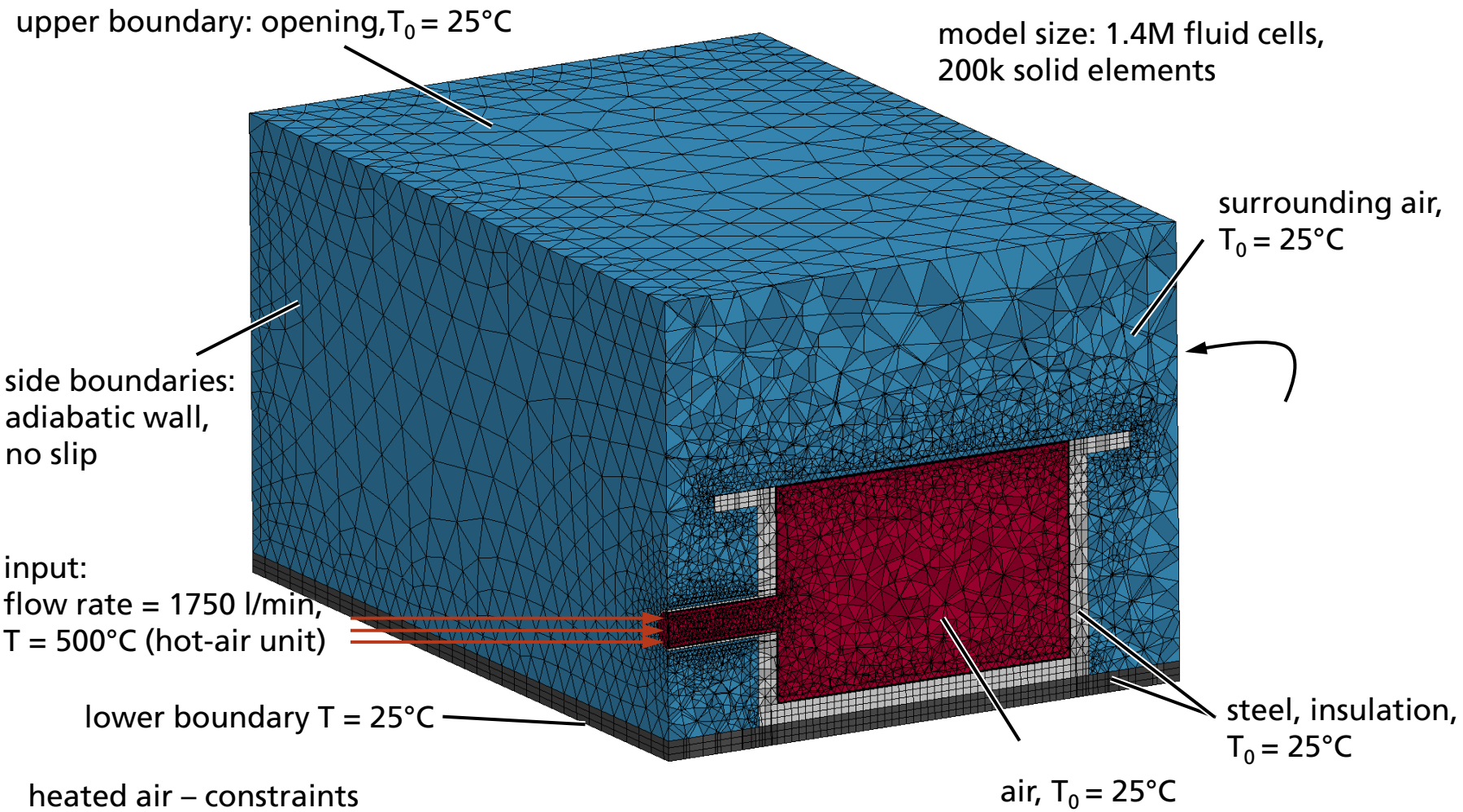
ISF using heated air

Global heating strategy – Simulation model



heated air – constraints

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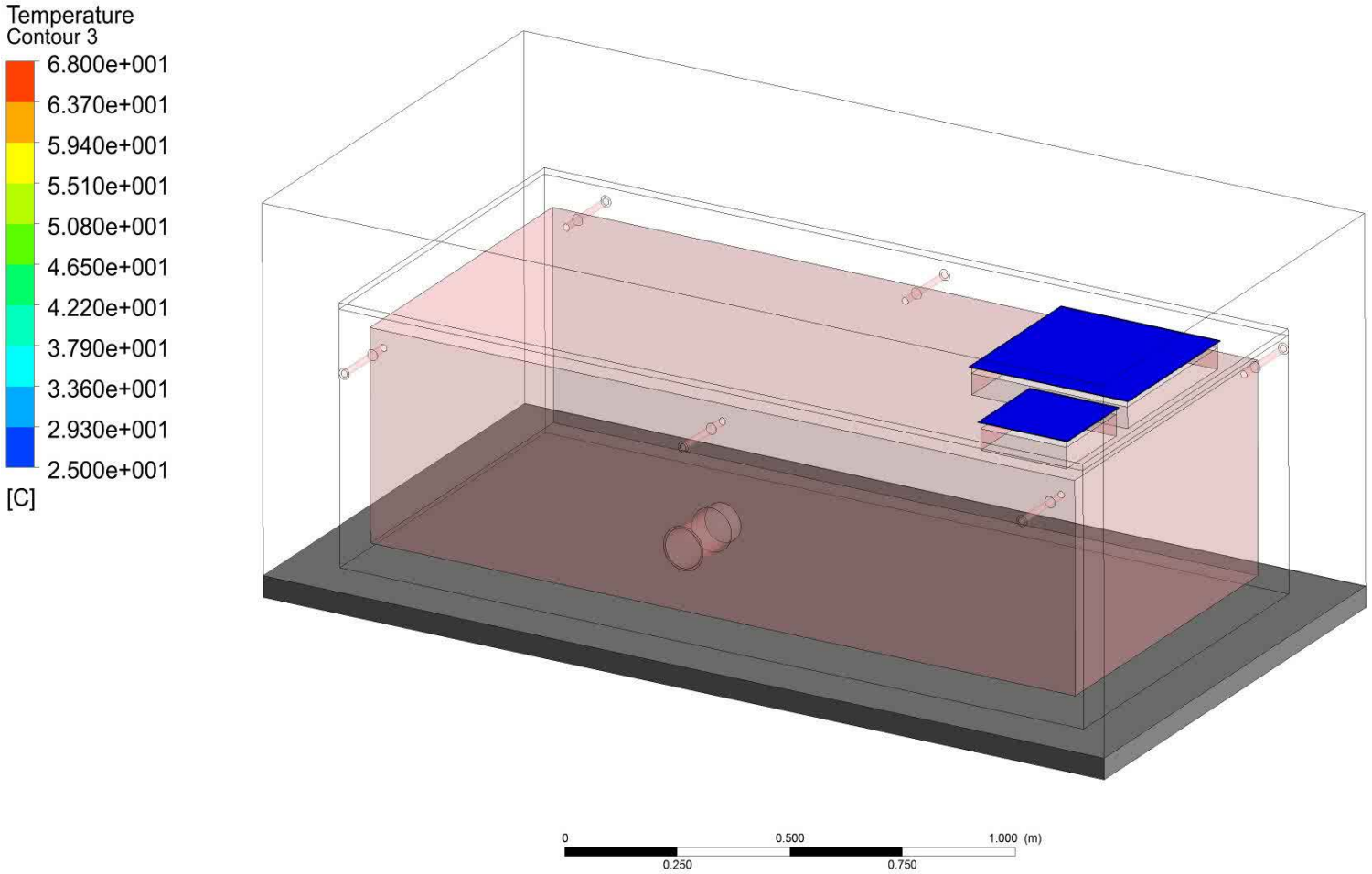
ISF using heated air

Global heating strategy – Simulation results (1)



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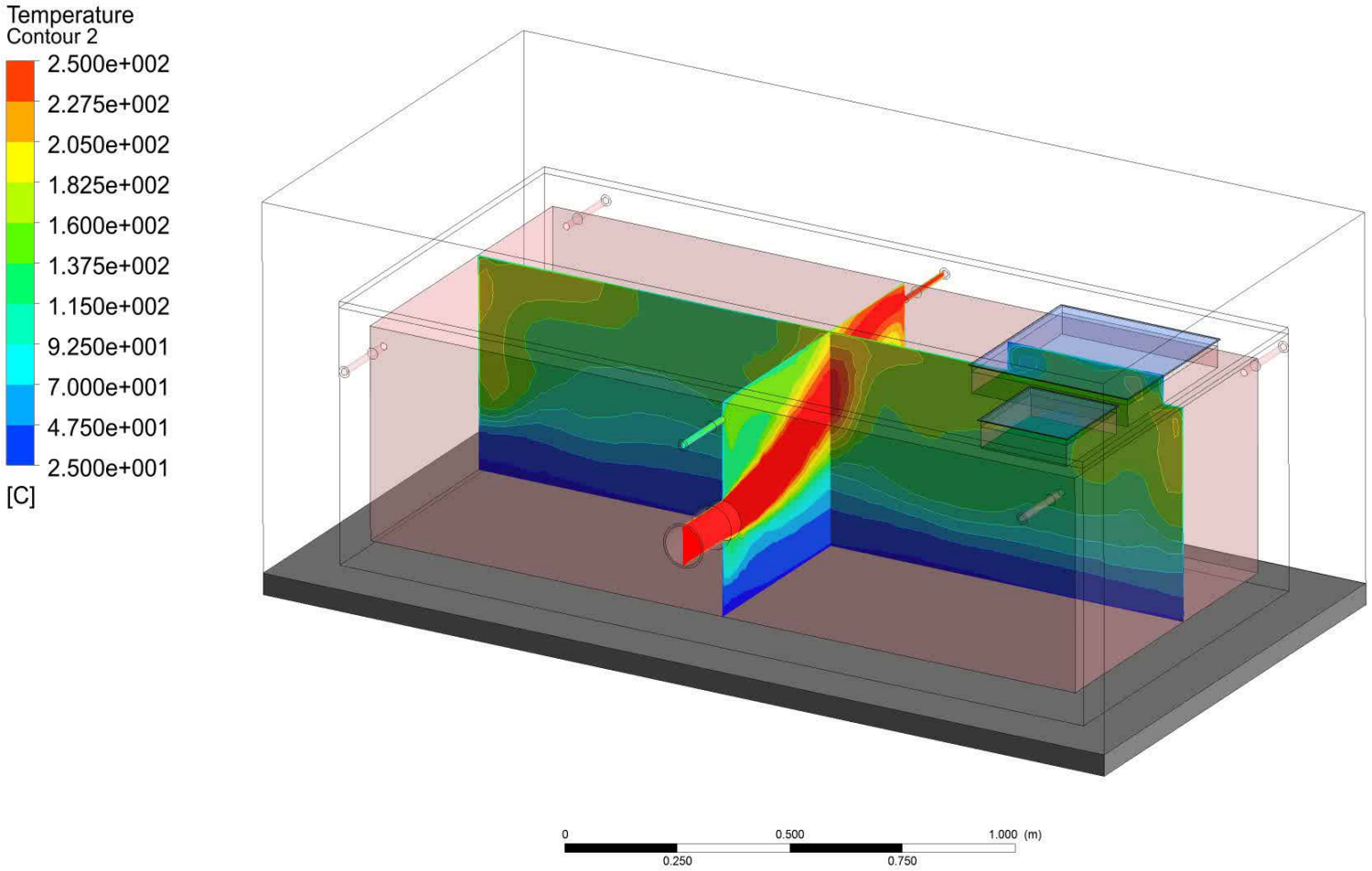
ISF using heated air

Global heating strategy – Simulation results (2)



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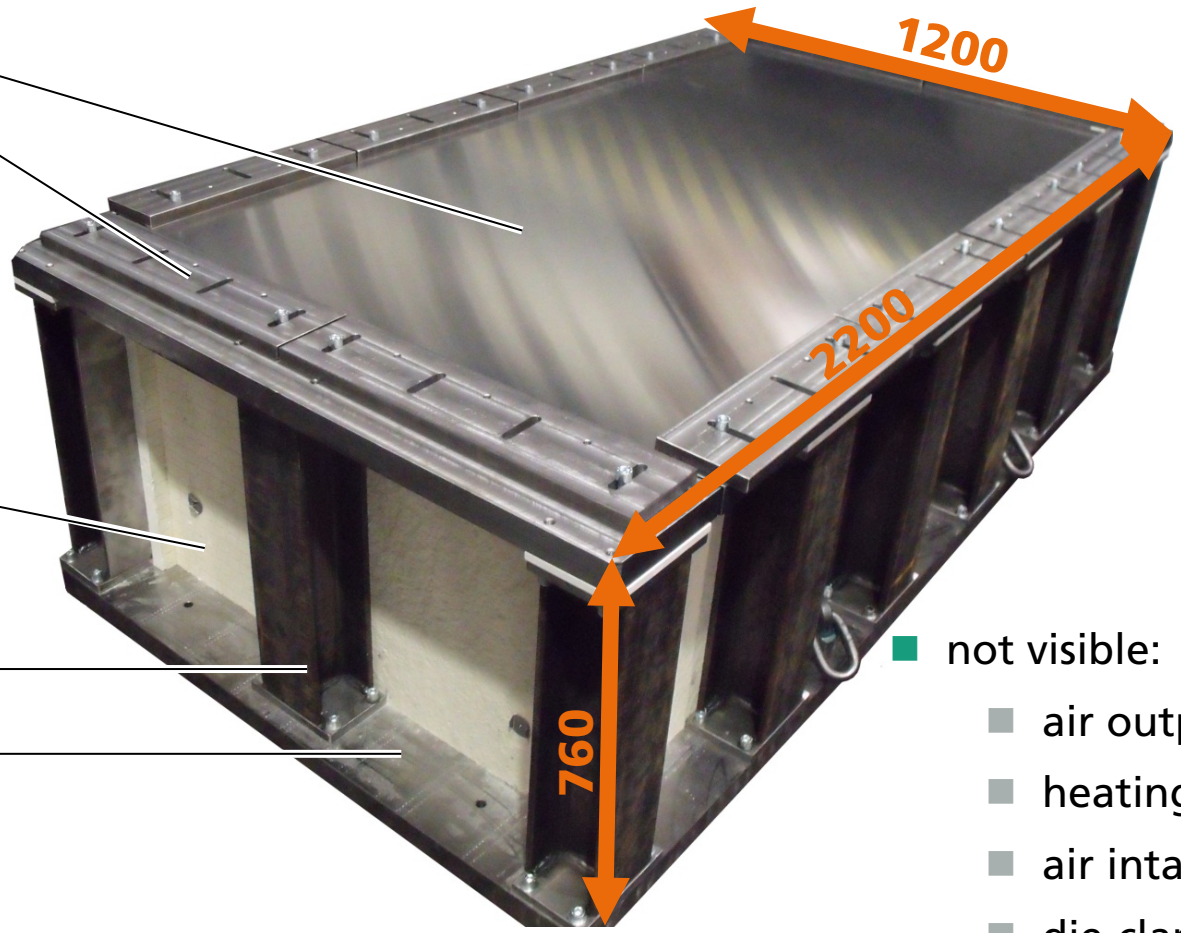
ISF using heated air

Heat assisted ISF set-up



- not visible:
  - air output
  - heating device
  - air intake
  - die-clamping plate

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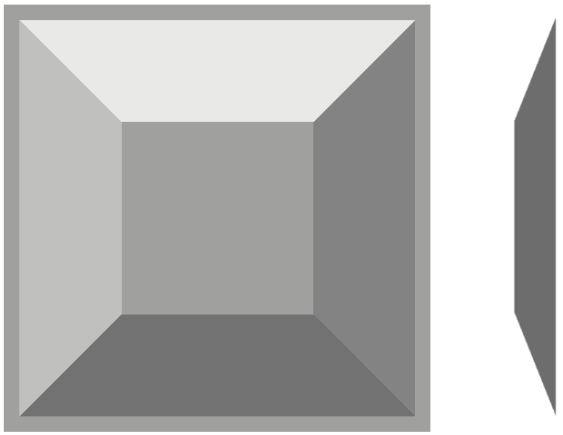
Temperature-supported incremental sheet forming
Test conditions

- experiments on the magnesium alloies AM50 und AZ31
- using of a uniform international test component
  - truncated pyramid with
  - 20° flank angle
  - 128 mm length of edge (big edge)
  - sheet thickness 1,2 mm
- test parameters
  - 2 m/min feed rate
  - 10 mm stylus diameter
  - z-constant course set-up
  - stable path direction
  - 0,394 mm adjusting increment (z-direction)



Test component „truncated pyramid“

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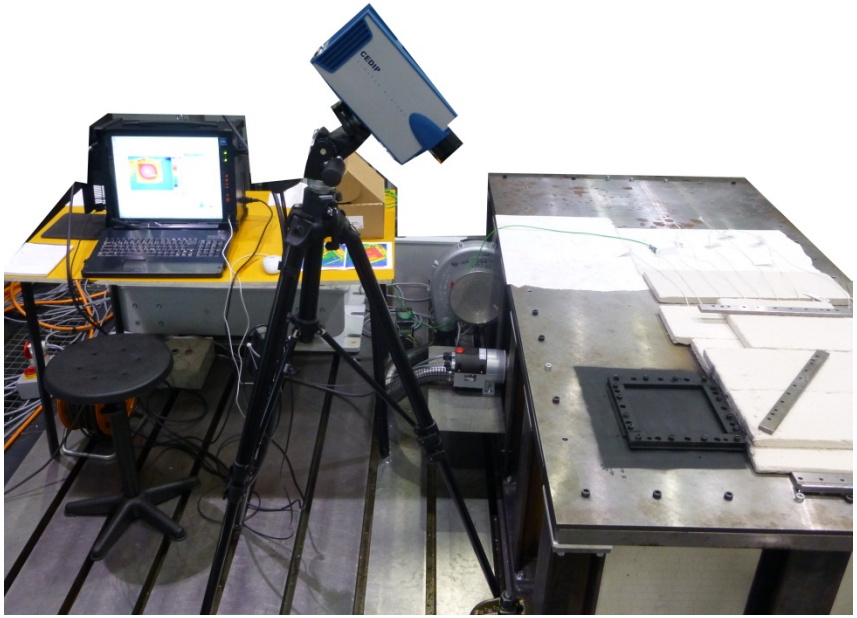
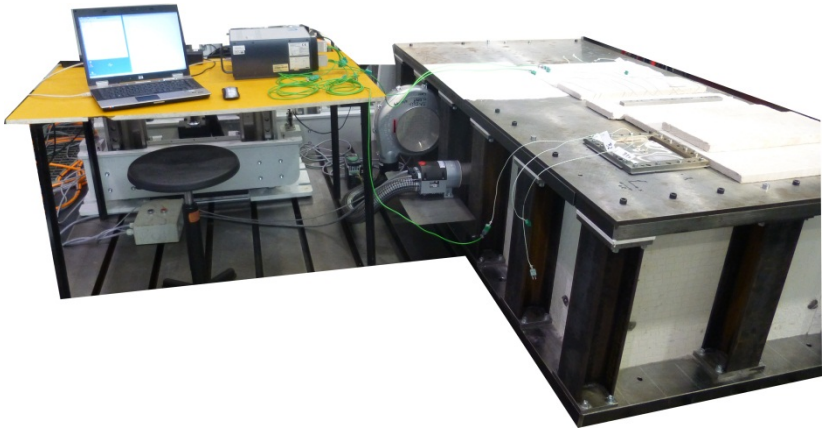
ISF using heated air
Test setup

- measurement by thermocouple and thermographic camera

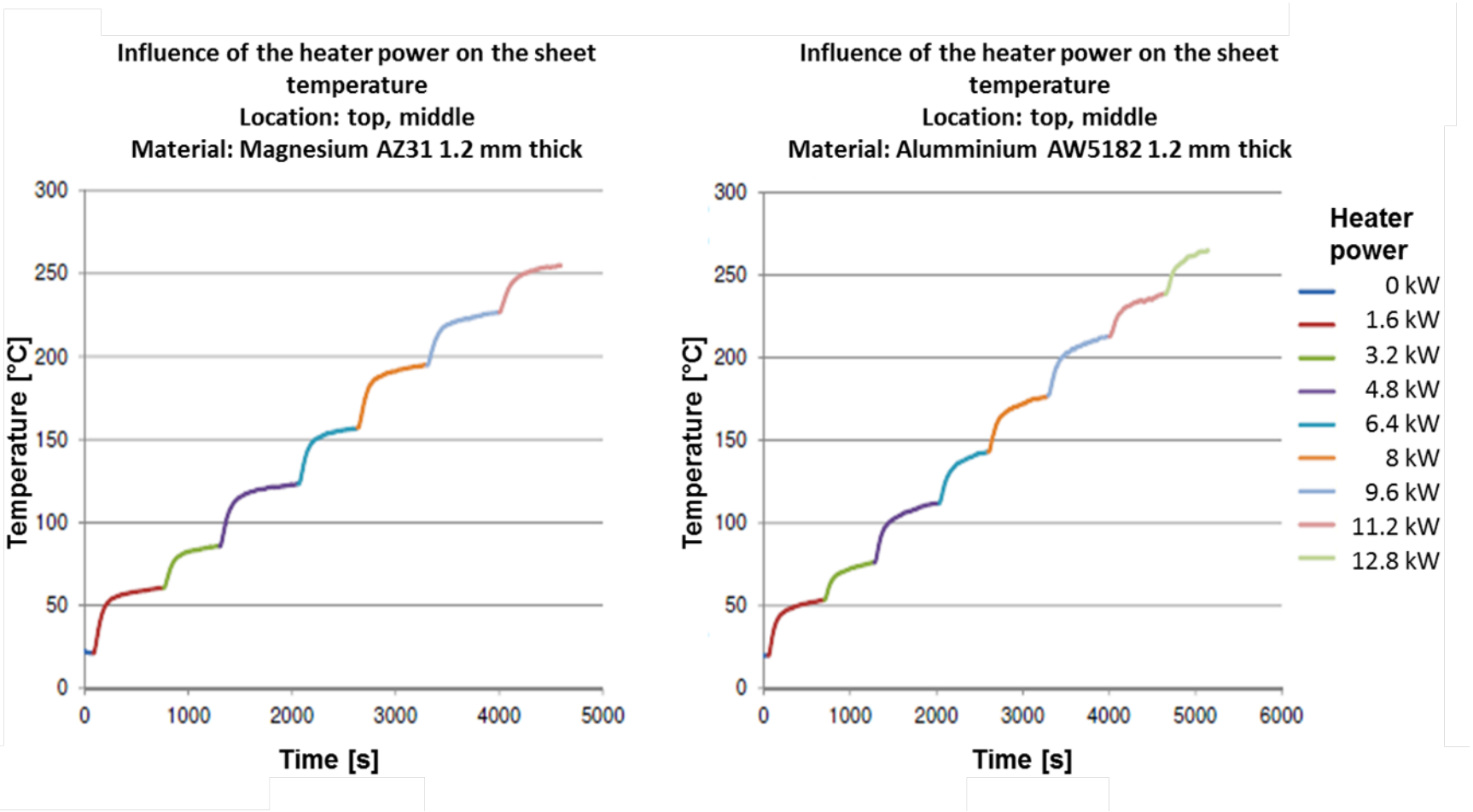




Test setup with thermographic camera (left) and thermocouple (right)

ISF using heated air

Influence of the heater power on sheet temperature



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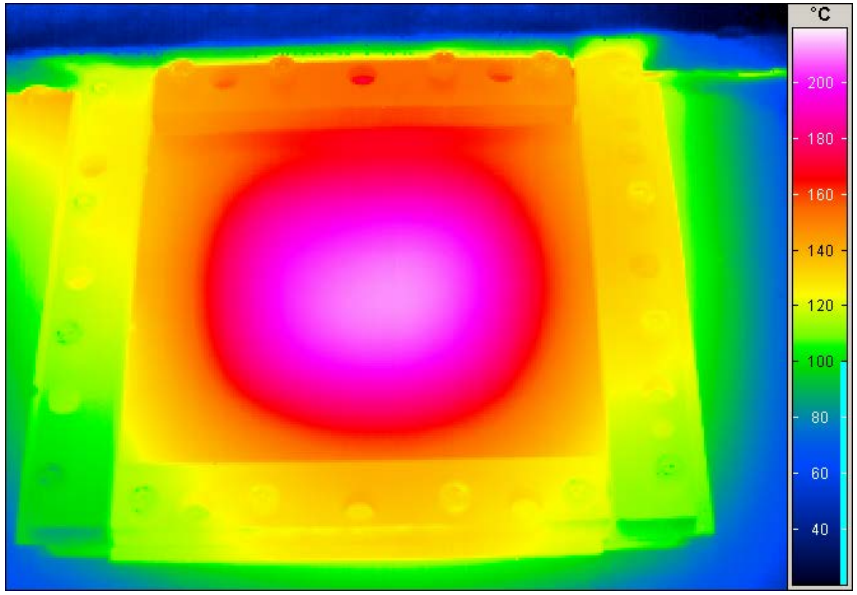
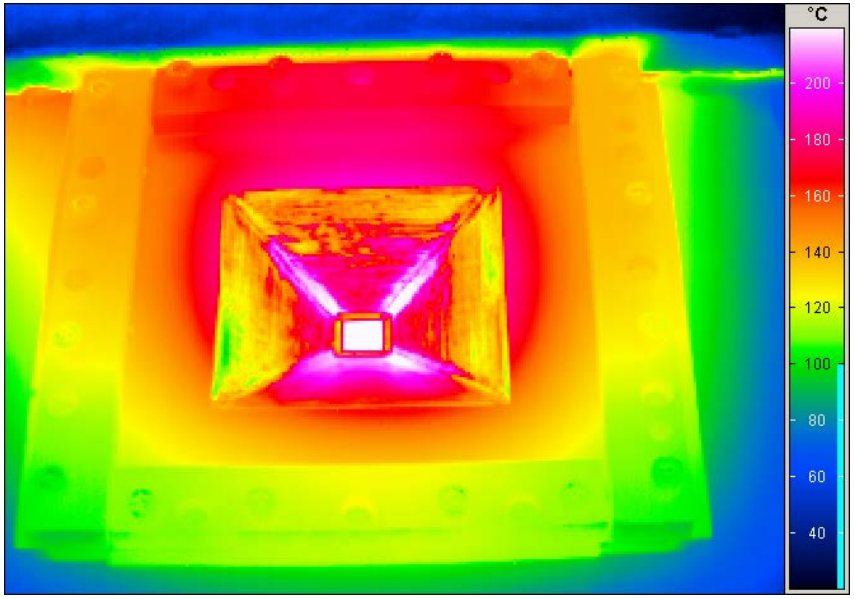
ISF using heated air
Forming experiments

Before start of experiments



After 521 s



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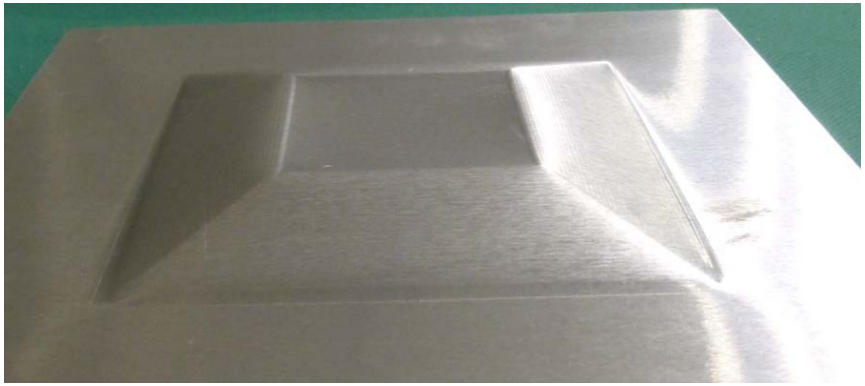
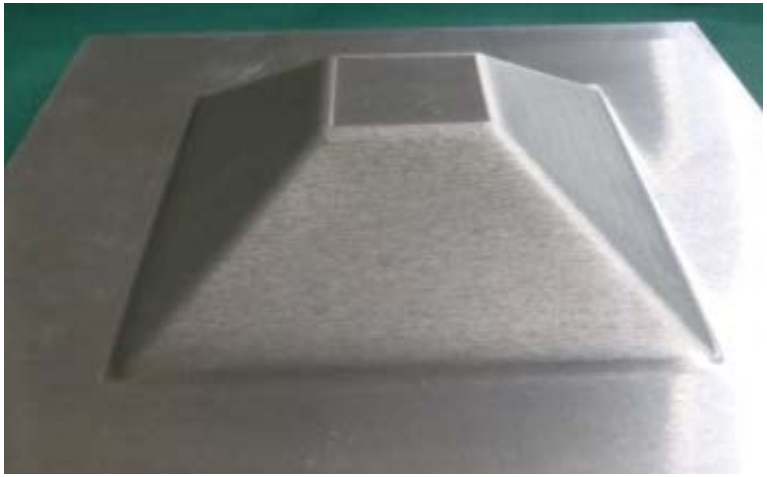
ISF using heated air
Forming results

- truncated pyramids (only sides formed)
- two different variants:

Variant	Depth	Angle
„flat“ truncated pyramid	12 mm	20°
„deep“ truncated pyramid	30 mm	determination of the maximum angle



„flat“ truncated pyramid



„deep“ truncated pyramid

ISF using heated air
Maximum angle

- comparision of forming results at 210 °C:

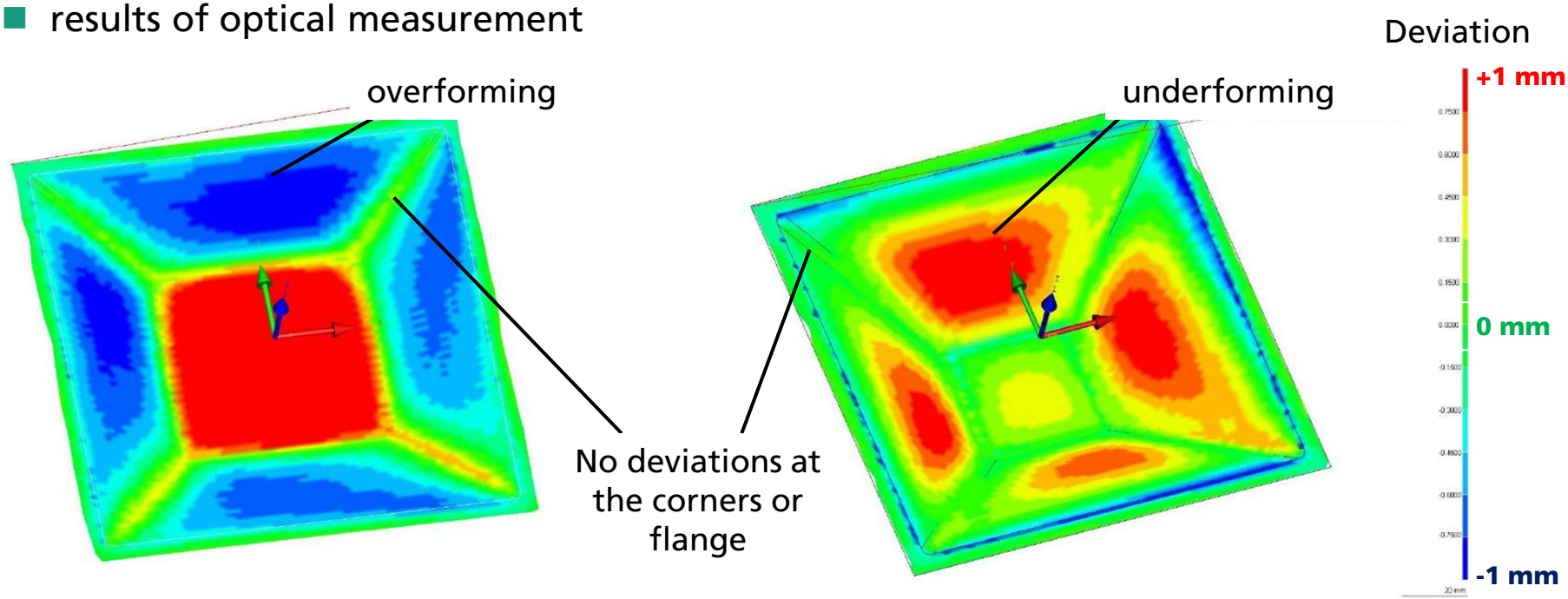
Formed sheet	Maximal angle
AZ31 (s_0 = 1,2 mm)	30°
AZ31 (s_0 = 2,0 mm)	30°
AM50 (s_0 = 1,2 mm)	26°
AM50 (s_0 = 2,0 mm)	26°

- influence of the sheet temperature (AZ31, s_0 = 1,2 mm):

Heating power	Sheet temperature	Maximal angle
6,4 kW	160 °C	26°
8 kW	185 °C	30°
9,6 kW	210 °C	30°
11,2 kW	235 °C	35°
12,8 kW	260 °C	35°

ISF using heated air
shape accuracy

- results of optical measurement



- influence of temperature
  - different effects on different component geometries
  - flat truncated pyramid (left): small deviation at rising temperature
  - deep truncated (right): bigger deviation at rising temperature

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Conclusions

- new variant of IFS for lightweight materials was developed
- difference to many other heat assisted variants of ISF: discussed process allows SPIF and TPIF without any changes of heating equipment
- second advance: heated air support is even temperature distribution on whole sheet
- temperature gradients in areas to form are not relevant for the process and part geometry afterwards
- proposed globally heated sheet allows a slim design of the stylus (without any heating equipment) and a fast ISF
- new ISF variant leads to common properties of soft aluminum ISF parts formed under room temperature
- quality of the flange area: no deviations can be detected → integration of new ISF process in manufacturing chains without any impact on peripheral processes

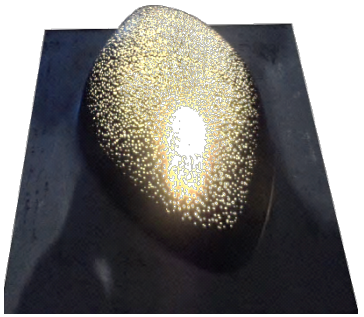
Thank you for your kind attention.

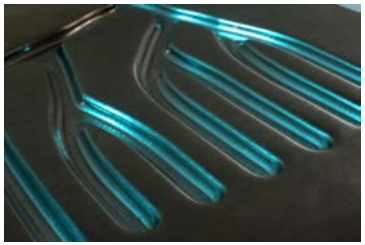
Dr.-Ing. Roland Müller

Sheet Metal Forming
Fraunhofer IWU
Reichenhainer Str. 88
09126 Chemnitz
Deutschland

Phone: +49 (0)371 / 5397-1464
EFax: +49 (0)371 / 5397-6-1464
roland.mueller@iwu.fraunhofer.de

www.iwu.fraunhofer.de





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