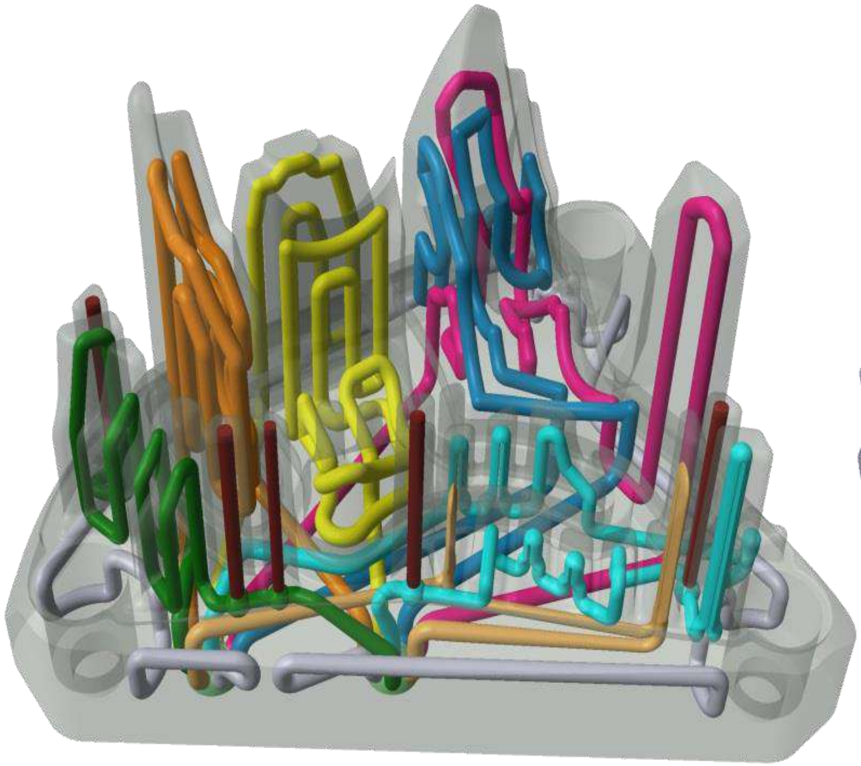
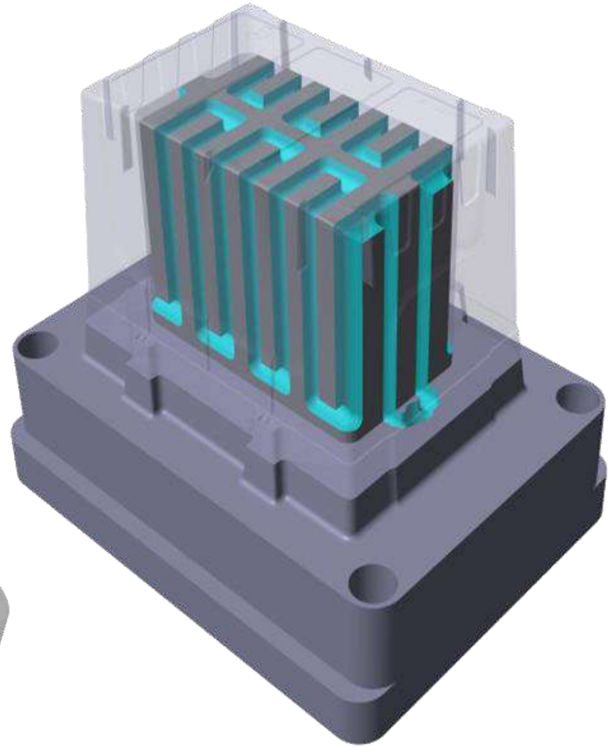
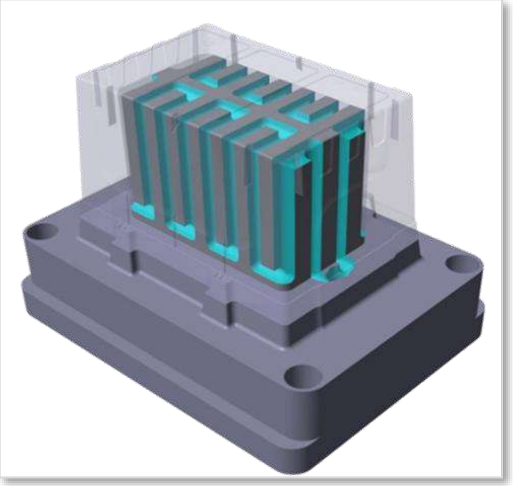
Conformal Cooling par excellence





Conformal Cooling par excellence



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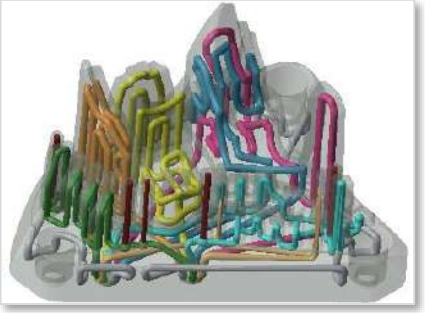
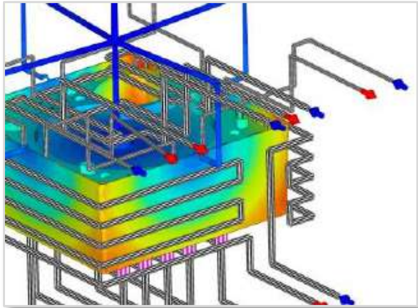
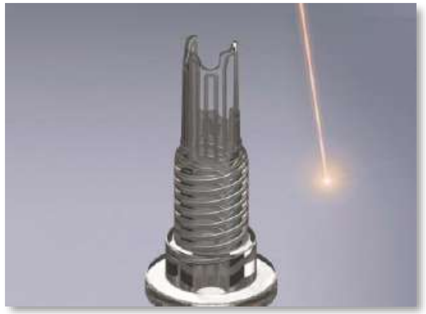
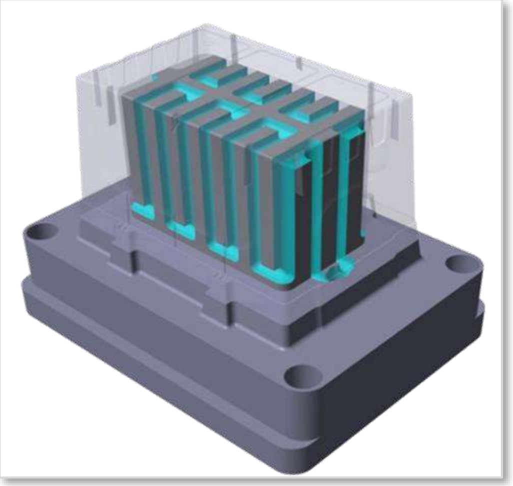
WE SEE THE BIGGER PICTURE

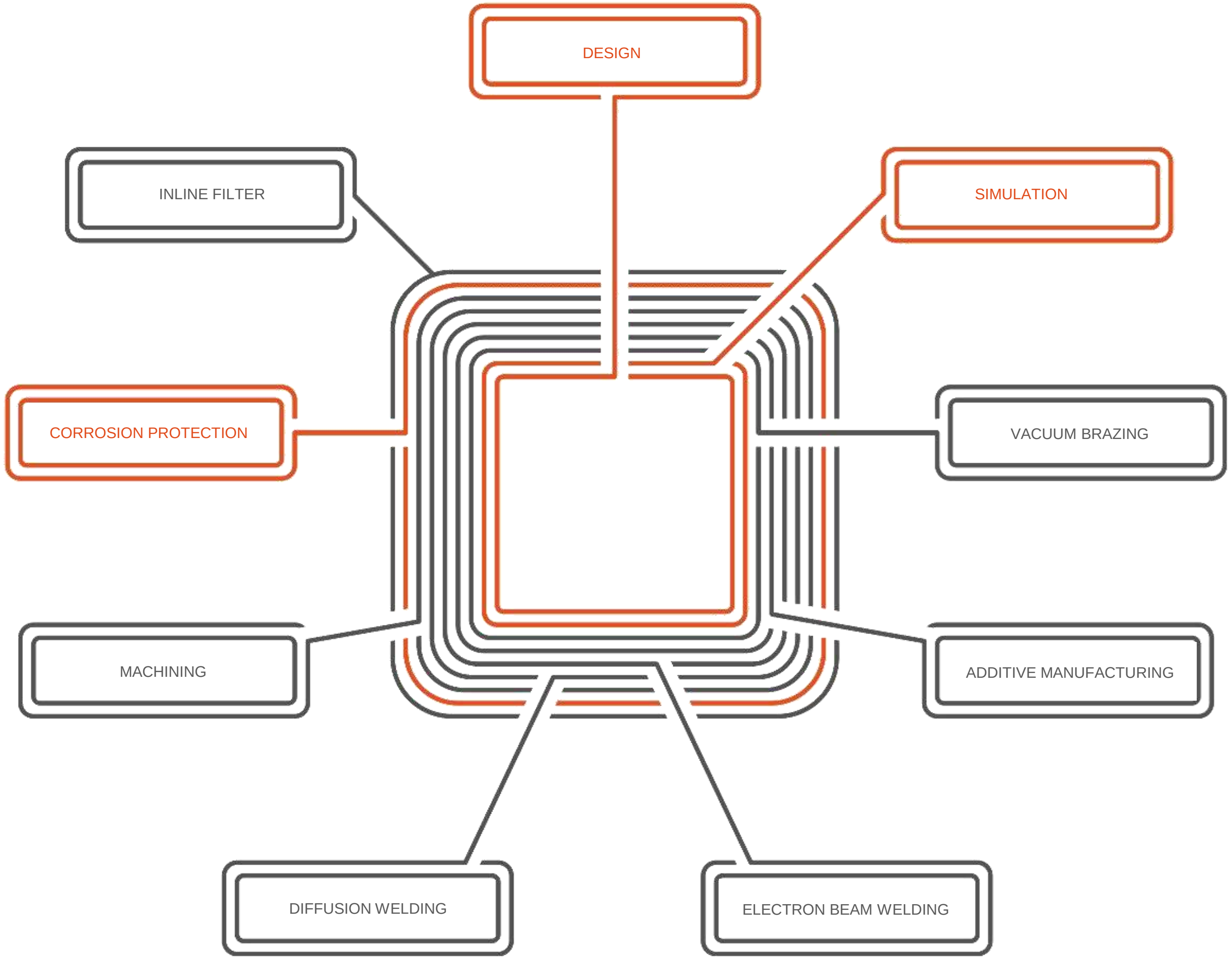


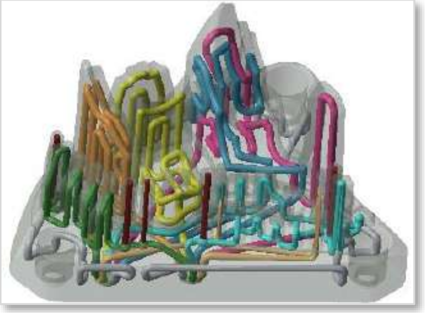


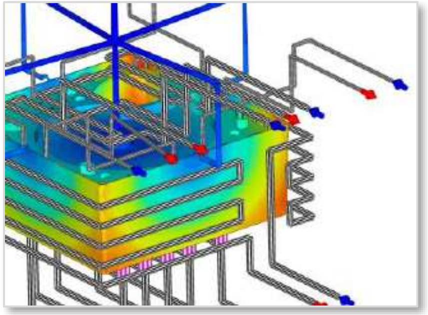


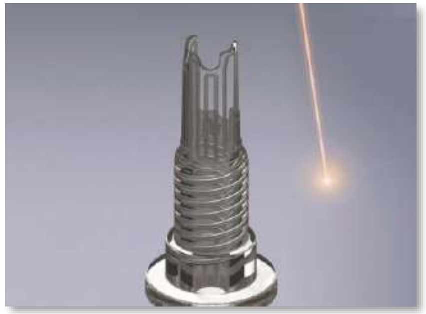
Our portfolio



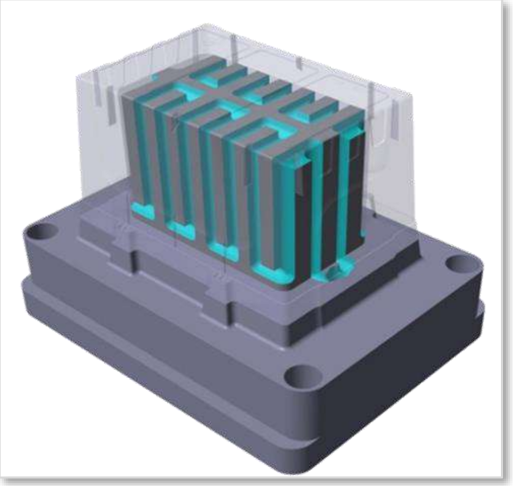








Who we are



iQtemp GmbH is a company of the Listemann group, with locations in Germany, Liechtenstein, Switzerland and Poland.

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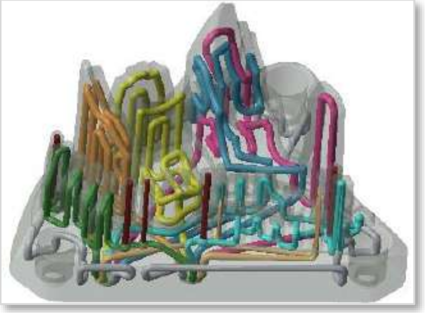
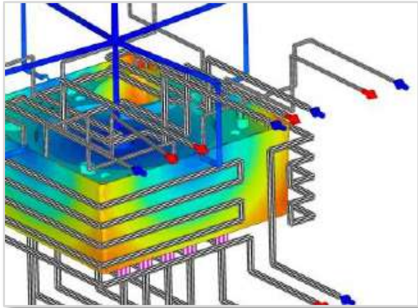
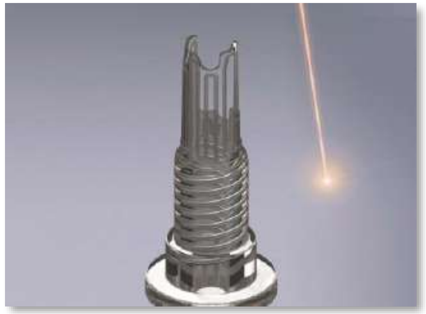
LISTEMANN
perfecting materials

Listemann AG
Werkstoff- und Wärmebehandlungstechnik

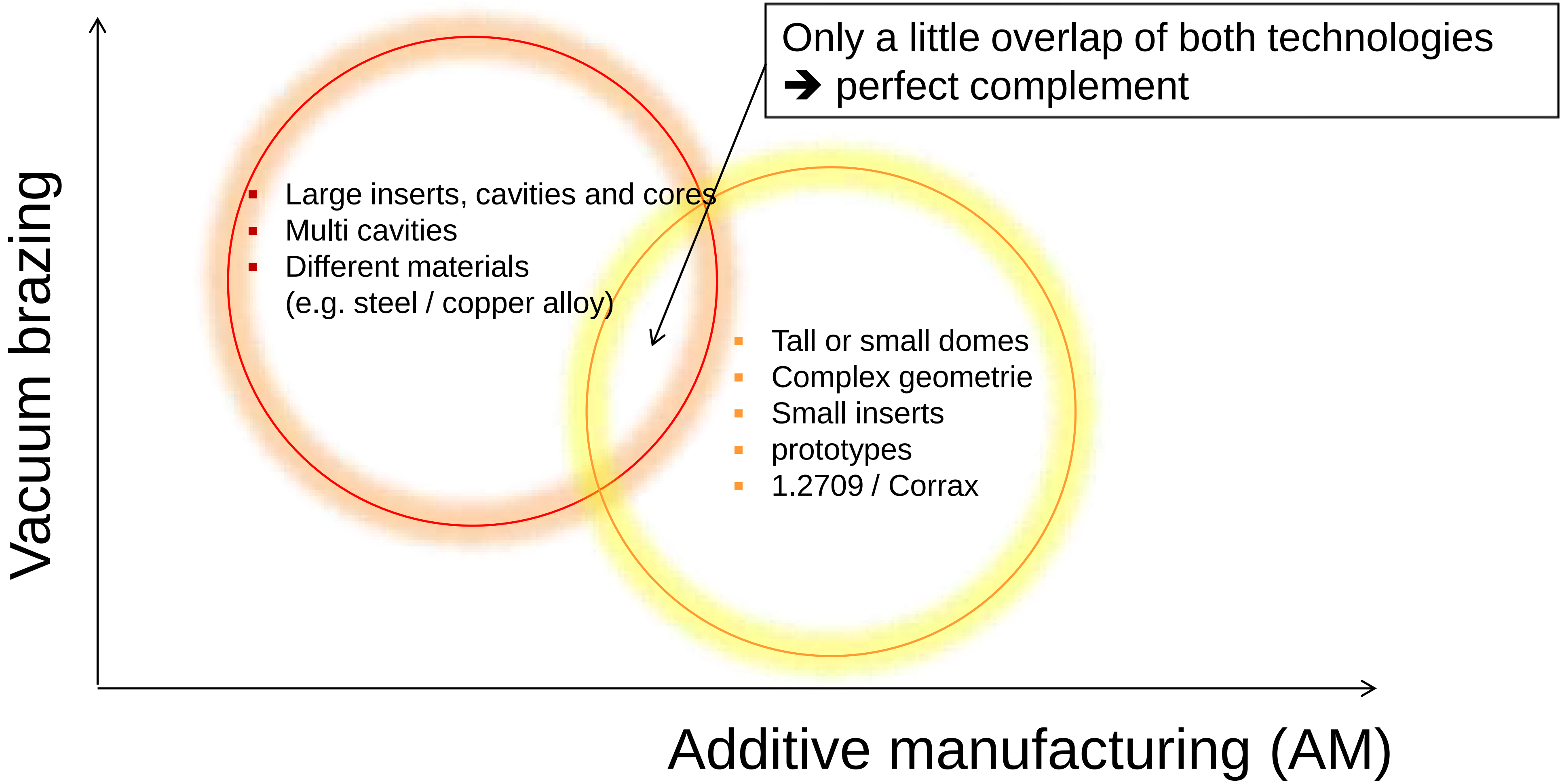
Listemann Polska
Technologia materiałów i obróbki cieplnej







The technology mix

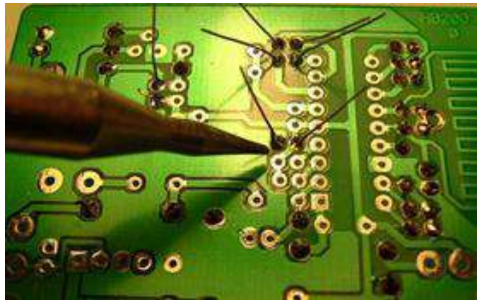


What is brazing?

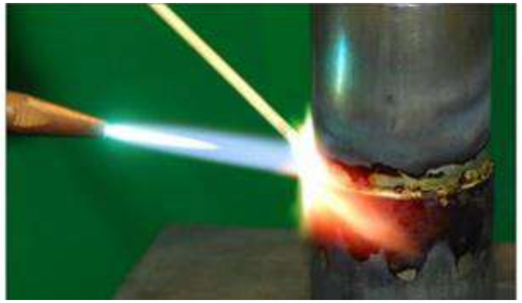
- Brazing is a thermal joining process where strong, metallurgical bonds are established between the base materials by the use of a braze filler metal.
- During joining the filler metal becomes liquid whereas the base material stays solid, in contrast to welding.
- In the interface area an alloying processes ensures high mechanical properties.

Classification of the brazing processes

Soldering (electronic components)	brazing (tubings)	High temperature brazing (turbine components)
< 450	450 – 900	> 900 °C



450



900

°C

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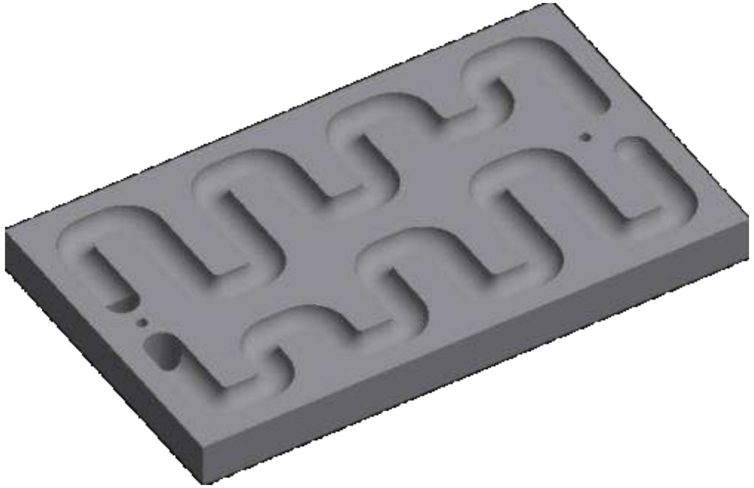
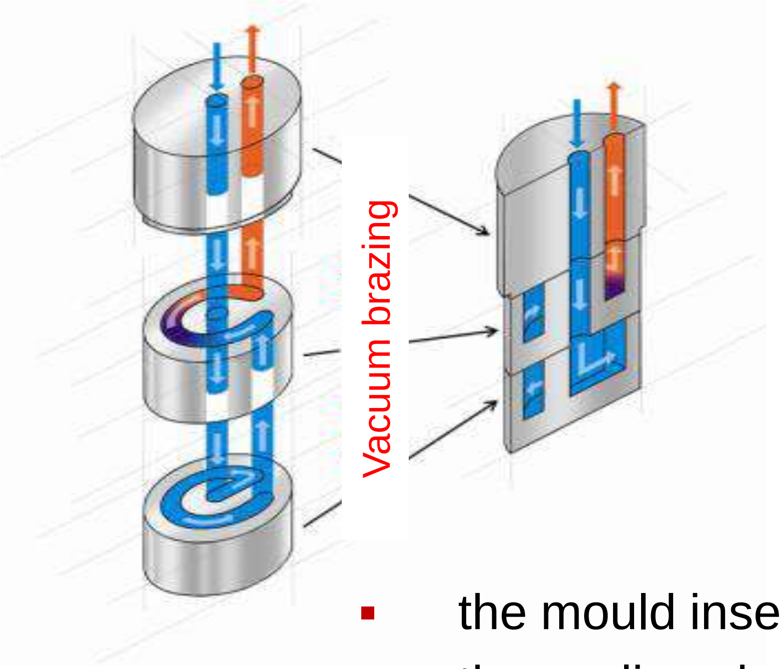
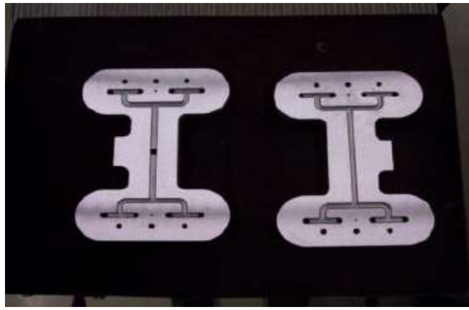
What is vacuum brazing?

- Brazing process is performed in a very clean vacuum atmosphere without any oxidation of the materials.
- Vacuum brazing enables high strength joints between similar and dissimilar materials.
- Most tool steels are brazed at the hardening temperature, so that brazing and hardening is performed in one process.



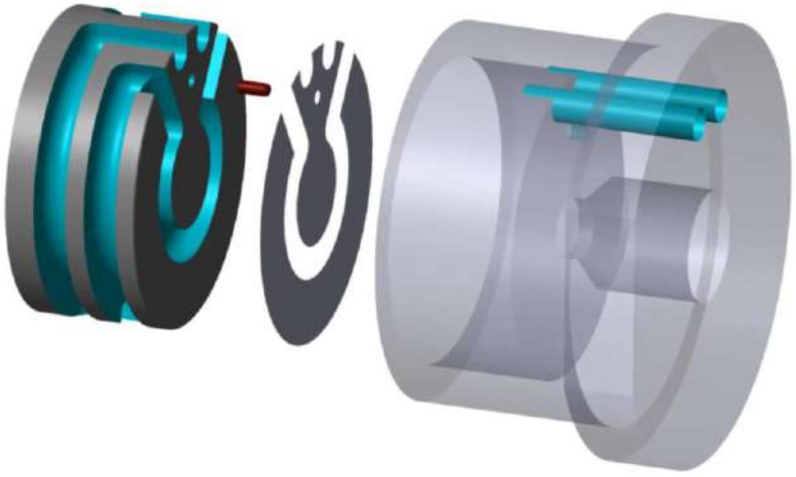
Component design for vacuum brazing

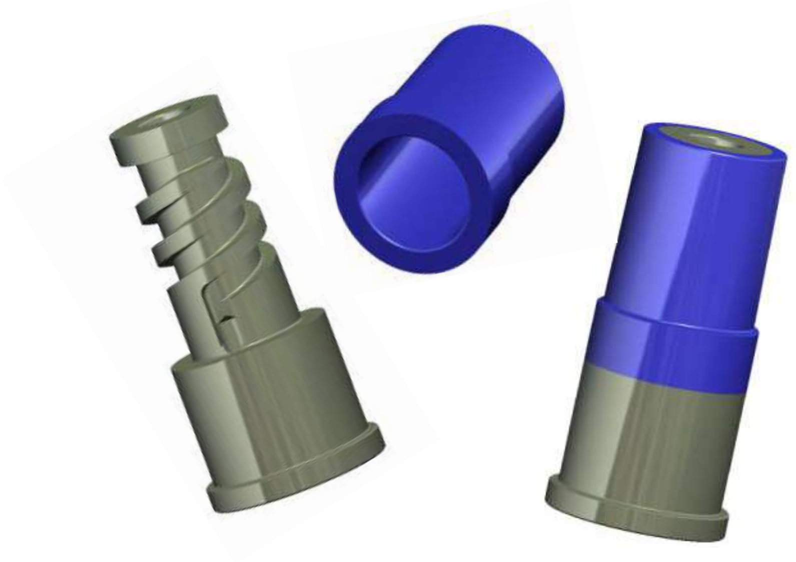




- the mould insert can be divided into several single components
- the cooling channels can be machined into the single parts easily
- with vacuum brazing the single parts are joined together with high strength and tightness
- hardening is integrated into the vacuum brazing process

Component design for vacuum brazing



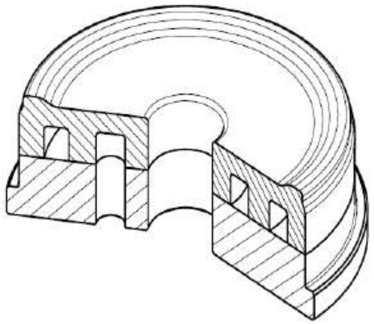


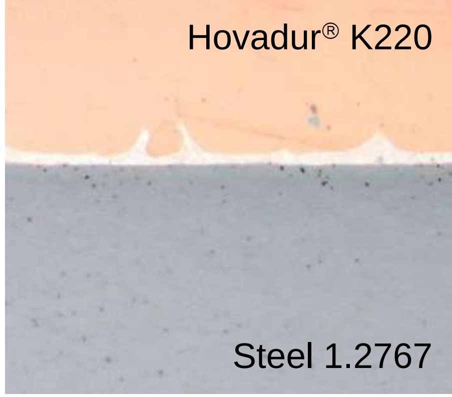
- the mould insert can be divided into a core and a sleeve
- the cooling channels can be machined into the single parts easily
- with vacuum brazing the parts are joined together with high strength and tightness
- hardening is integrated into the vacuum brazing process

Component design for vacuum brazing

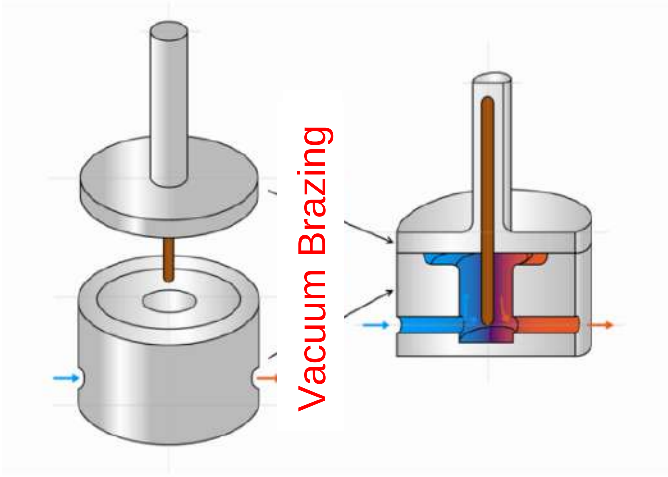
Hovadur / Ampcoloy

1.2714 / 1.2767

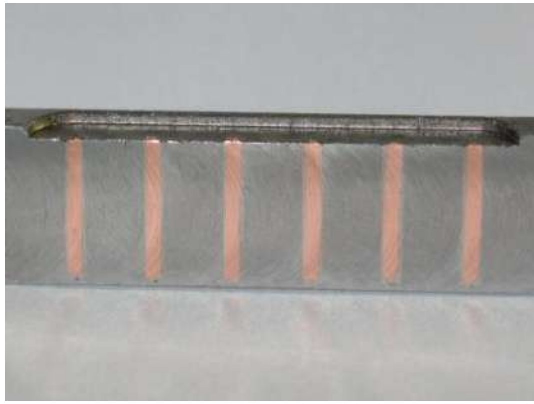




- expensive copper alloy can be used specifically
- superior thermal flow between copper and steel
- re-hardening of the copper alloy is possible



- copper pins are brazed into the drilled hole
- ideal thermal transfer between copper and steel
- copper pin protrudes into the cooling channel surrounded by water
- hardening is integrated into the vacuum brazing process



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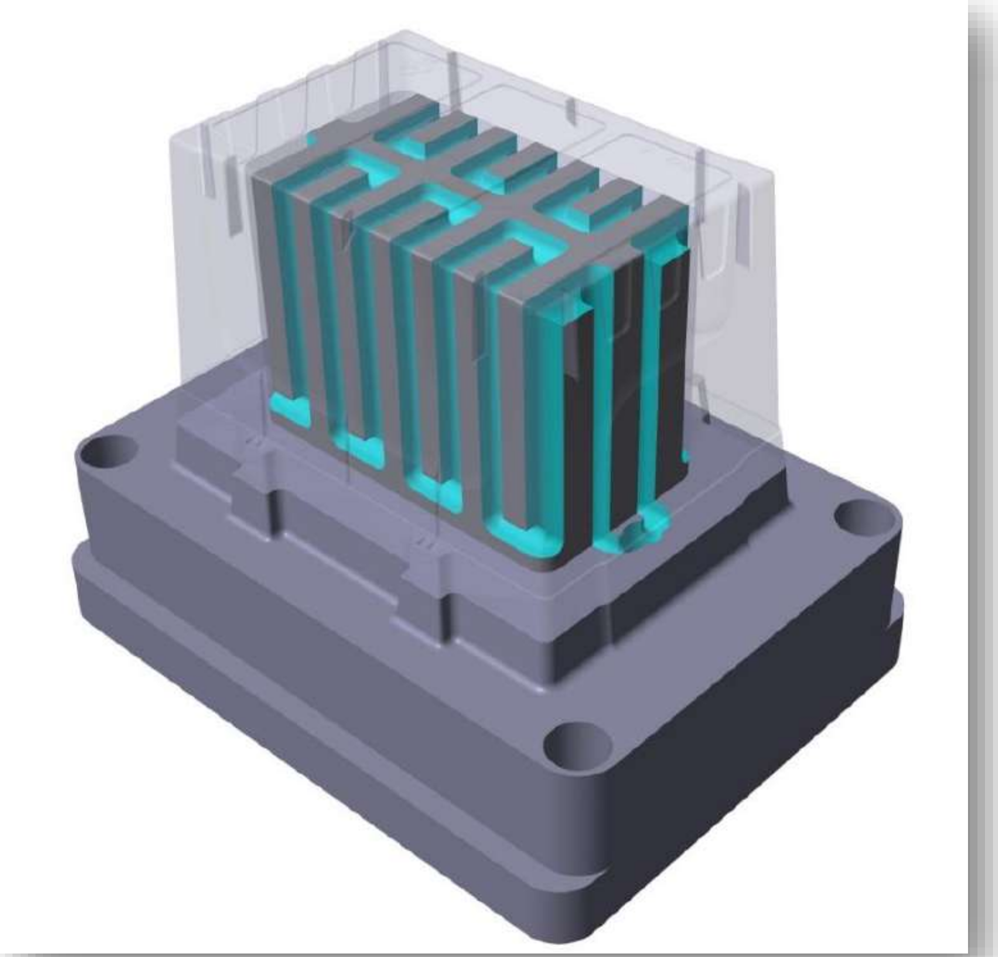
Example vacuum brazing:



INFORMATION:

Vacuum brazed insert from 1.2343

3-part version – core/slieve and slices – 2 vacuum brazing operation

cooling channels Ø6mm parallel connected;
resulting cross section Ø8,5 mm

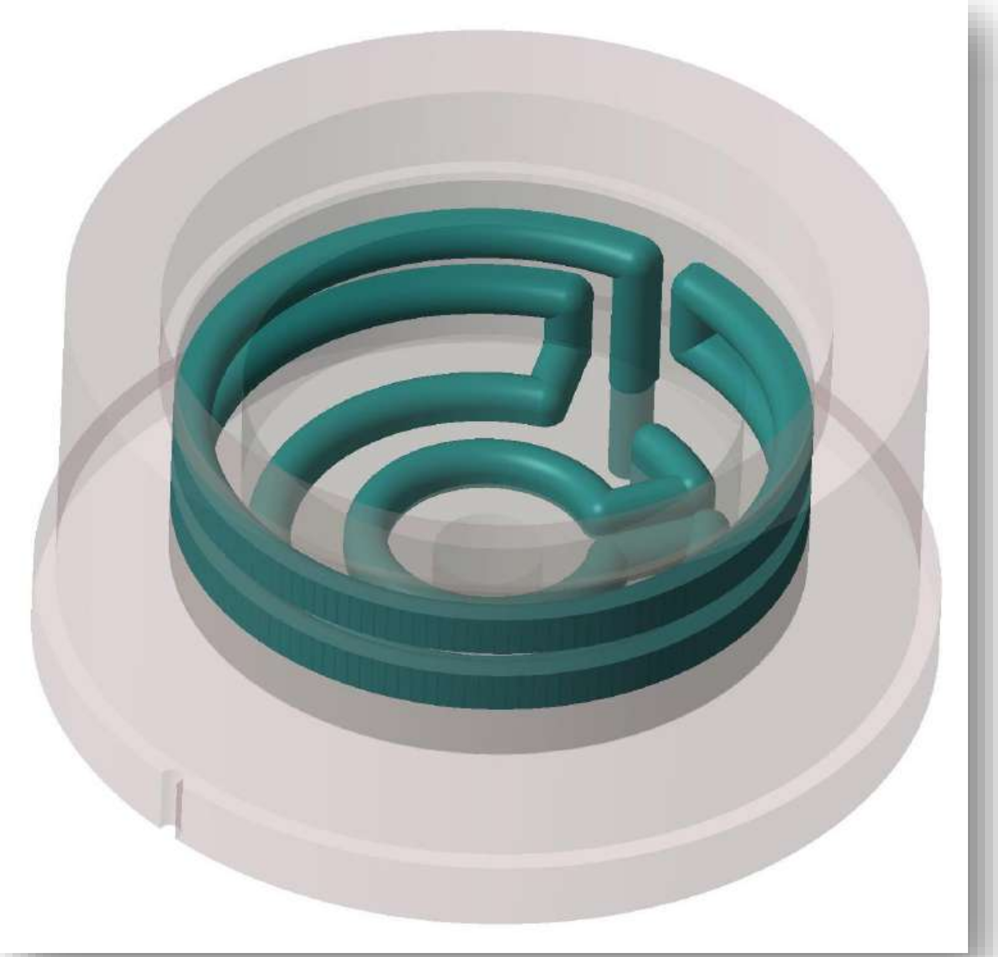
PROJECT FLOW:

Design of the cooling, definition of the brazing separations incl. drawings and data for the manufacturing of the brazing blanks by iQtemp GmbH

manufacturing of the brazing pre-components by the customer.

vacuum brazing, hardening and tempering, Rockwell hardness test and 100%-helium-leak test before delivery by iQtemp.

Example vacuum brazing:



INFORMATION:

Vacuum brazed insert from 1.2343 ESU,

core and sleeve design

cooling channels Ø6mm

PROJECT FLOW:

Design of the cooling, definition of the brazing separations incl. drawings and data for the manufacturing of the brazing blanks by iQtemp GmbH

manufacturing of the brazing pre-components by the customer.

vacuum brazing, hardening and tempering, Rockwell hardness test and 100%-helium-leak test before delivery by iQtemp.

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Example vacuum brazing:

INFORMATION:

Vacuum brazed insert from 1.2343 ESU, 3 part design – slices

Complex cooling design with **6-fold parallel connection** Ø3 mm corresponding Ø7,4 mm

Cooling time reduction of **58%** from **12s** to **5s**.

Full series production mould with 48 cavities and a **14% increased production rate** compared to the conventional 96-cavity mould.

PROJECT FLOW:

Design of the cooling, definition of the brazing separations incl. drawings and data for the manufacturing of the brazing blanks by iQtemp GmbH

manufacturing of the brazing pre-components by the customer.

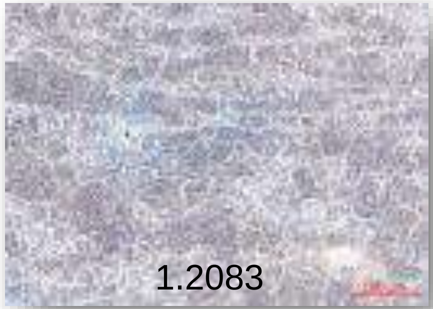
vacuum brazing, hardening and tempering, Rockwell hardness test and 100%-helium-leak test before delivery by iQtemp.

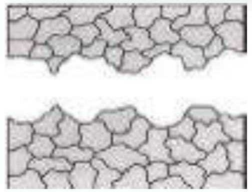
DIFFUSION WELDING – JOINTS AS IF FROM ONE CAST

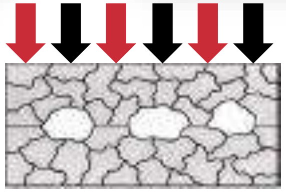
- Diffusion welding is a material-locking joining process that does not require the use of any filler material. The welded joint is visually undetectable, even when polished. The welded joints have comparable properties to the base material.
- The components to be joined are pressed together under high vacuum, at high temperatures, with high pressure load This results in a material exchange in the solid state and thus in a high-strength welded joint. In most cases, no filler material is used, which is why no joint zone is visible. Diffusion bonding can be used for joining materials of the same type (steels, aluminum, copper, titanium and nickel alloys) as well as for material combinations.
- Tool, die and mould making, food and pharmaceutical industry, mechanical engineering, semiconductor technology.

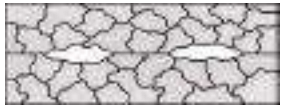
DIFFUSION WELDING – JOINTS AS IF FROM ONE CAST

- Materially bonded and thus highly durable and temperature-resistant joints.
- High polishability of the components, as no joining zone is visible.
- Suitable for injection moulding of highly transparent parts.
- No oxidation of the components, as the process takes place in a high vacuum.
- Heat treatment of the welded components according to customer specifications

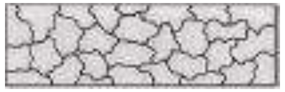



component surfaces before welding


Pressure and temperature

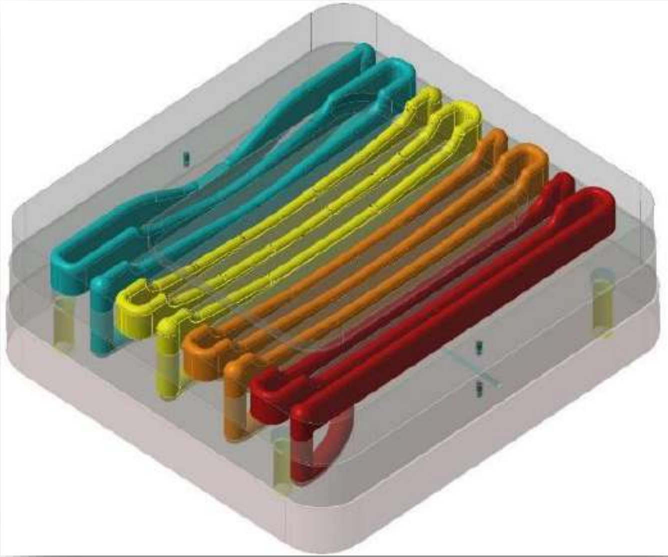

Flattening the pores


closing the pores


Part after welding

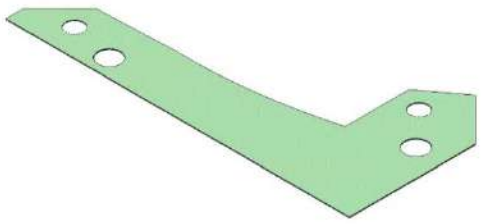
DIFFUSION WELDING – REQUIREMENTS

- Surfaces surface-ground with Ra 0.4, plane parallelism ±0.02
- with multiple components: all parts same height ±0.02
- Thickness shrinkage due to the joining process approx. 0.5 mm
- Therefore, the cooling channels must be machined 0.25 mm deeper per side.



What is additive manufacturing AM?

- AM (laser melting in a powder bed) or colloquially 3D printing is an additive manufacturing process in which a component is generated layer by layer from metal powder using a laser.
- The metal powder is applied in 40µm - 60µm thick layers by a coater (squeegee) on the base plate and homogeneously melted with one or more lasers and thus welded, creating the components layer by layer including the designed internal geometries.
- This results in an incomparable constructive freedom in the design of complex and conformal temperature control systems in injection moulds and die-casting tools, as well as for other technical components.



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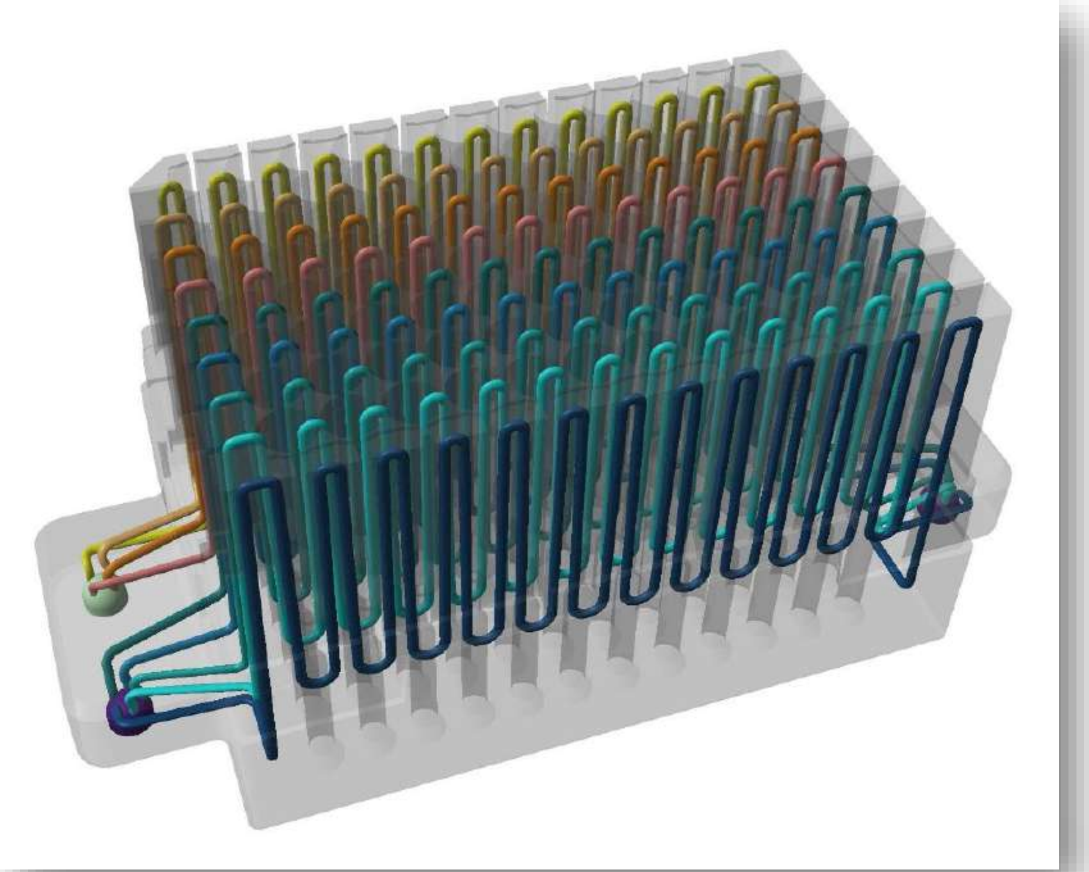
Steel comparison chart

	H13 (1.2344)	420SS (1.2083)	H11 (1.2343)	1.2709	Böhler M789
technical elastic limit 0,2% Rp0,2	1520 MPa	1360 MPa	1400 MPa	1980 MPa	1754 Mpa
tensile strength Rm	1830 MPa	1780 MPa	1600 MPa	2040 MPa	1835MPa
breaking elongation A	no value	no value	no value	3,70%	9,20%
elastic modulus	210000 MPa	200000 MPa	215000 MPa	237000 MPa	188000 MPa
working hardness	52 - 54 HRC	48 - 52 HRC	52 - 54 HRC	52 - 54 HRC	52 - 54 HRC
density	7,8 kg / dm³	7,8 kg / dm³	7,8 kg / dm³	8,1 kg / dm³	7,8 kg / dm³
coefficient of thermal expansion	12,6 X 10^{-6} m/(mK)	11,0 X 10^{-6} m/(mK)	11,3 X 10^{-6} m/(mK)	10,3 X 10^{-6} m/(mK)	11,0 X 10^{-6} m/(mK)
thermal conductivity [20°C]	24,9 W/(m.K)	19 W/(m.K)	27,8 W/(m.K)	20 W/(m.K)	~ 16 W/(m.K)
corrosion resistance	no	yes	no	no	yes

Example AM:



INFORMATION:

This conformal cooling system is running in full production since more than 30 month.

Geometry:
Vertical ellipse 1,3 mm x 1,8 mm
corresponding Ø 1,53 mm.

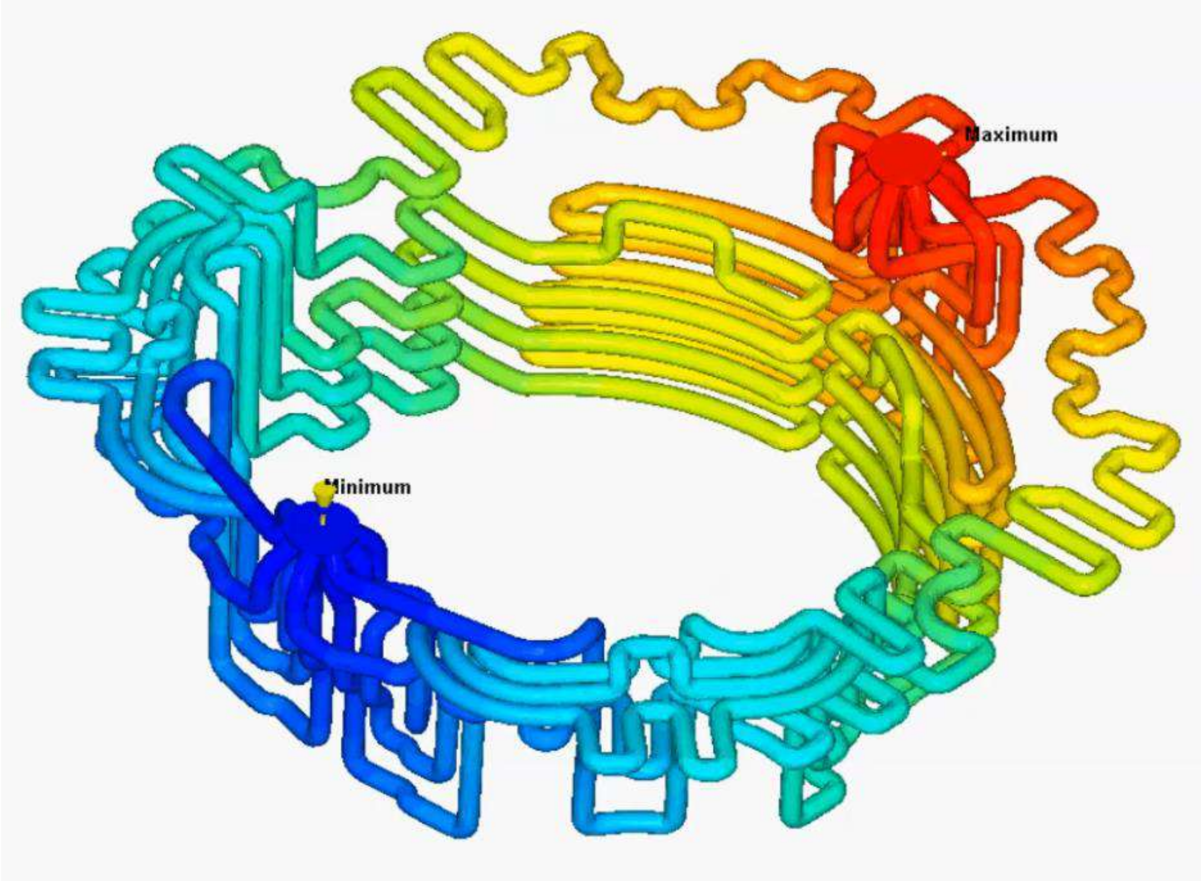
2 closed loops	1x 4-times parallel
	1x 5-times parallel

are running with a water pressure of 6 bars.
The cooling water is filtered.

Total length of all channels is about 12.500 mm!

Cooling time was reduced to the half!

Example AM:

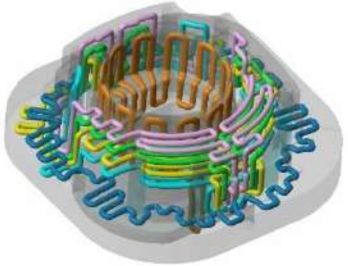


INFORMATION:

2-cavity 2C mold (electrical industry)

Cooling geometry:
10-fold parallel connection Ø3 corresponding Ø9,5 mm
perfectly balanced. Flow rate at 4 bar pressure 21 l/min

Cycle time reduction:
From 72 s in a poorly made single-cavity mould to 28 s
in an AM conformal cooled 2-cavity full production mould



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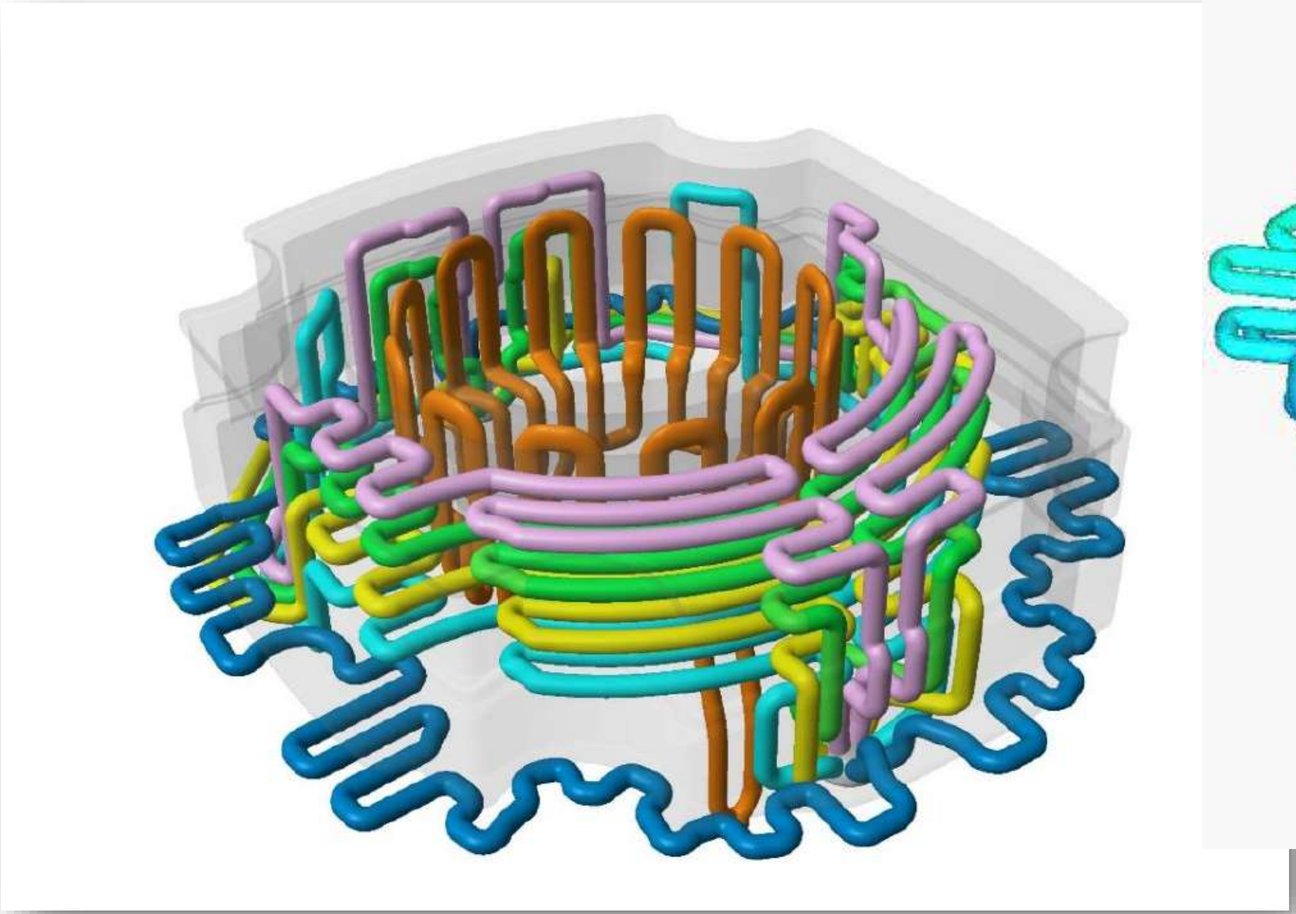
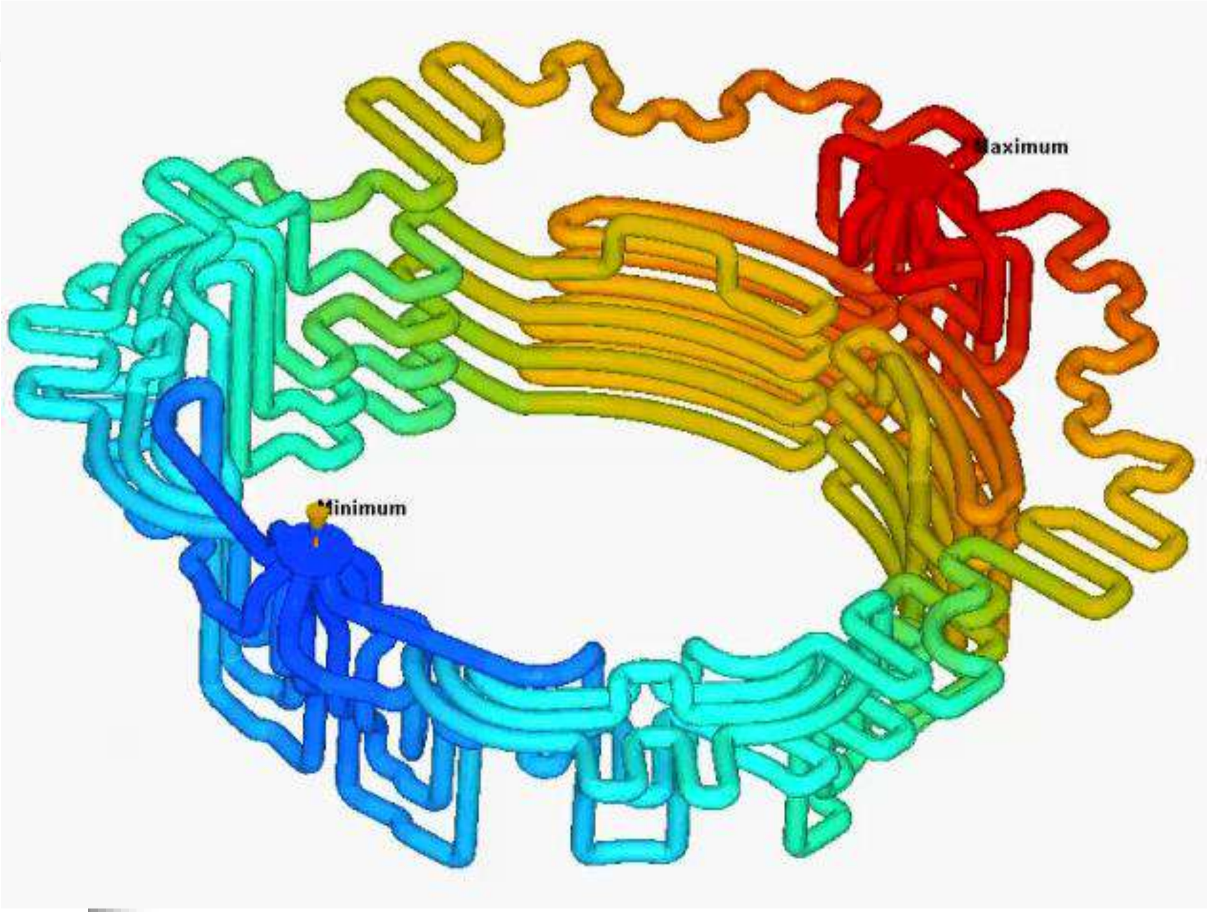
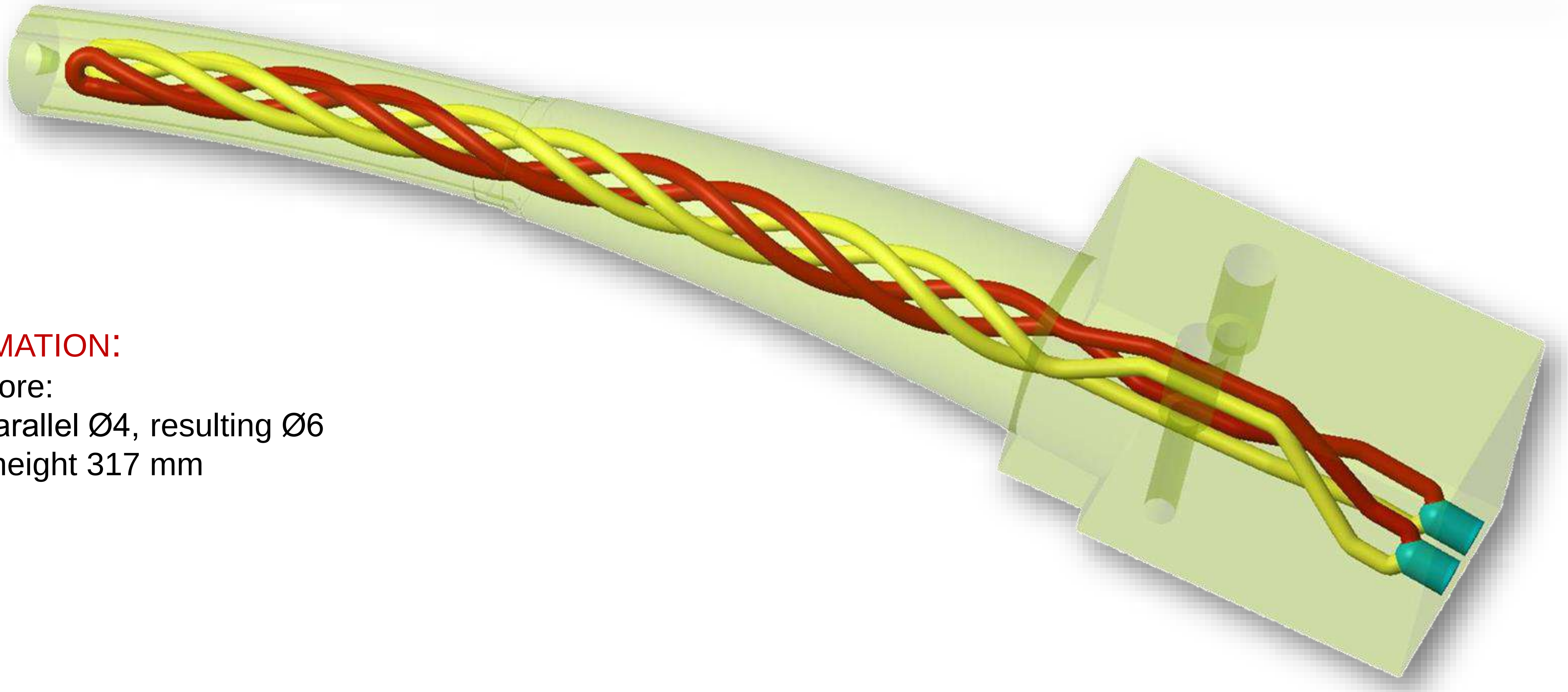
Example AM: Balancing of parallel-connected cooling channels



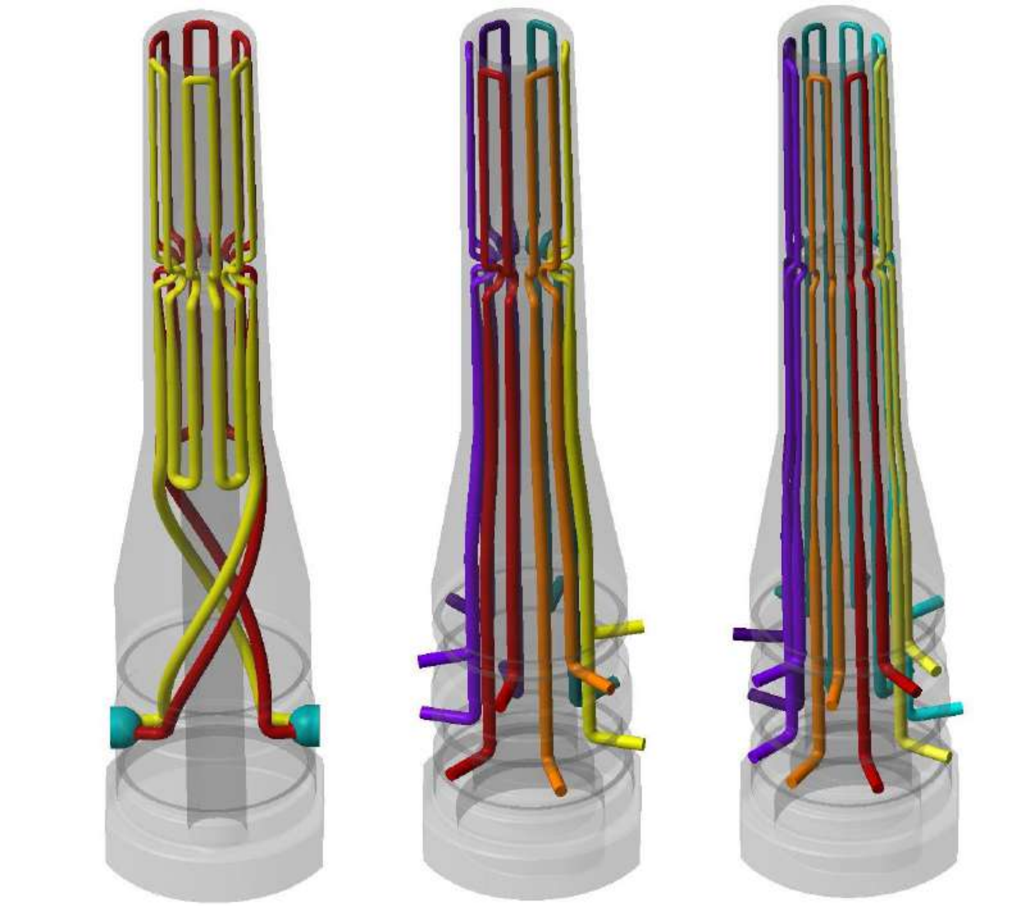


Example AM:



INFORMATION:
swivel core:
2-fold parallel Ø4, resulting Ø6
overall height 317 mm

Example AM:



INFORMATION:

8-cavity mold (writing utensil)

Contour sleeve with nozzle geometry

ØDA Ø21,5 mm; smallest wall thickness steel 2,88 mm

Injection pressure 1.500 bar

Cooling channel 1,3 x 1,8 corresponding Ø1,53 mm

Smallest wall thickness 0,82 mm between cooling and plastic

Life Cycle: **1,15 Mio Cycles** 2. variant

> 1,5 Mio Cycles 3. variant

1. option (test core, use in an existing mold)
   2-fold parallel connection inside the core
   Corresponding cooling Ø 2,16 mm.
   One cooling level in the mold plate.

2. option (new 8-cavity full series production mold)
   6-fold parallel connection inside the core
   Corresponding cooling Ø 3,75 mm.
   Two cooling level in the mold plate.

3. optimisation: 8-fold parallel Ø1,3 mm

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Example AM:

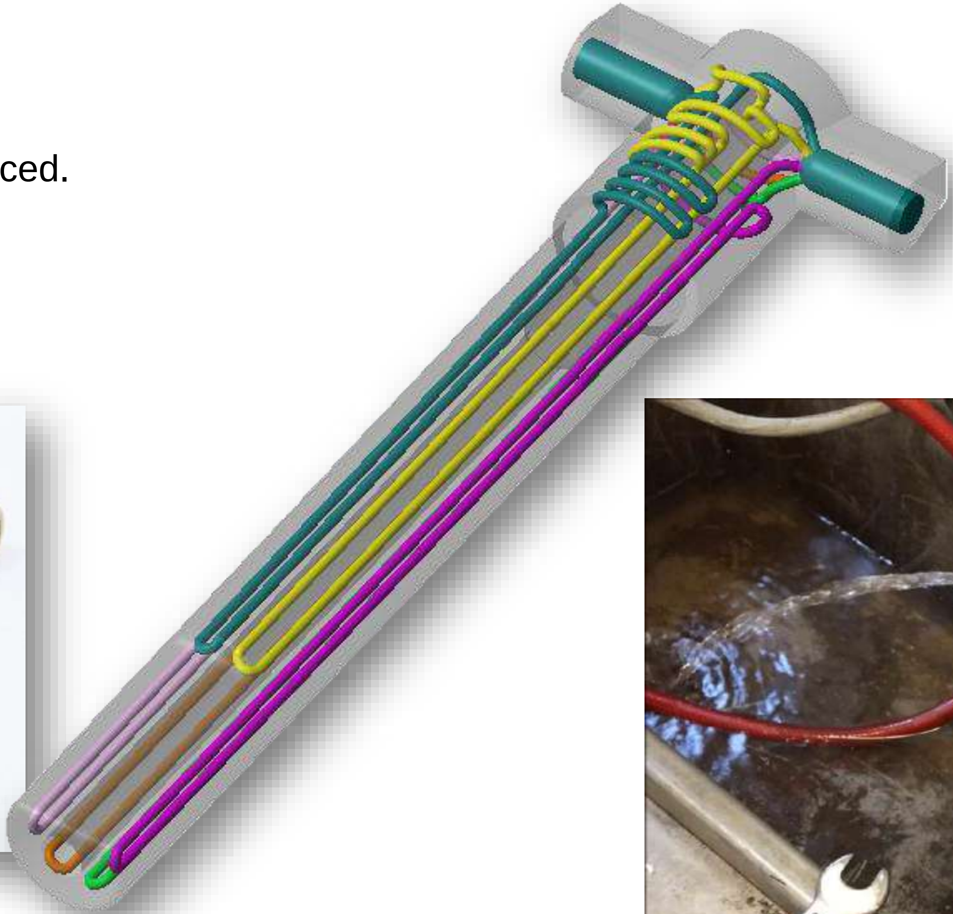
INFORMATION:

Mold insert with conformal cooling Ø1.

6-fold parallel connected and fully balanced.

Flow rate at 6 bar 1,6 l/min

Ø12,1; rest wall thickness 1,1 mm



Example AM: (Die-casting insert)

INFORMATION:

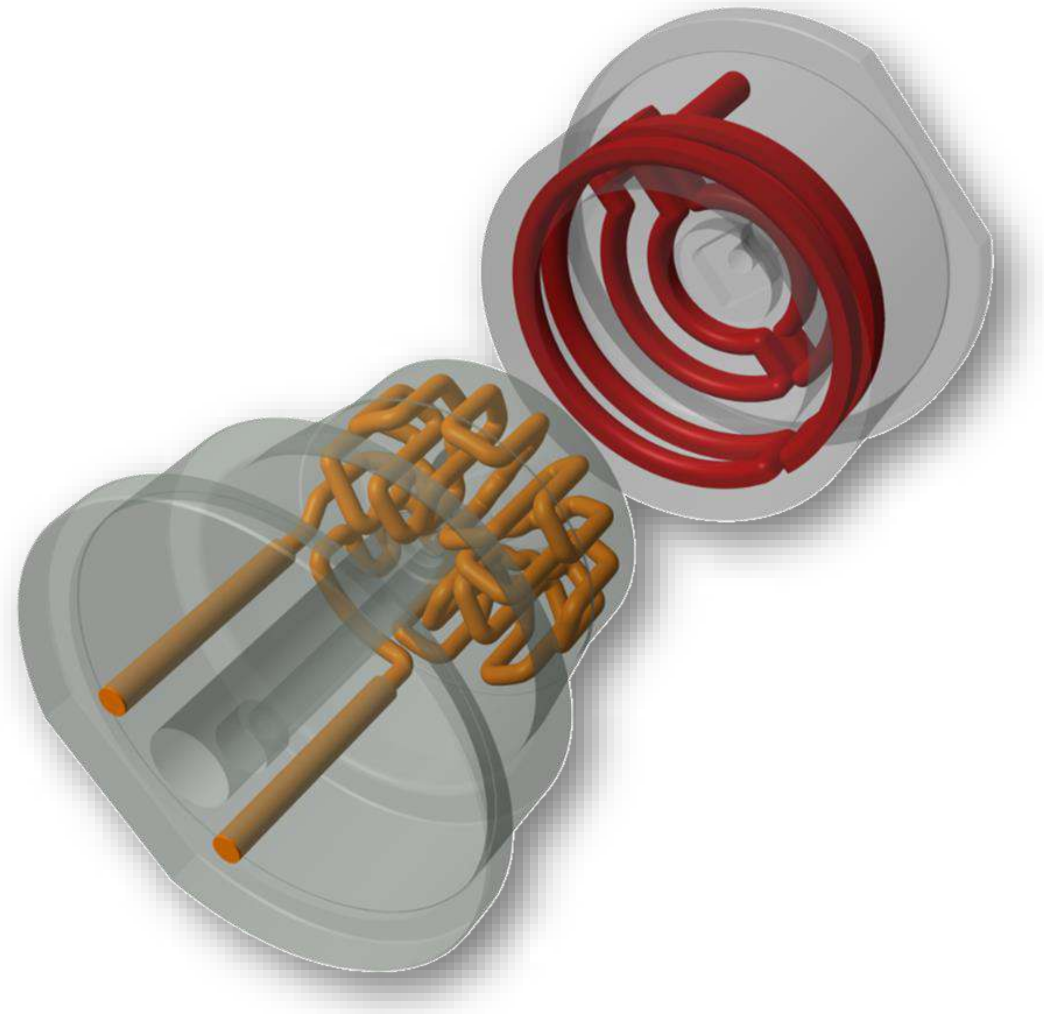
Conformal cooled die-casting insert built on a hybrid.

Weight 13,5 kg.

Without this design the insert could not have been produced economically.

In order to ensure that the entire contour is conformaly cooled, 3 milled diverting elements were inserted in the hybrid by means of electron beam welding (EBW) for the cooling diversion.

Combination of technologies (Optimisation by vacuum brazing and additive manufacturing)



INFORMATION:

Core fh laser generated from 1.2709.

Insert mh vacuum brazed from 1.2343 ESU.

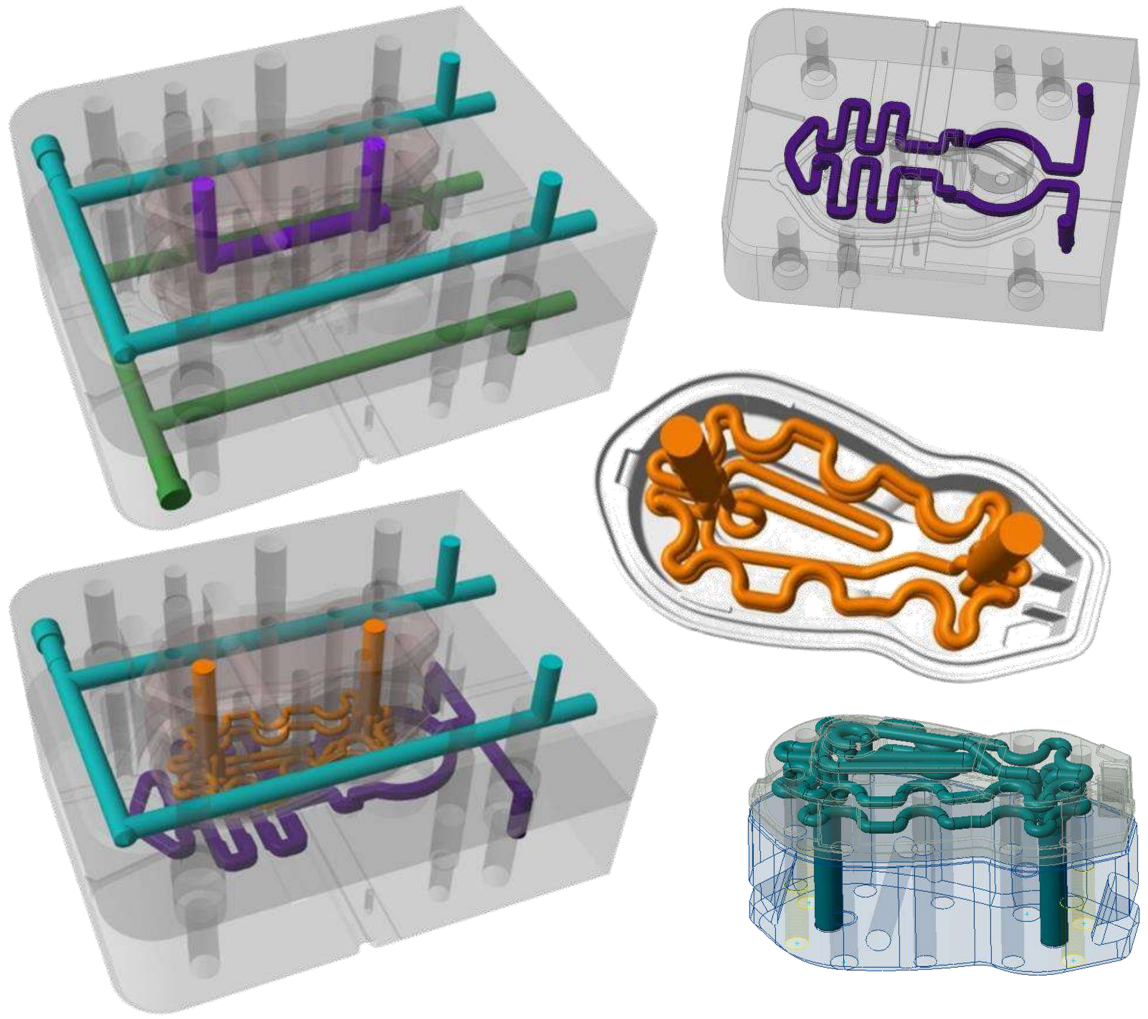
Cooling design by iQtemp GmbH.

Production of the brazing blanks at the customer.

Vacuum brazing and hardening at Listemann AG.

Additive manufacturing at iQtemp GmbH.

Combination of technologies (Optimisation by vacuum brazing and additive manufacturing)



INFORMATION:

Mold insert FH and core MH using conventional cooling.

Cycle time:	32,8 s
cooling time:	18 s

Material: PBT 30% GF

Mold insert FH (vacuum brazed) and core MH (additive manufactured) including conformal cooling.

Cycle time:	24,3 s
Cooling time:	9,5 sec
cooling time reduction:	48%

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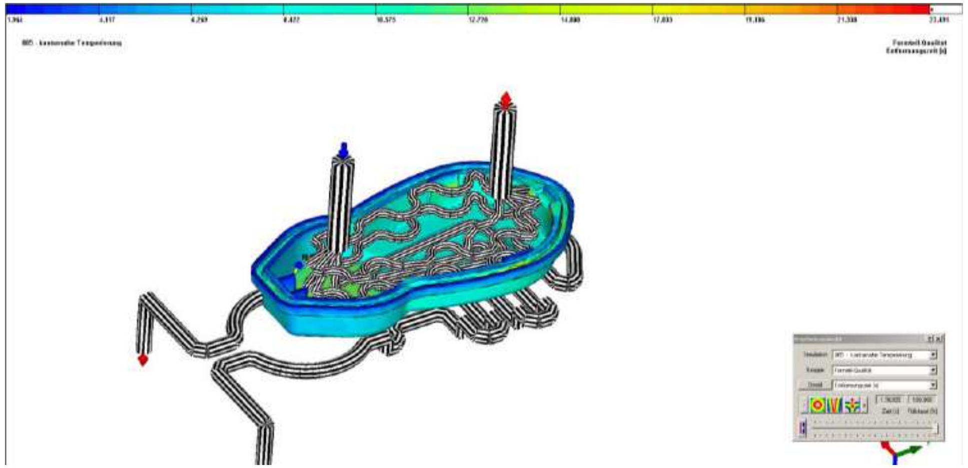
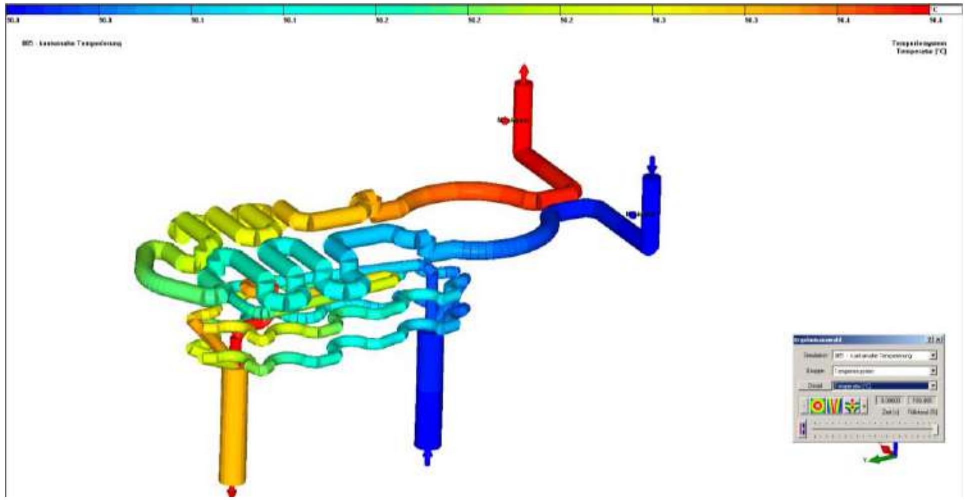
Combination of technologies (Optimisation by vacuum brazing and additive manufacturing)





INFORMATION:

The optimization shown before was simulated in advance. The results of the simulation have been confirmed exactly in the injection molding process.

The determination of the simulated demolding time was 23,5 s.

In consideration of injection time, holding pressure and secondary-time given by the process data sheet, the cooling time has been reduced from 18 s to 9,5 s.

Reduction of cooling time of 48%.

Maximum increase of the water temperature in the cooling circuit is only 0,4°K.

This means that a better cooling effect do not come along with a significantly higher temperature of the cooling liquid.

Enhanced flow design results in a highly turbulent flow in the cooling channels to ensure a very effective heat transmission.

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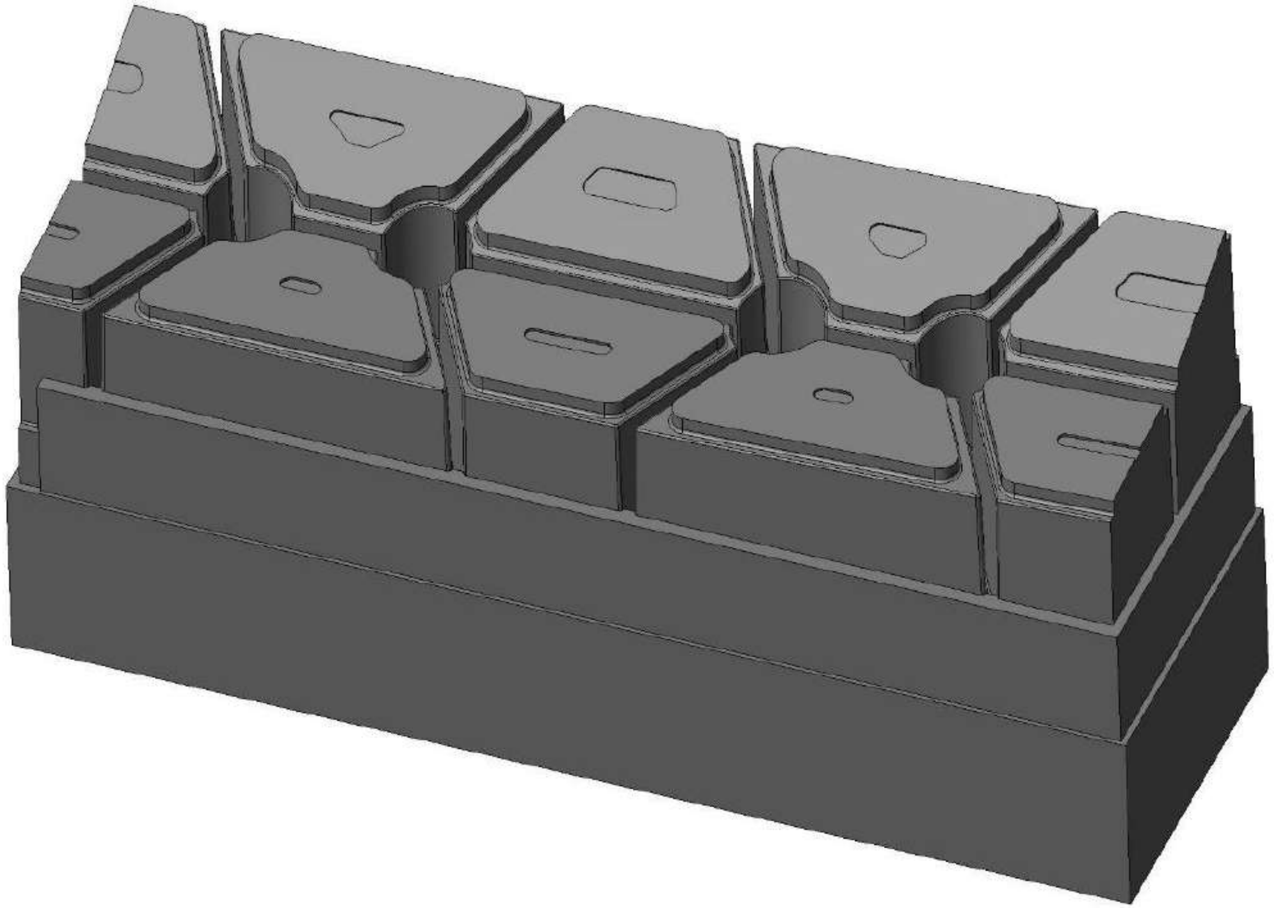
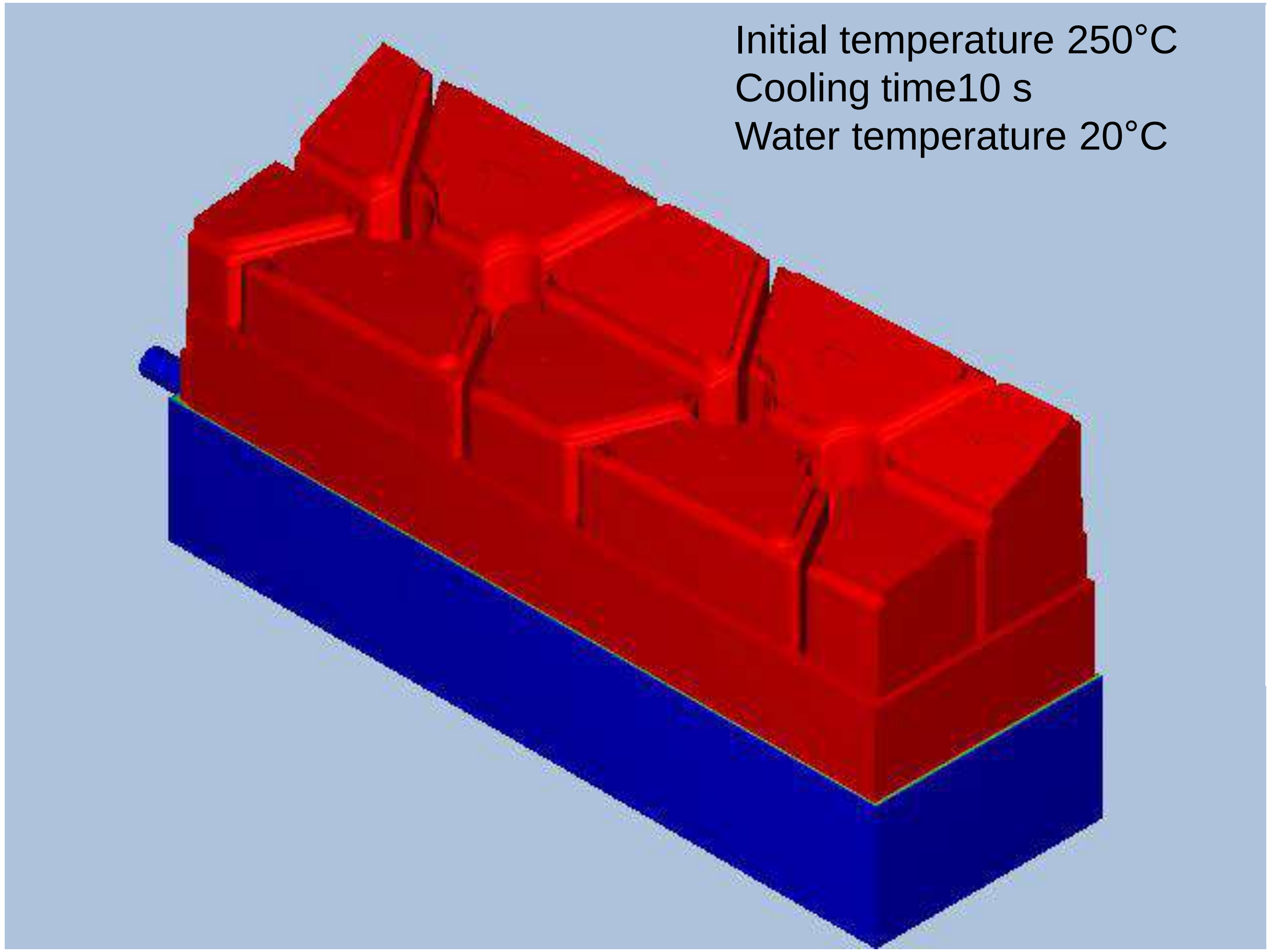
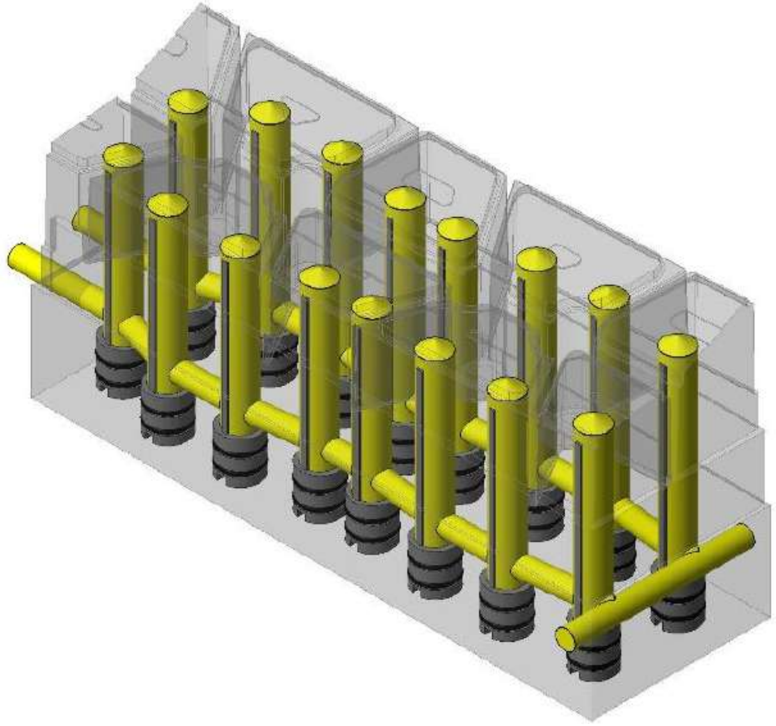
Optimised design – a comparison



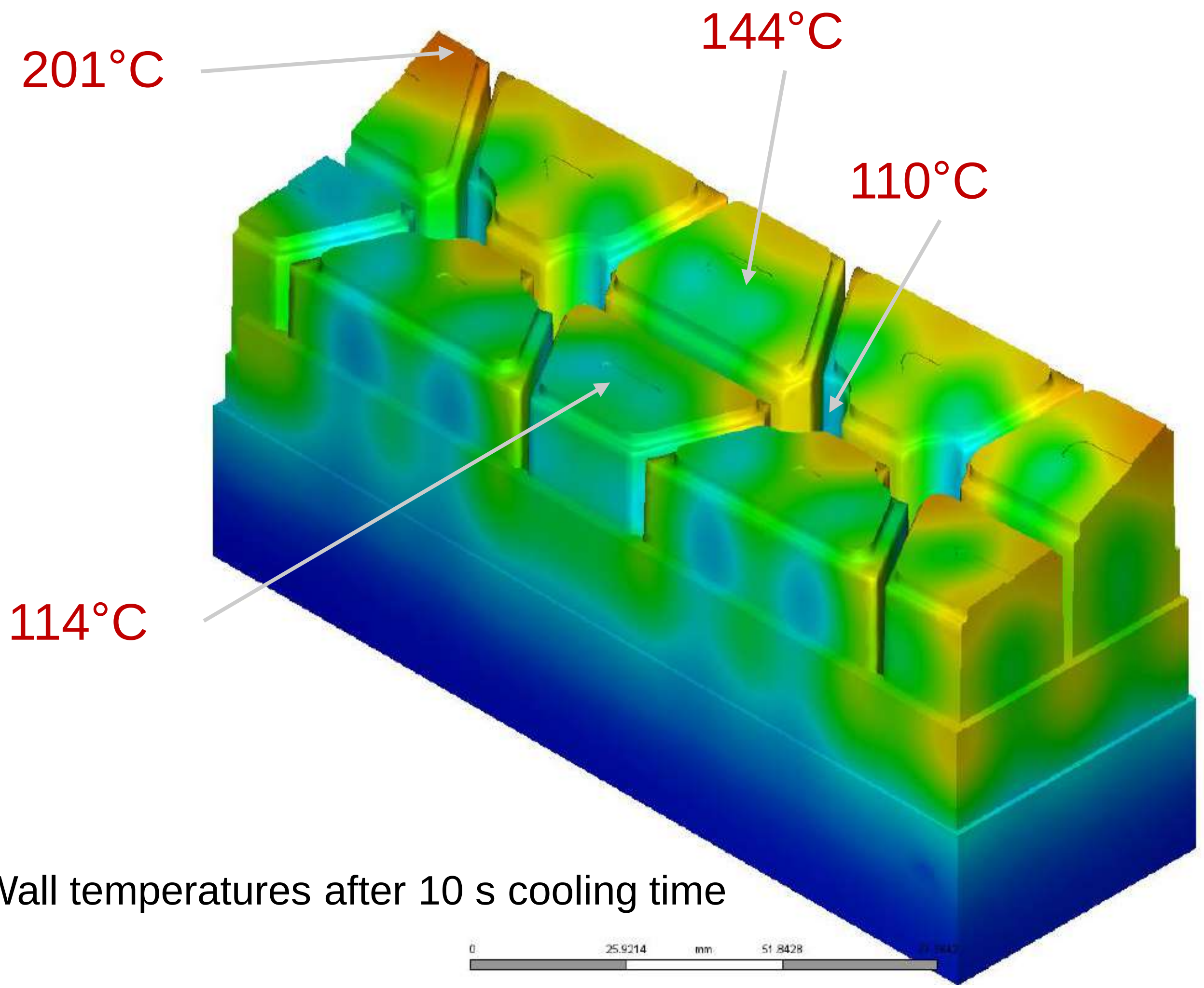
Optimised design – a comparison





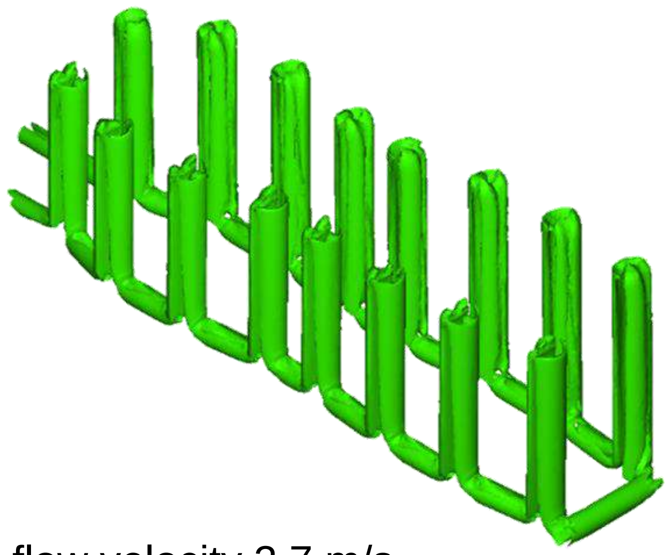
Conventional design with riser holes and baffles.

Optimised design – a comparison



Wall temperatures after 10 s cooling time

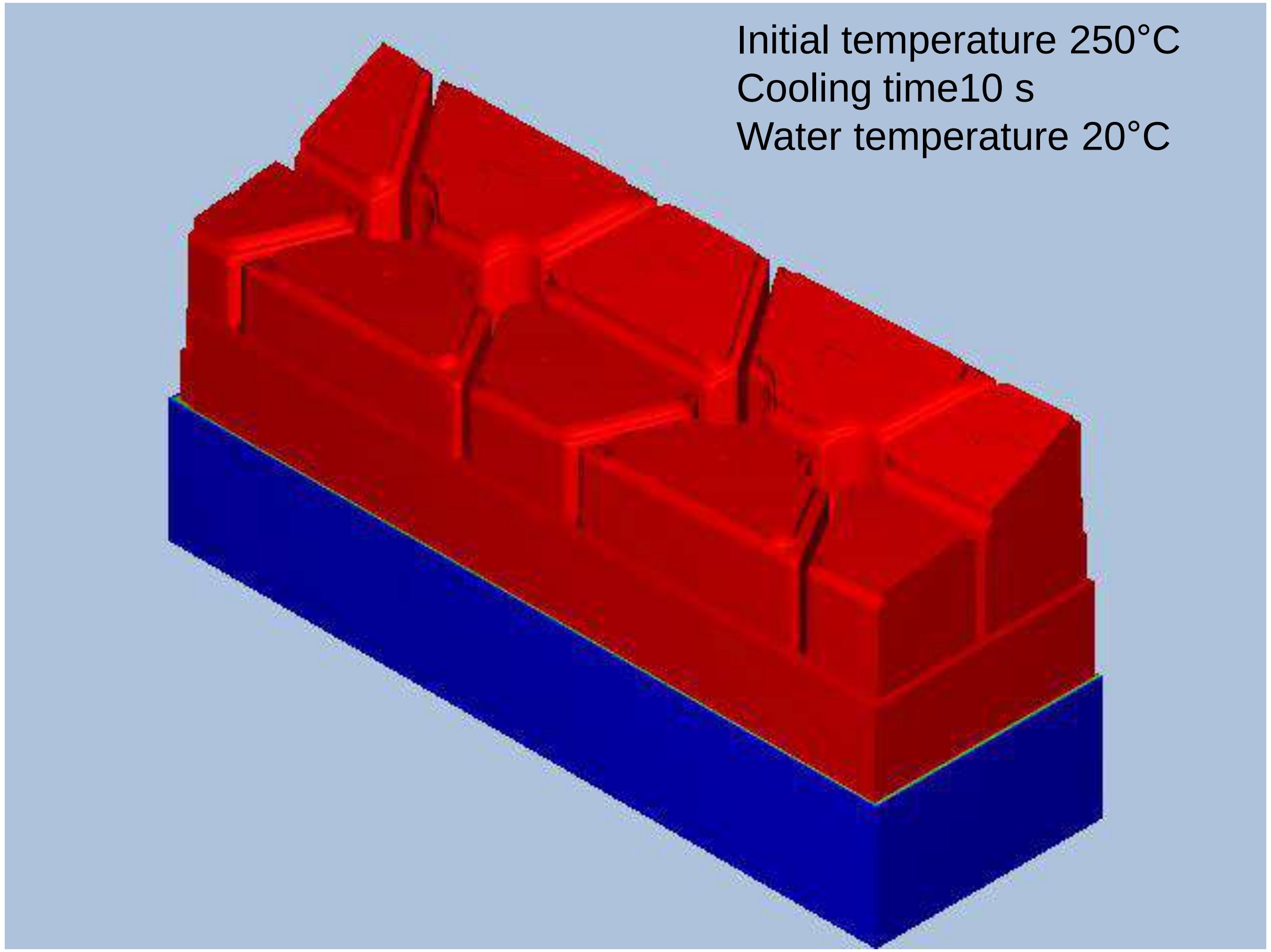
Conventional design with riser holes and baffles.

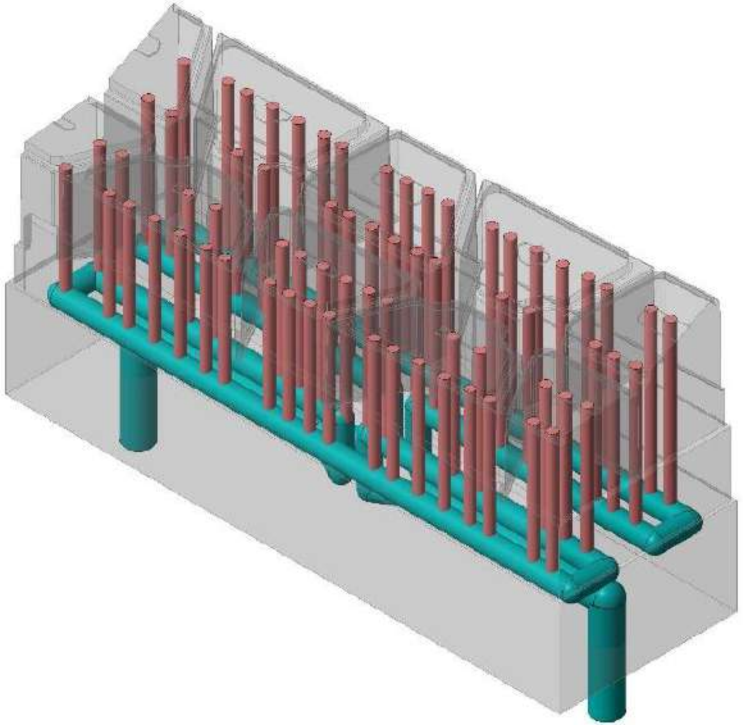


Average flow velocity 2.7 m/s

	3,5 bar	6 bar
Flow rate	4 l/min	5,2 l/min
Average flow velocity	2,7 m/s	3,5 m/s
Reynolds number	9.800	12.740

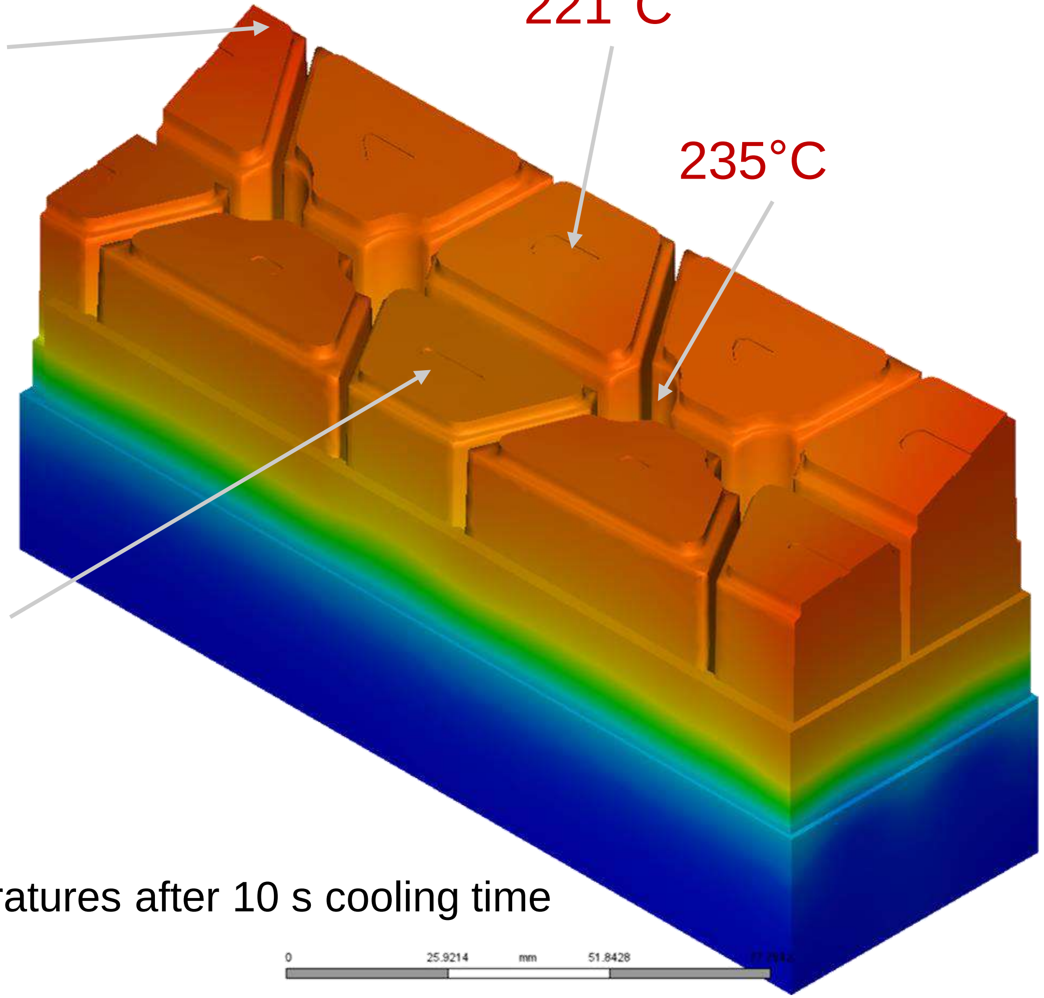
Optimised design – a comparison





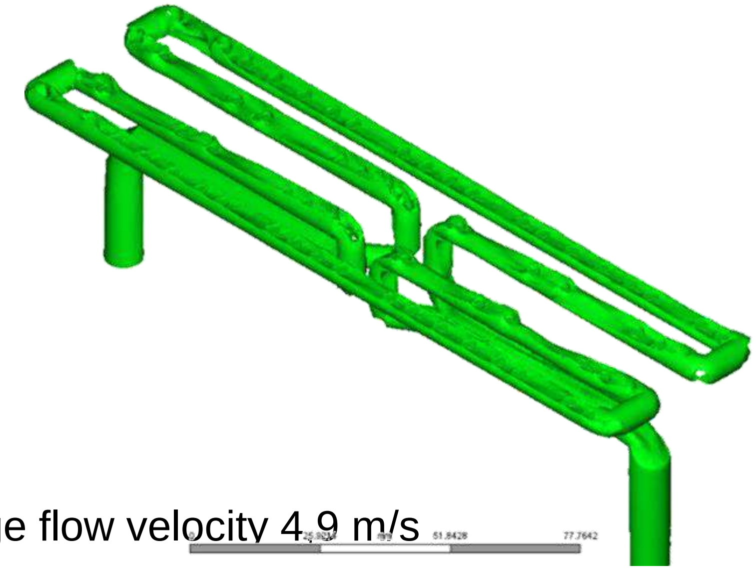
Vacuum-brazed version with many copper pins around which the water flows.

Optimised design – a comparison



Wall temperatures after 10 s cooling time

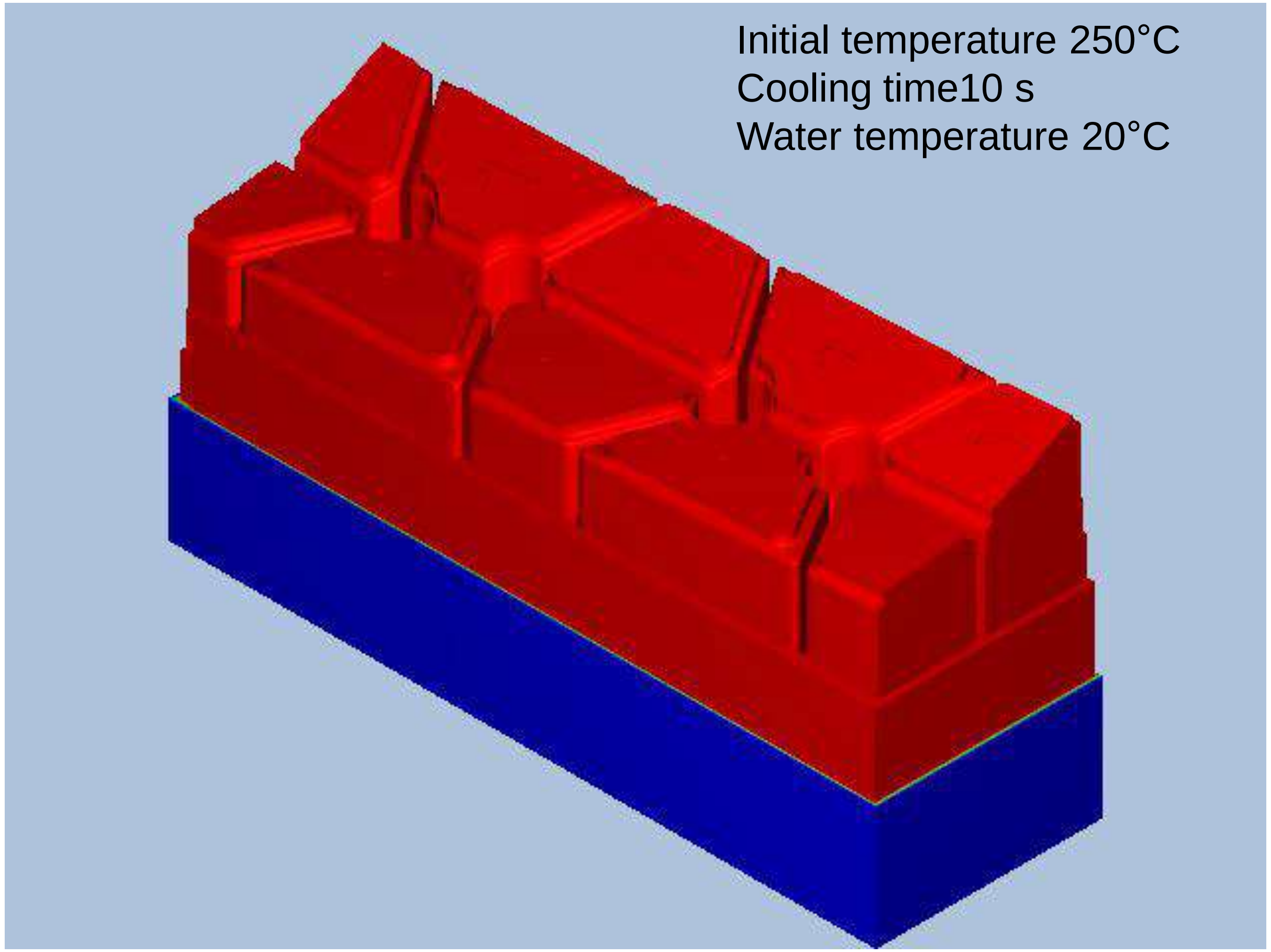
Vacuum-brazed version with many copper pins around which the water flows.

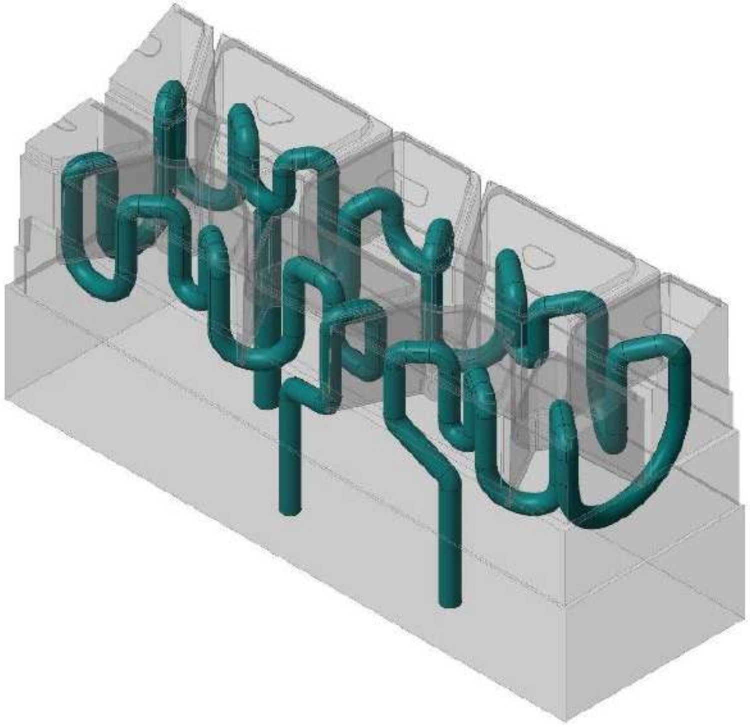


Average flow velocity 4,9 m/s

	3,5 bar	6 bar
Flow rate	16 l/min	20,8 l/min
Average flow velocity	4,9 m/s	6,0 m/s
Reynolds number	29.400	38.220

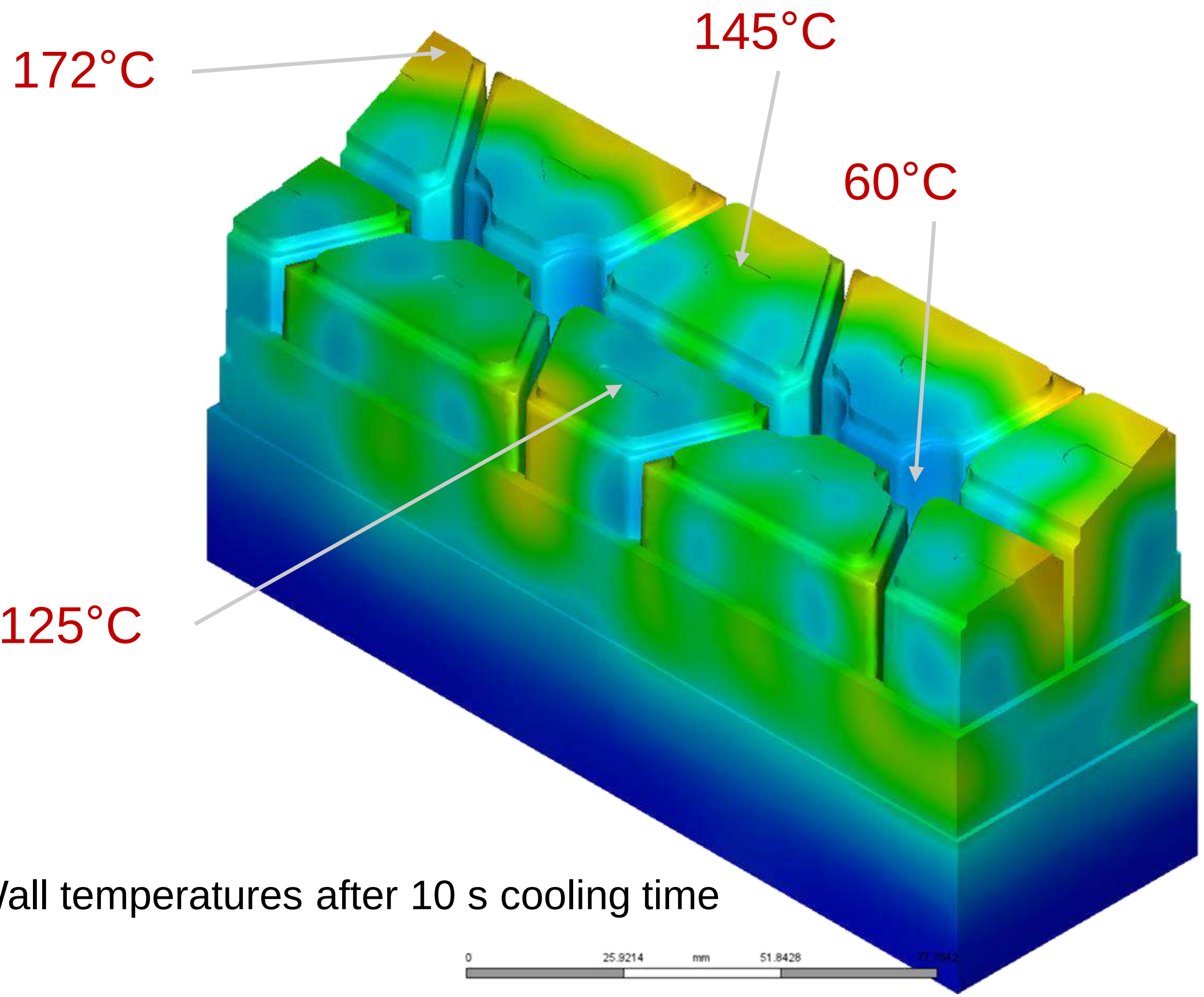
Optimised design – a comparison





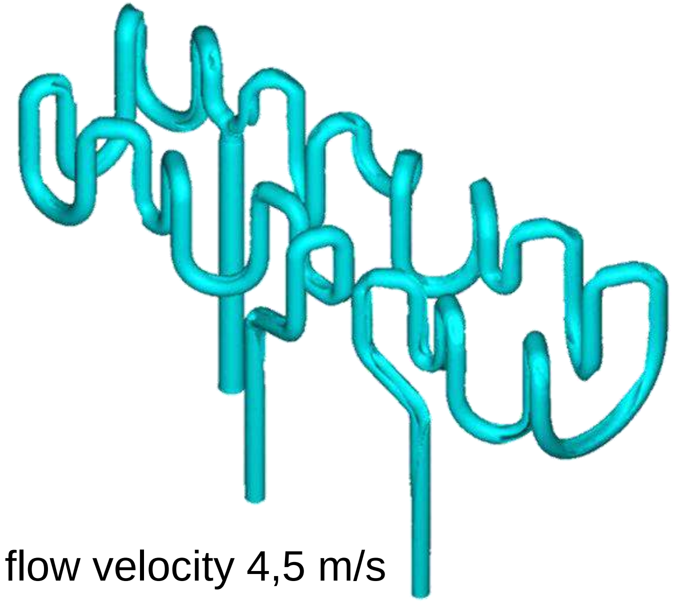
non-optimised, simple additive tempering.
(Customer design)

Optimised design – a comparison



Wall temperatures after 10 s cooling time

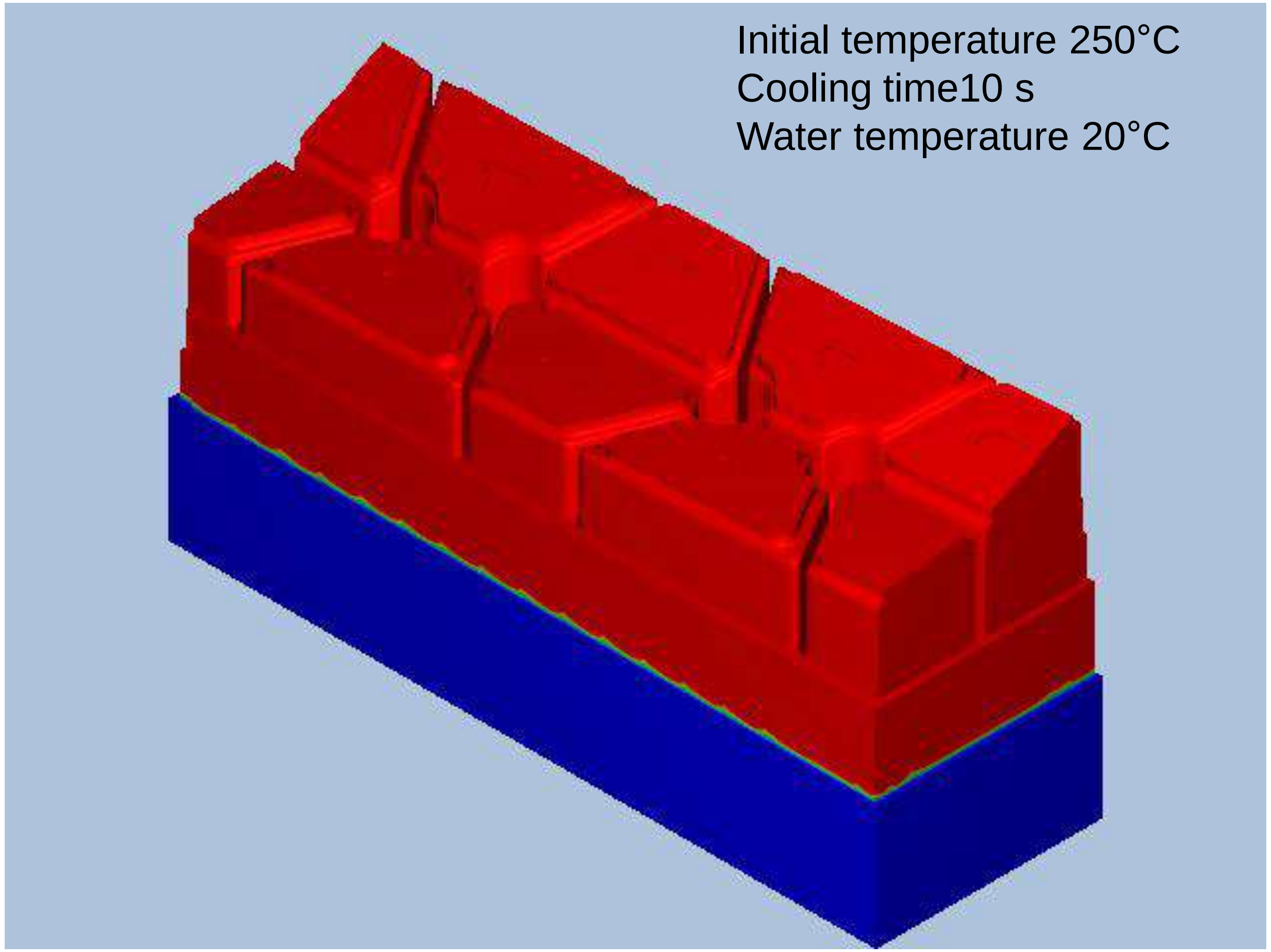
non-optimised, simple additive tempering.
(Customer design)

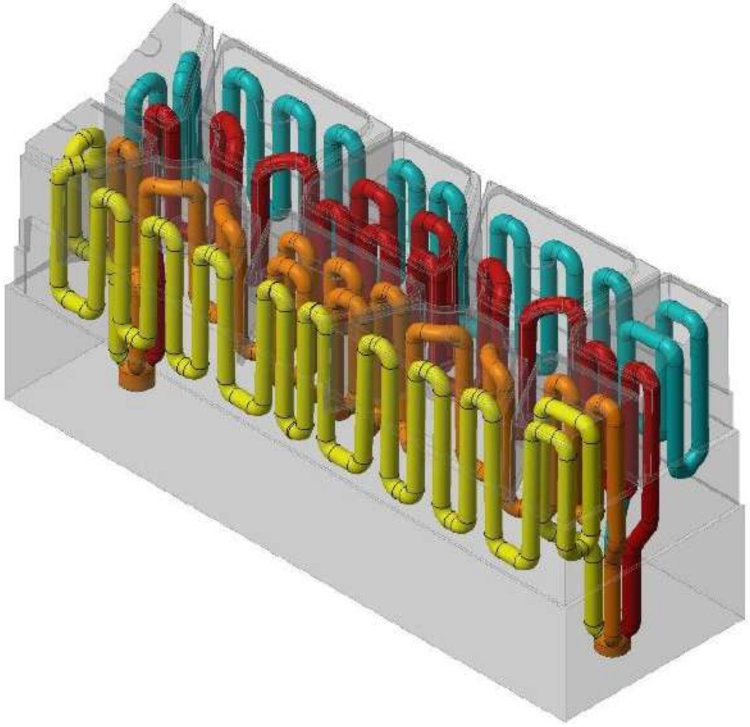


Average flow velocity 4,5 m/s

	3,5 bar	6 bar
Flow rate	10,5 l/min	13,7 l/min
Average flow velocity	4,5 m/s	5,9 m/s
Reynolds number	22.500	29.250

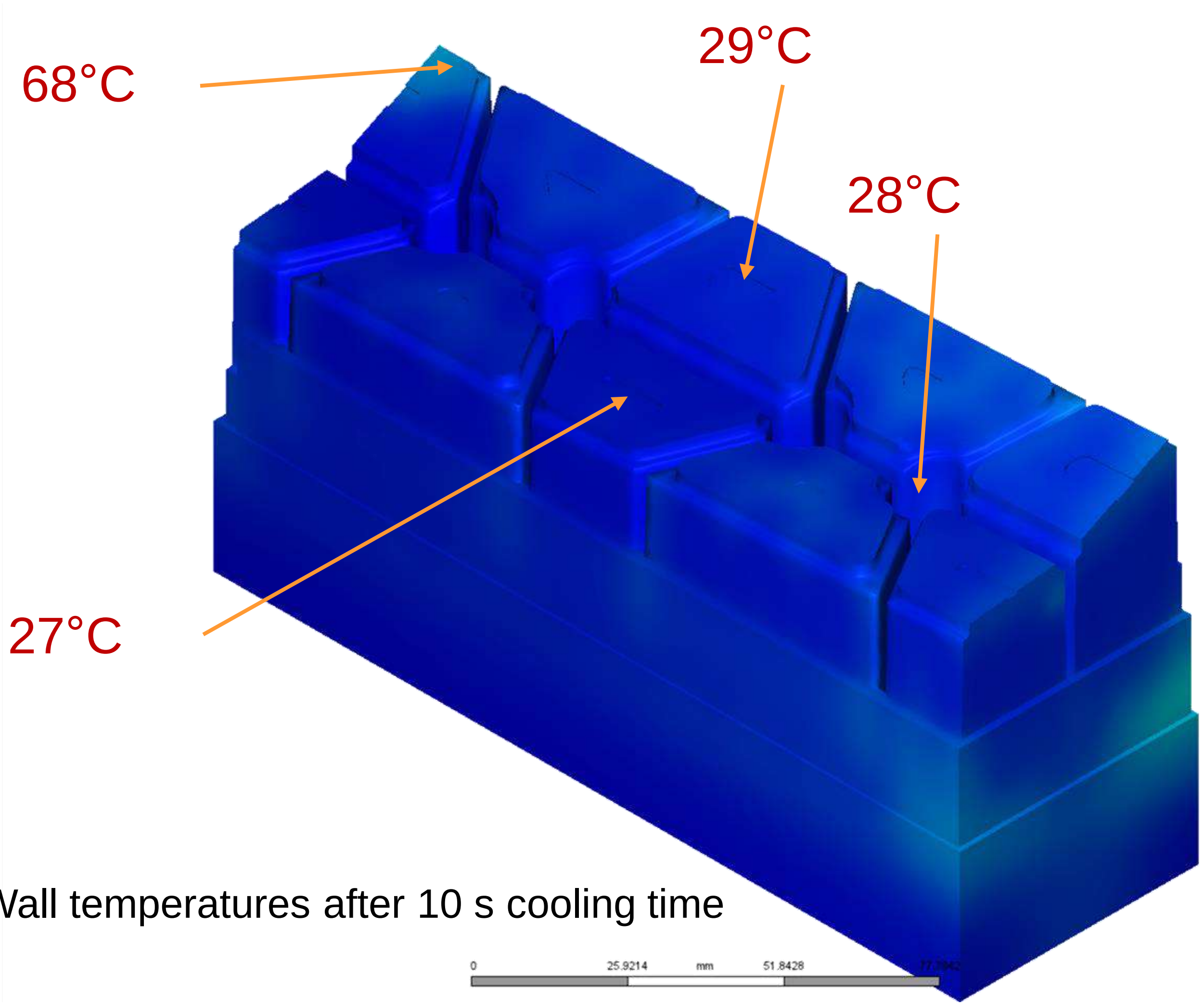
Optimised design – a comparison





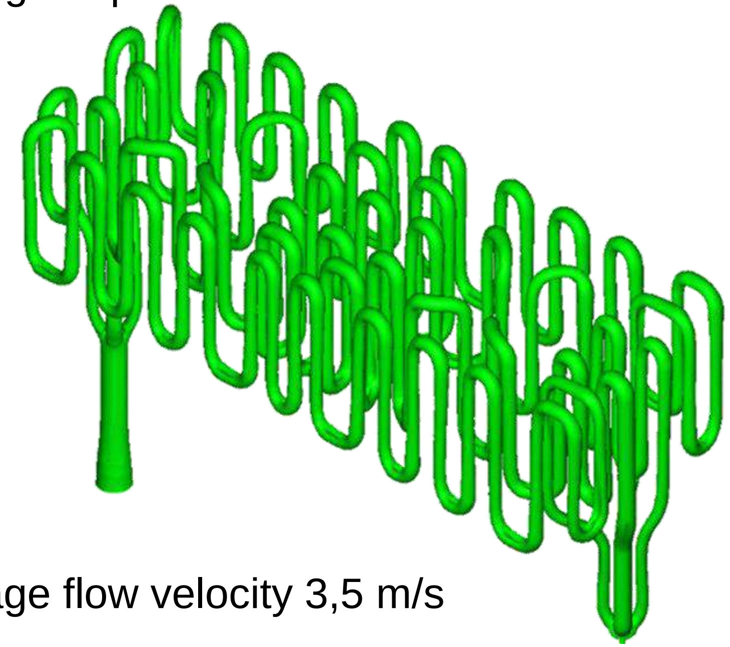
Optimized and balanced additive conformal cooling temperature control.

Optimised design – a comparison



Wall temperatures after 10 s cooling time

Optimized and balanced additive conformal cooling temperature control.

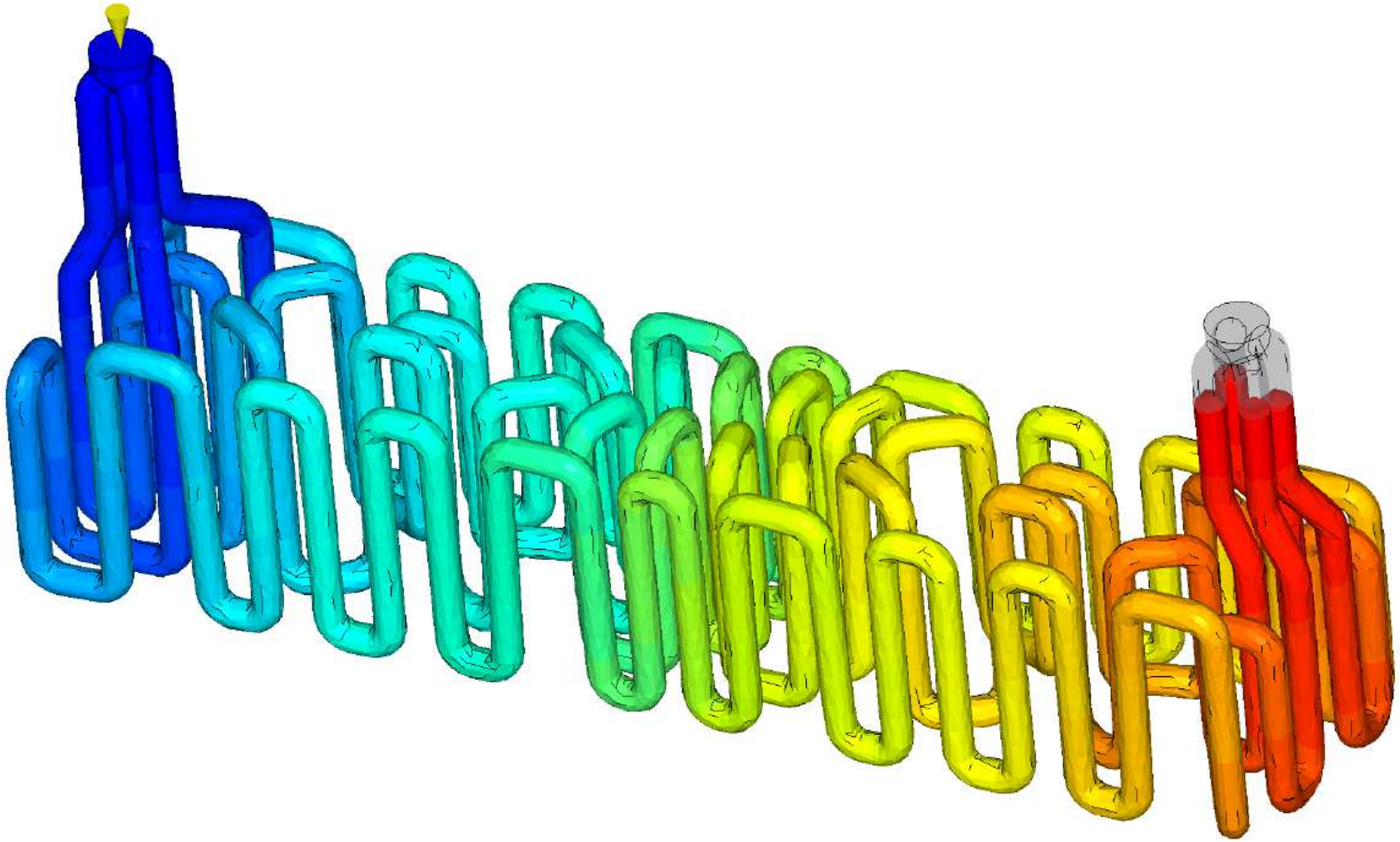


Average flow velocity 3,5 m/s

	3,5 bar	6 bar
Flow rate	10,2 l/min	13,2 l/min
Average flow velocity	3,5 m/s	4,5 m/s
Reynolds number	14.000	18.200

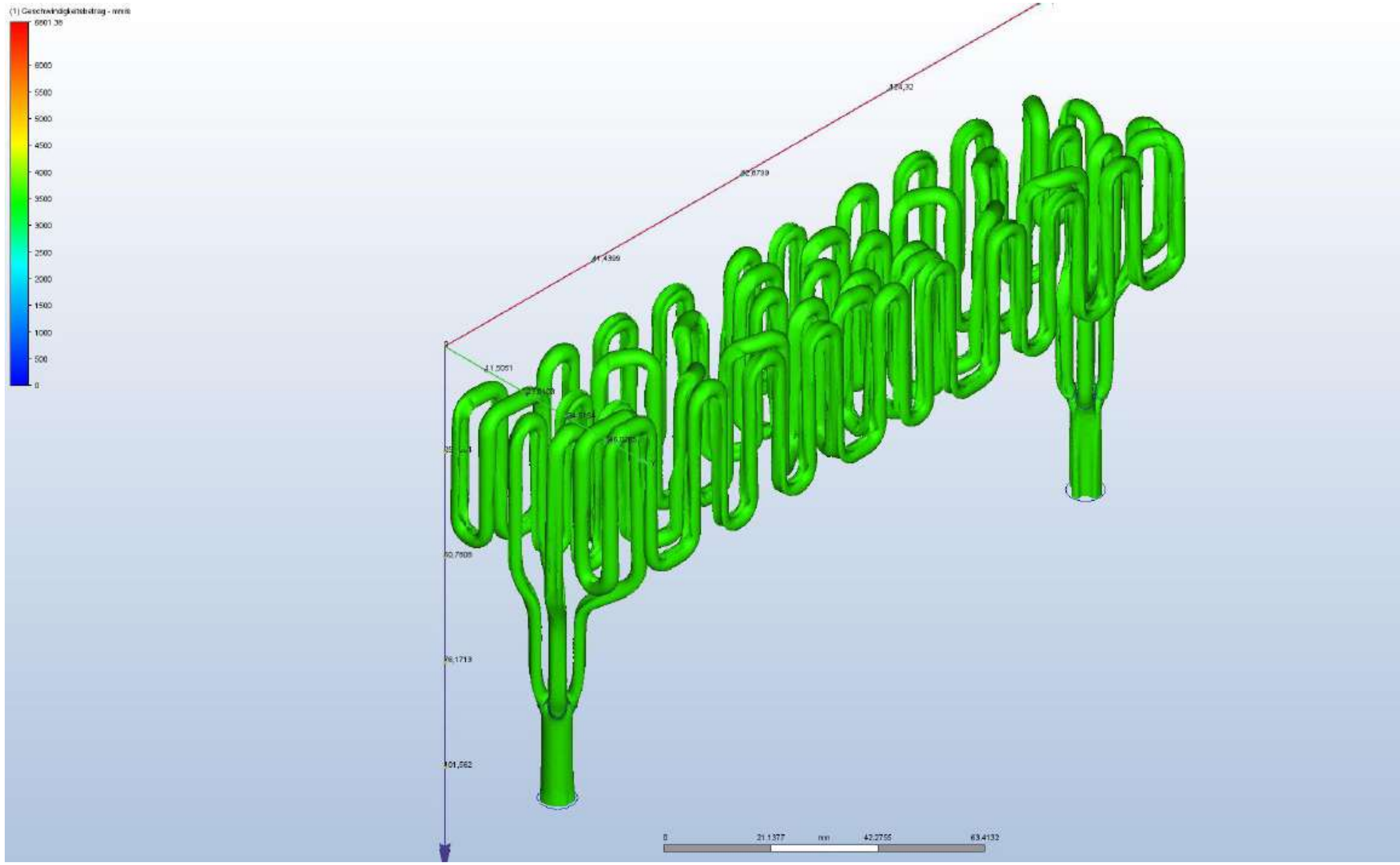
Optimised design – a comparison

Balancing of the parallel connected cooling system



Optimised design – a comparison

CFD Flow velocity isoperimetric surfaces at 3.6 m/s



Simulated flow rate at 3,5 bar:
(f.l.t.r)

C1	**2,53 l / min**
C2	**2,56 l / min**
C3	**2,53 l / min**
C4	**2,55 l / min**
Total:	**10,20 l / min**

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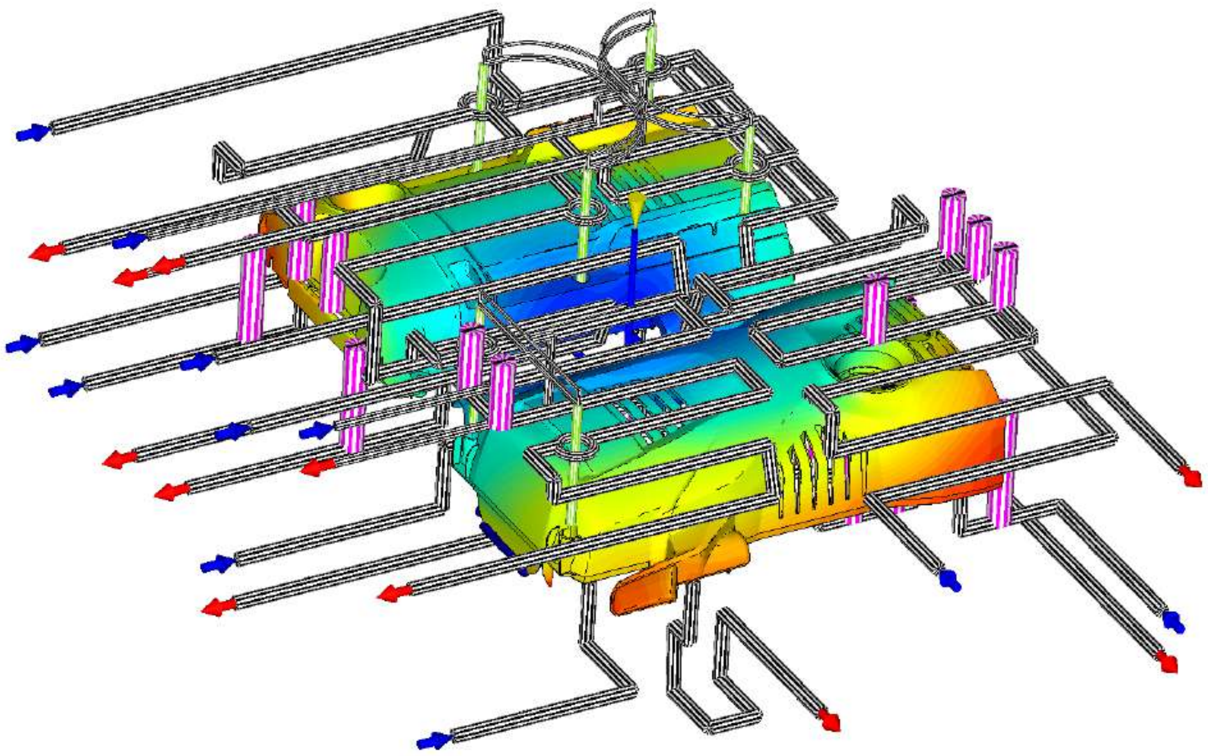
Simulation (injection moulding simulation)



INFORMATION:

A Simulation package consists of:

1. running the entire injection molding process of the existing mold in our simulation software with mapping of the real parameter.

   For this we need a detailed data sheet of the existing injection molding process and a data sheet of the used plastic material.
2. Determination of the cycle time relevant areas
3. Optimization of the conventional cooling in order to improve the injection molding process.
4. Design of the conformal cooling.
5. running the entire injection molding process of the optimized mold in our simulation software with optimized parameter.
6. Assessment of the simulation results

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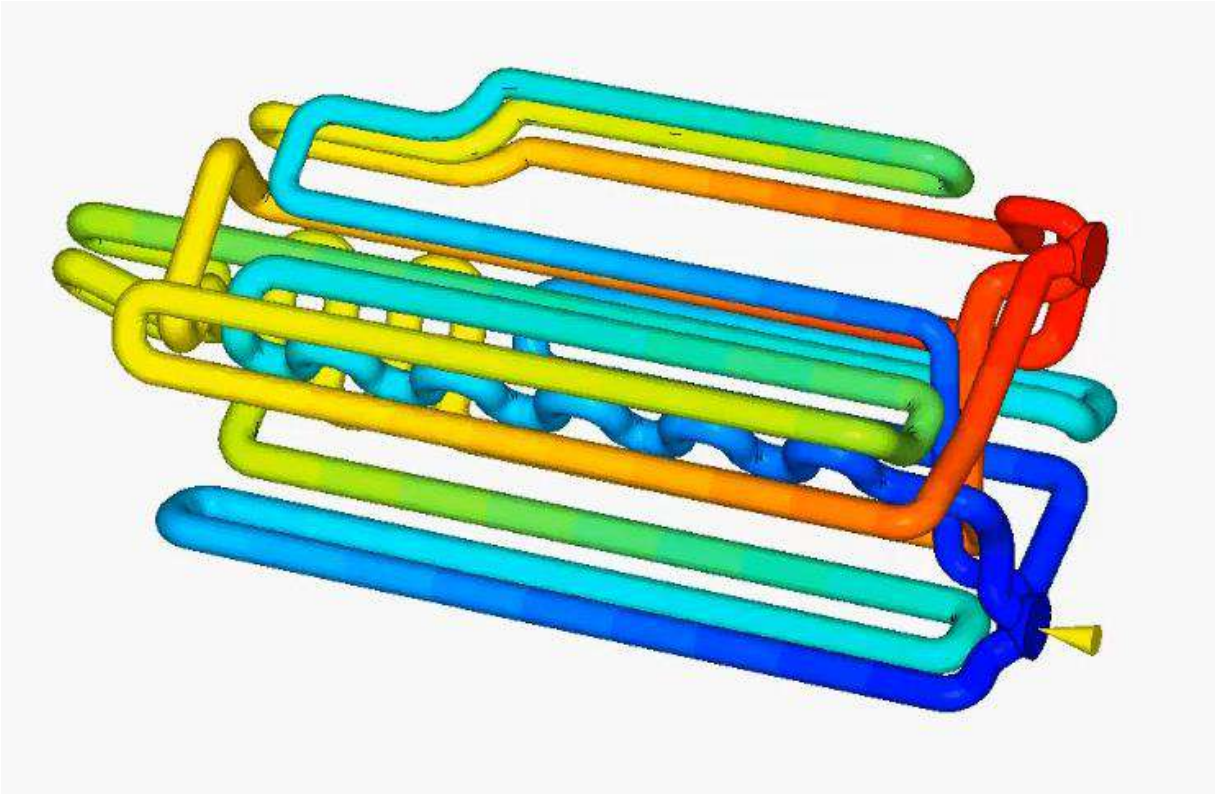
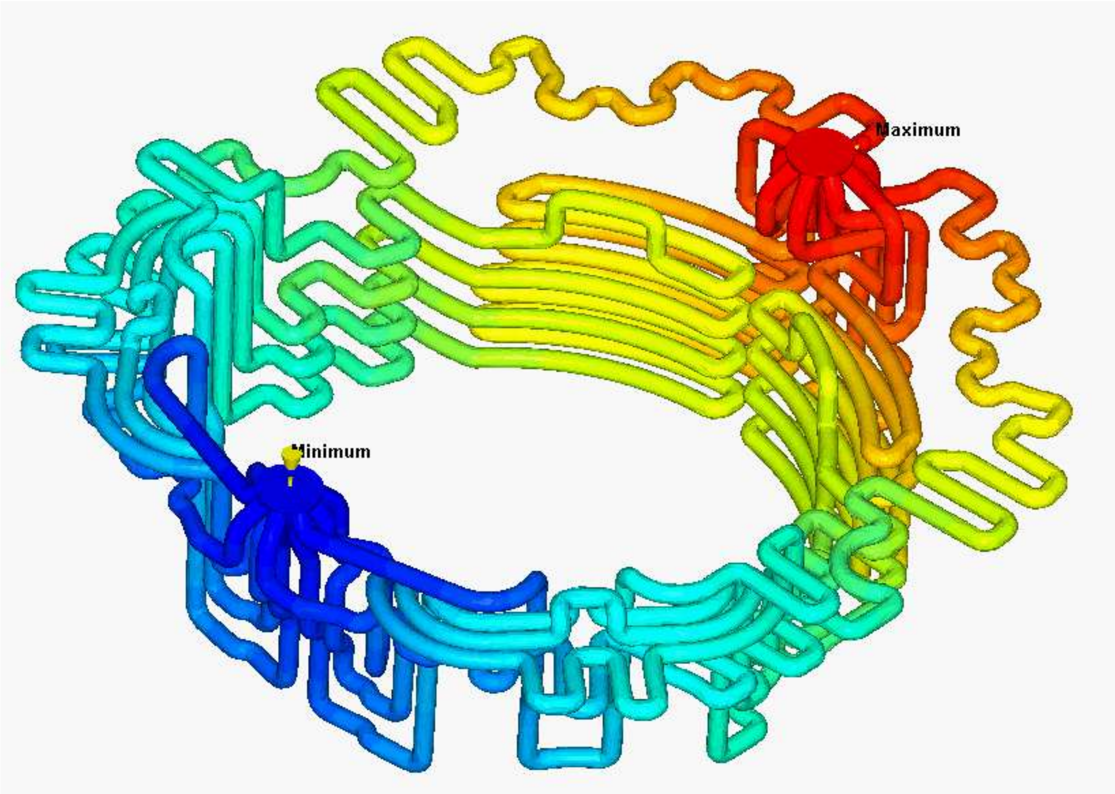
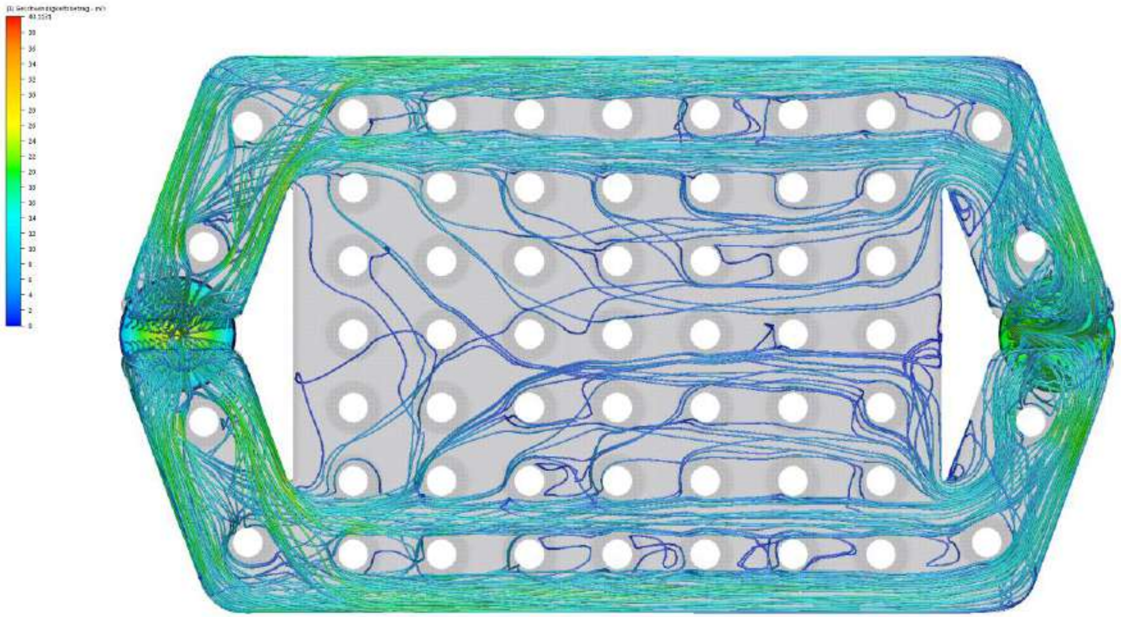
Simulation (Balancing of complex, parallel-connected cooling systems)

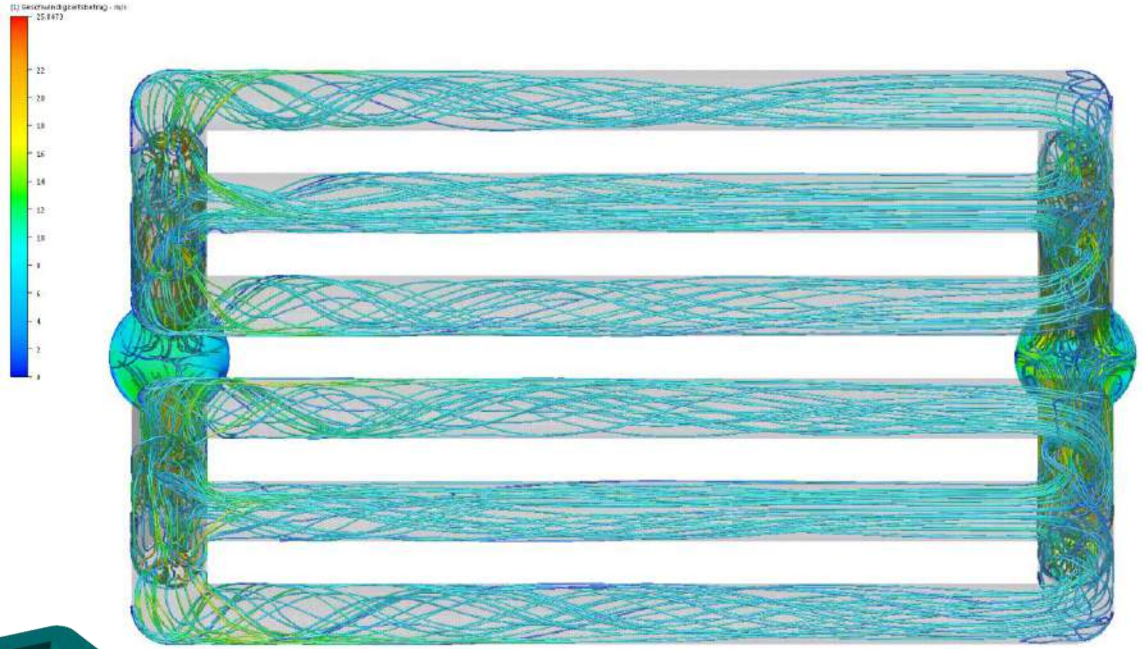


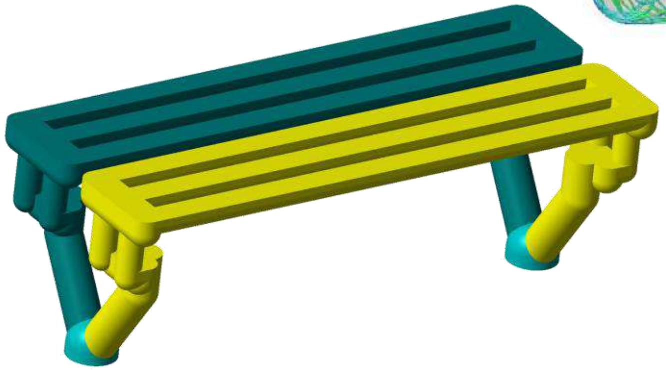


Simulation (CFD – flow rate, flow veloctiy)

net structure **vs** **balanced 6-fold parallel connected cooling**







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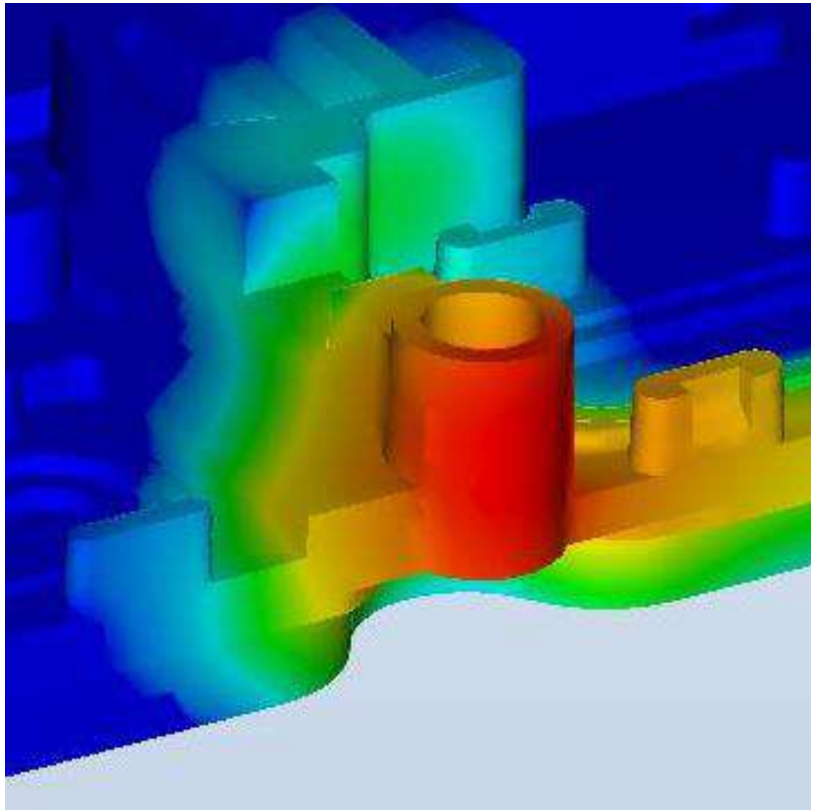
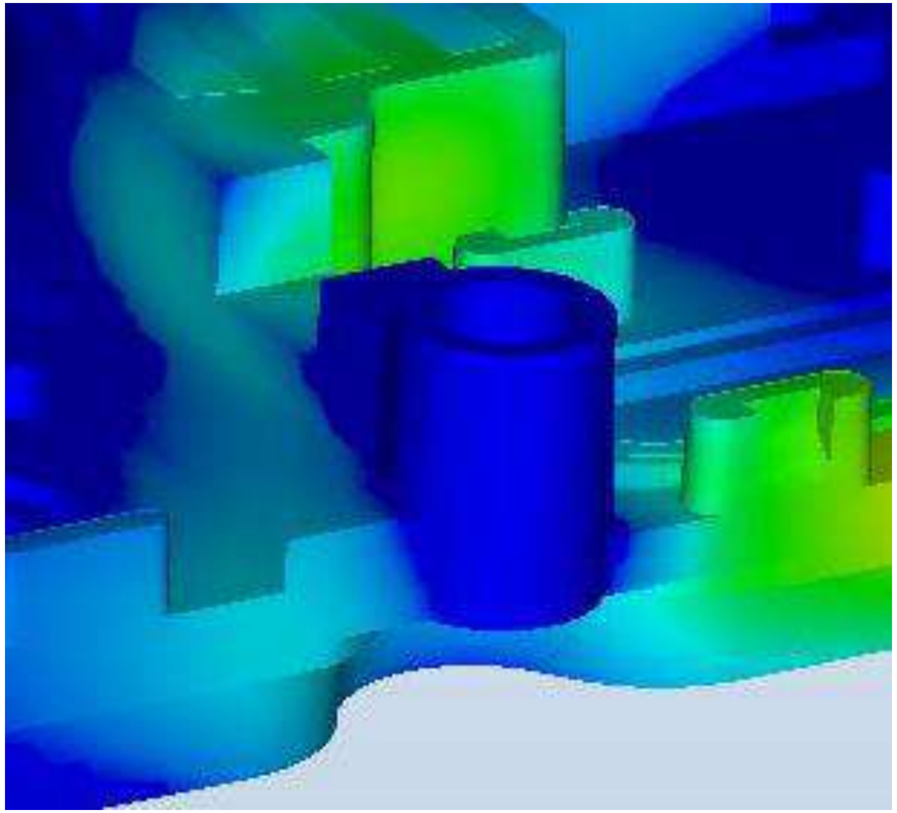
Simulation (CDF – heat transfer processes)

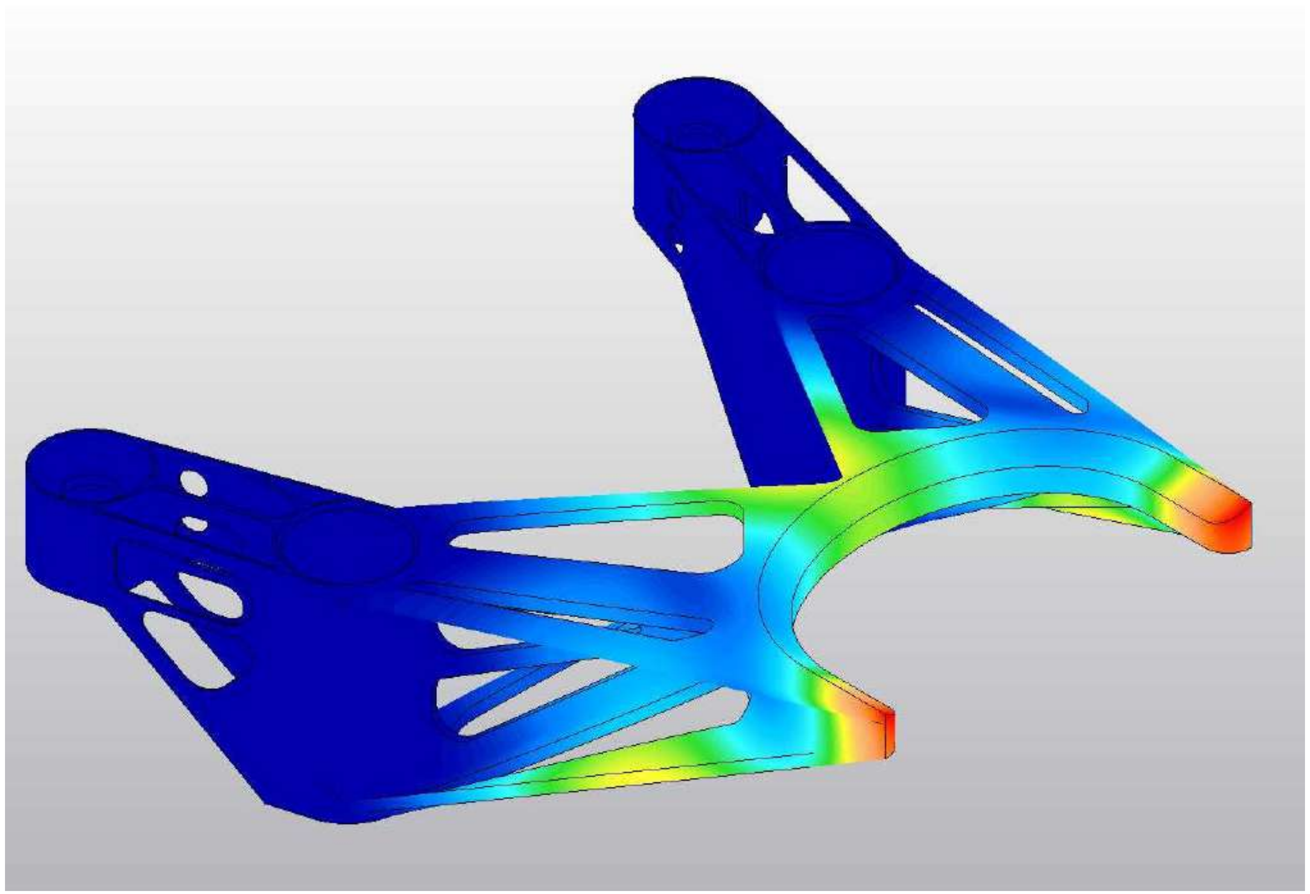
hot spot area before and after the optimization





Simulation (FEM – structure analysis, light weight design)

Design of an additive manufactured light weight grab

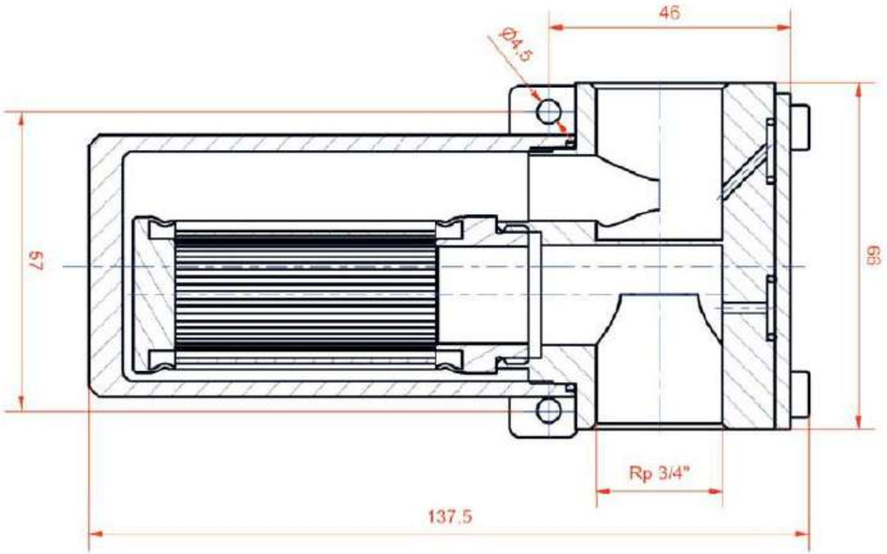


Requirements for using conformal cooling

- Use of suitable filtering systems

LF80-200

LF80-200 with maintenance indicator



Edelstahl-Leitungsfilter LF 80-200

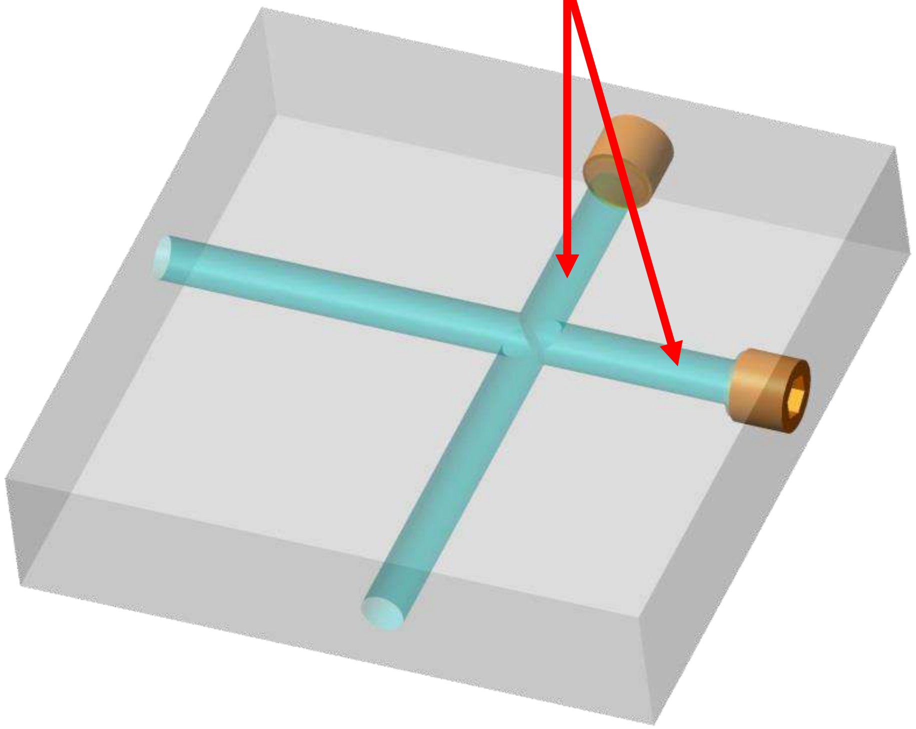
Material	Edelstahl 1.4305
Anschlussgewinde	G 3/4“
Temperiermedium	Wasser / Öl
Druckbereich	PN 16
Betriebstemperatur	-10°C / 260°C
Dichtung	PTFE
Abmessungen	76 x 56 x 131 mm (L x B x H)
Gewicht	ca. 1,3 kg
Montage	Wandhalterung

Intelligence + quality for moulds and dies

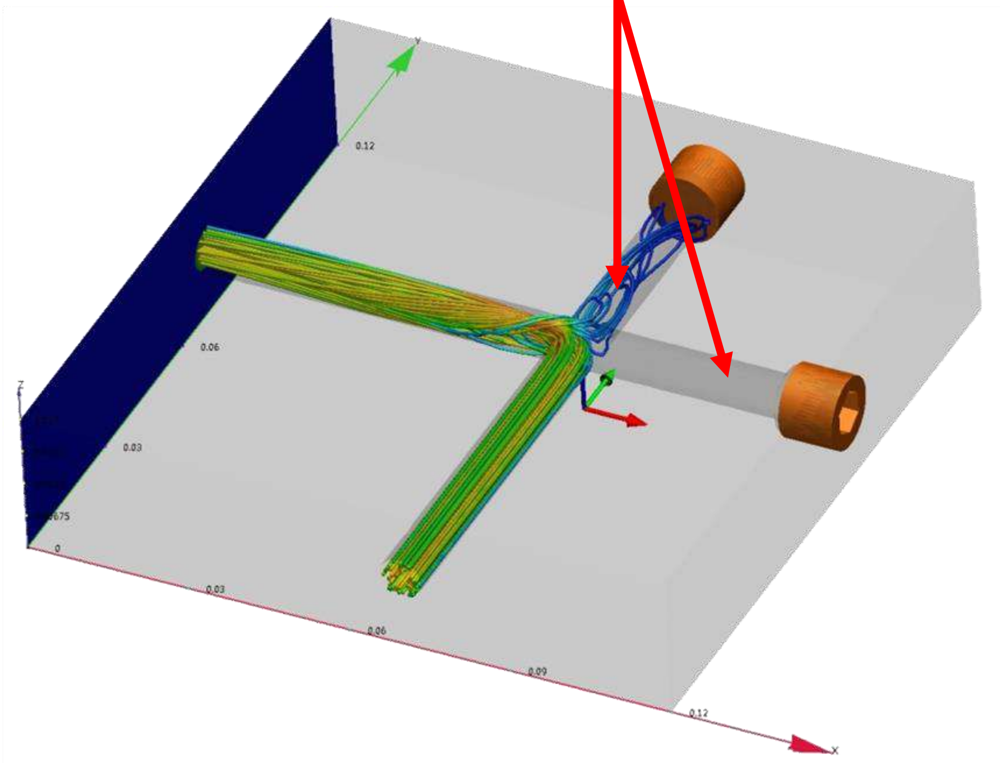
Requirements for using conformal cooling

- Avoid dead ends in your mold

Dead end - area without flow.
Risk of depositions.

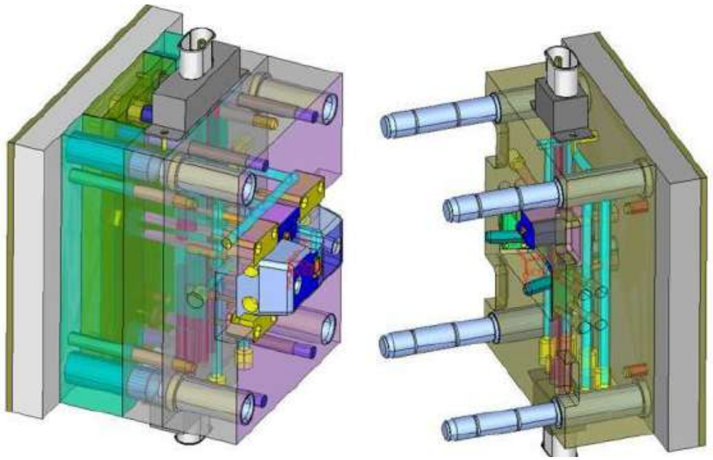


Area without flow.
Risk of depositions.

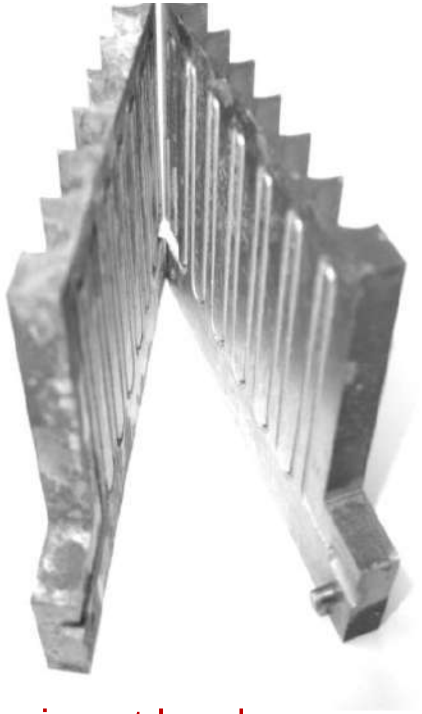


Requirements for using conformal cooling

- conformal cooling circuits have to be connected separately.
- if necessary the channels should be maintained and cleaned with an ultrasonic cleaner.
- Calcination can, if it even occurs, be removed with special rinsing plants with citric acid.
- When storing the mold, dry the channels by compressed air.



Corrosion protection (AnoxPro coating):



The insert has been manufactured in two parts, which where coated in the assembled state:

- AnoxPro coating is an innovative, hard lacquer coating with a metallic component due to which it exhibits active corrosion protection.
- The AnoxPro coating has a layer thickness of only 10µm. This ensures an essentially identical surface roughness inside the cooling channels as compared prior to treatment, thus cooling capacity remains the same.
- Coating of cooling channels is done in a very secure process. All that is required is to coat the walls of the cooling channel with the lacquer and subsequently to remove the excess material with pressurized air. The coating process is finished off by tempering at approx. 200°C.
- AnoxPro not only protects from corrosion but also slows down deposition of calcium and bacteria.
- AnoxPro is applicable for variothermal processes up to a temperature of 180°C

Corrosion protection (AnoxPro coating):

1.2709, uncoated

1.2709, with AnoxPro coating, approx. 10 µm layer thickness

- AnoxPro coating is an innovative, hard lacquer coating with a metallic component due to which it exhibits active corrosion protection.
- The AnoxPro coating has a layer thickness of only 10µm. This ensures an essentially identical surface roughness inside the cooling channels as compared prior to treatment, thus cooling capacity remains the same.
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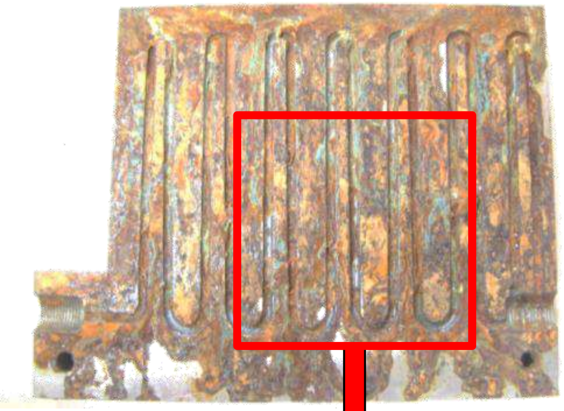
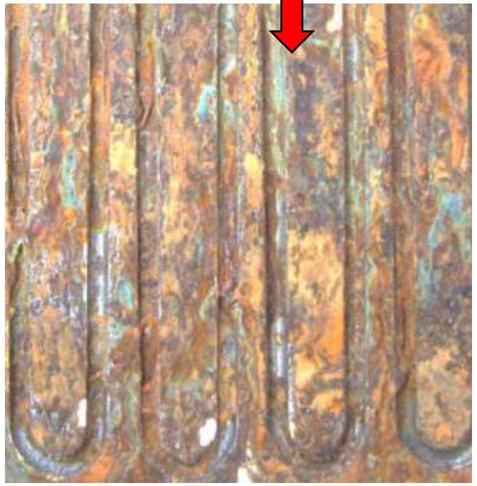
- AnoxPro not only protects from corrosion but also slows down deposition of calcium and bacteria.
- AnoxPro is applicable for variothermal processes up to a temperature of 180°C

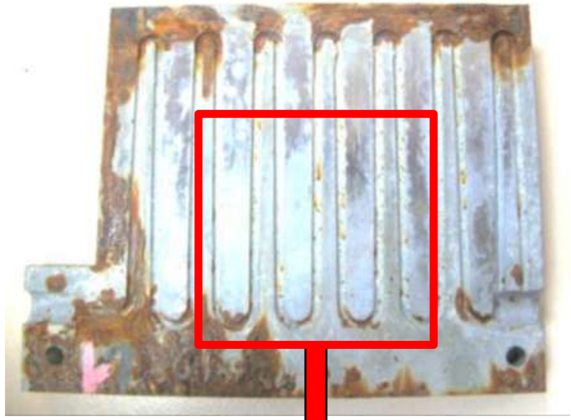
Corrosion protection (AnoxPro coating after 230 h salt spray test):

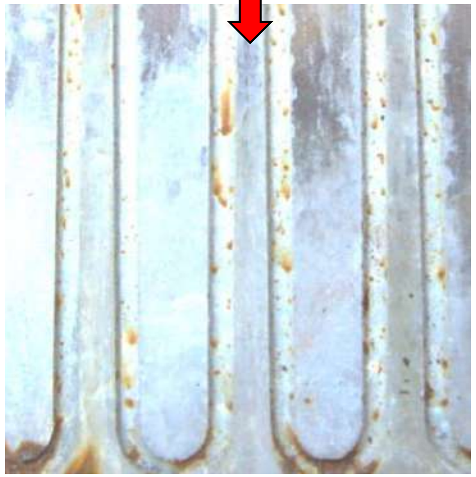


uncoated



AnoxPro coated





Conclusion: The uncoated half's display massive corrosion after 230 hours of salt mist testing over the whole surface.

In the case of the AnoxPro coated parts only the uncoated areas show massive corrosion. The coated area exhibit only minimal corrosion.

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