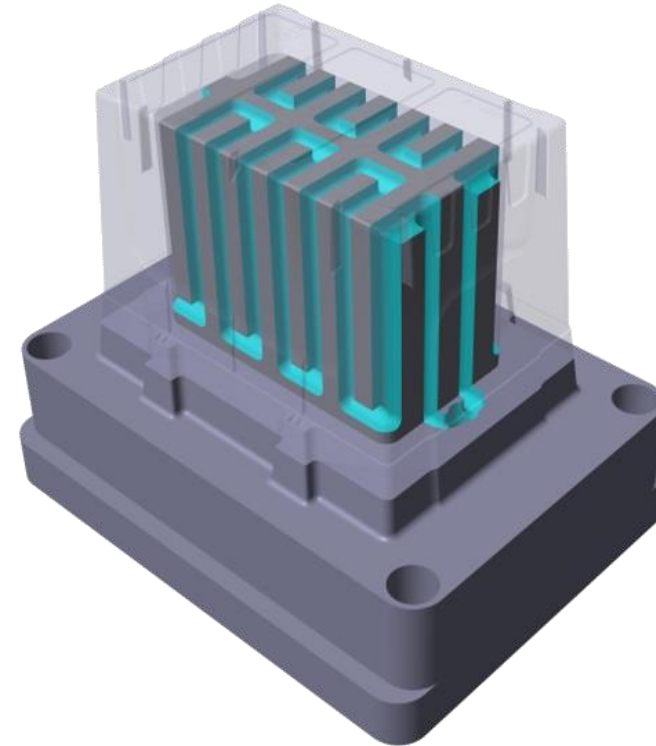
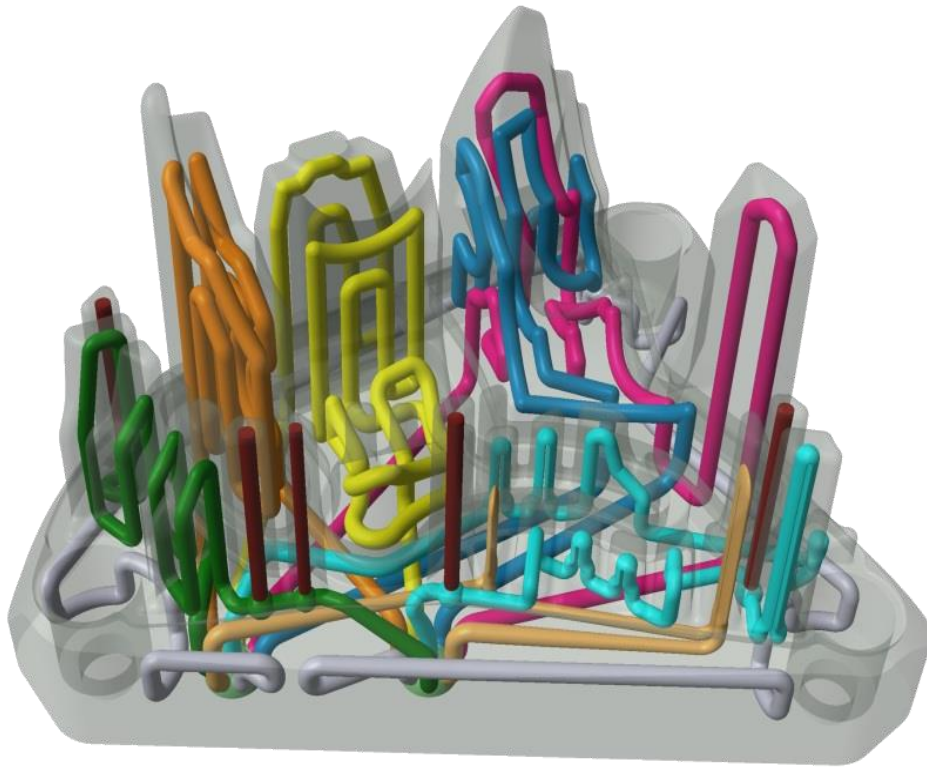
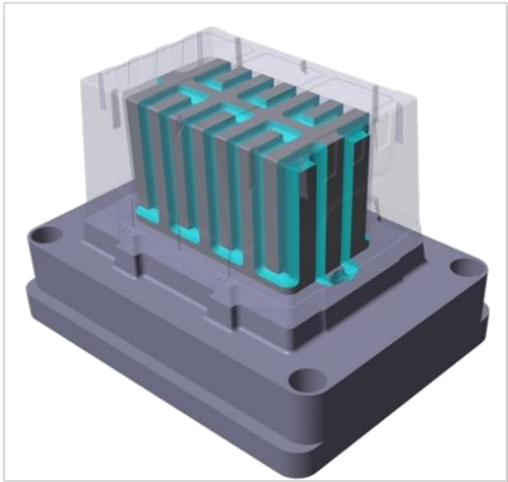


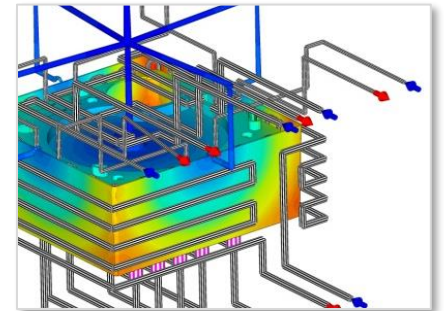
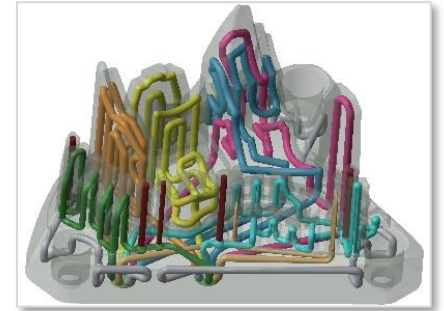
Conformal Cooling par excellence



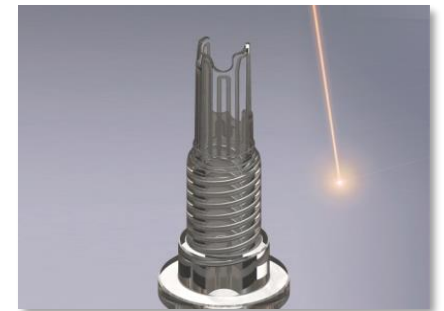
Conformal Cooling par excellence



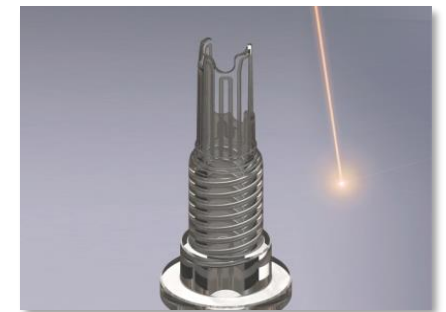
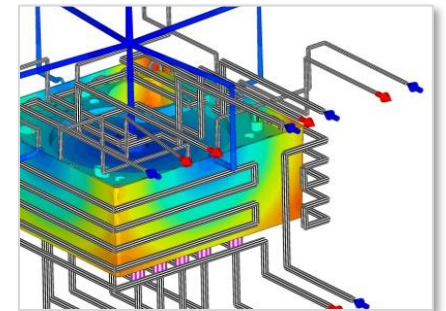
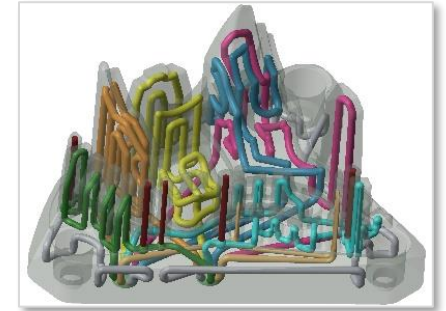
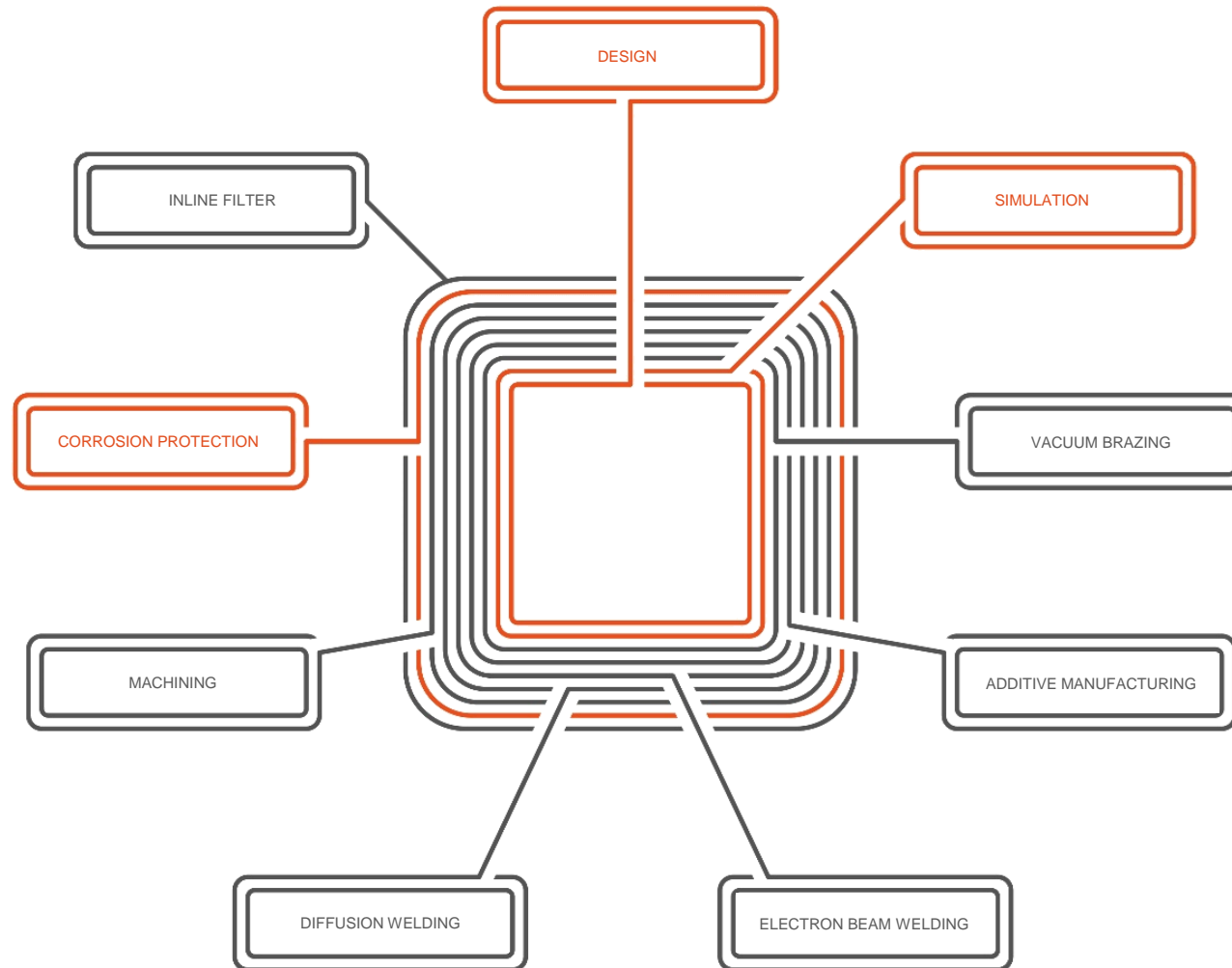
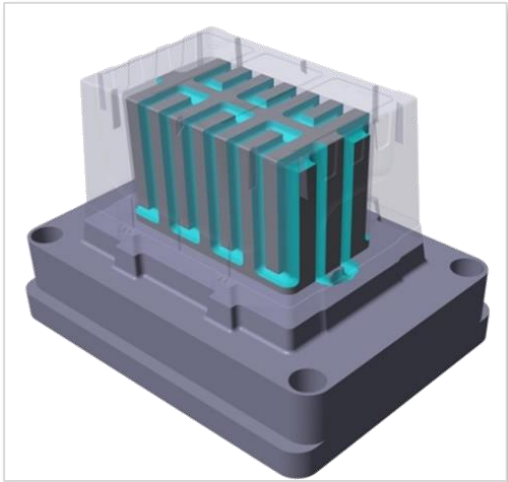
Intelligence + quality for moulds and dies



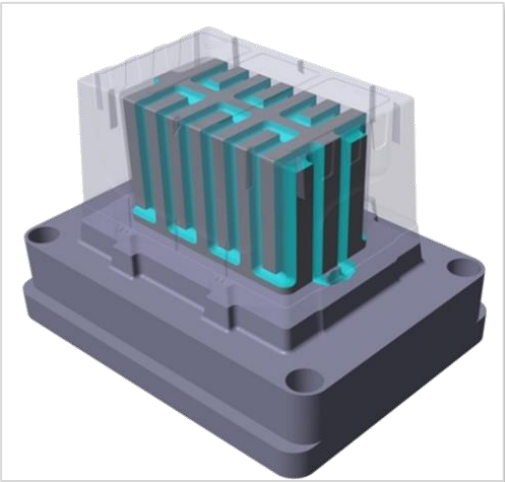
**WE SEE THE
BIGGER PICTURE**



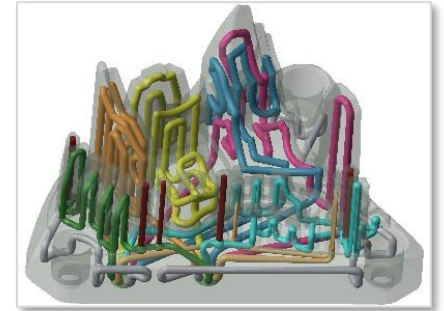
Our portfolio



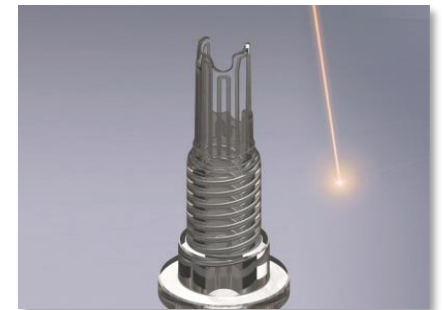
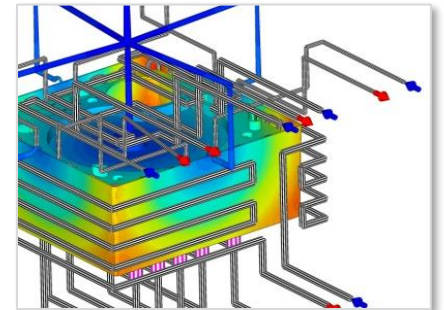
Who we are



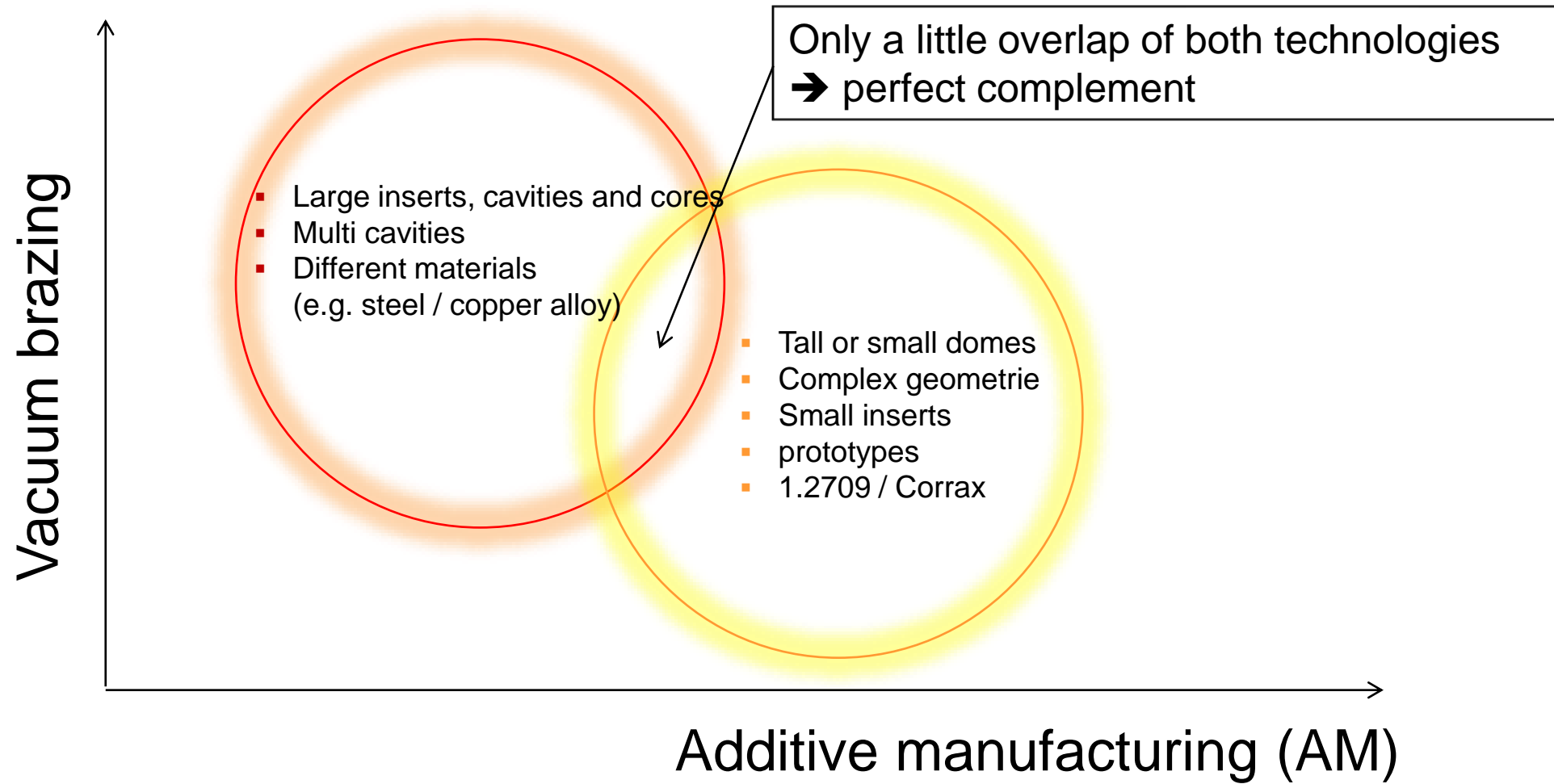
iQtemp GmbH is a company of the Listemann group, with locations in Germany, Liechtenstein, Switzerland and Poland.



Intelligence + quality for moulds and dies



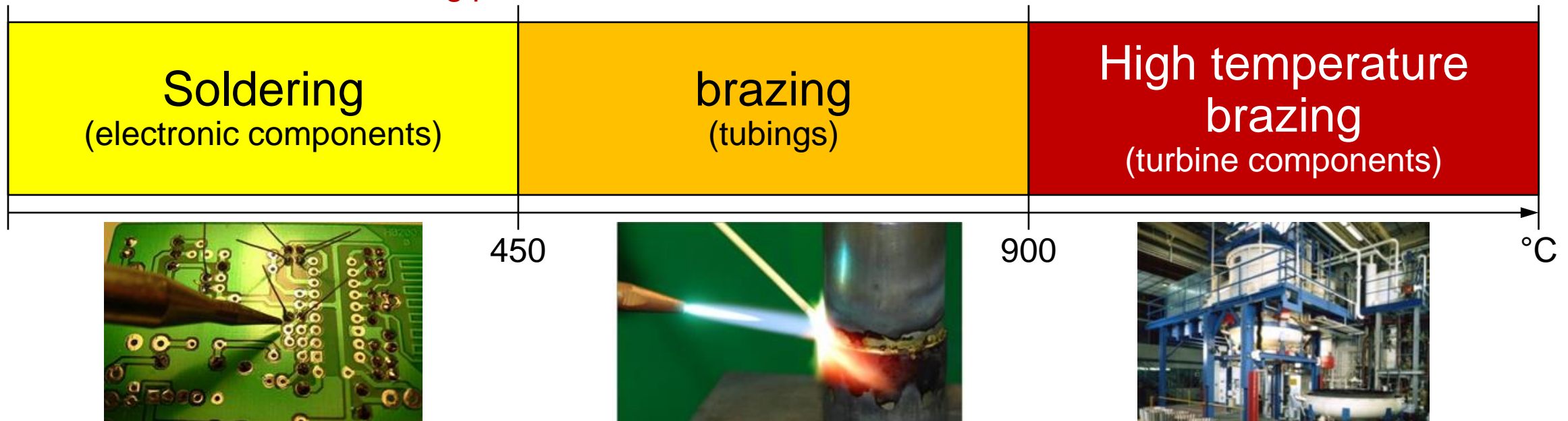
The technology mix



What is brazing?

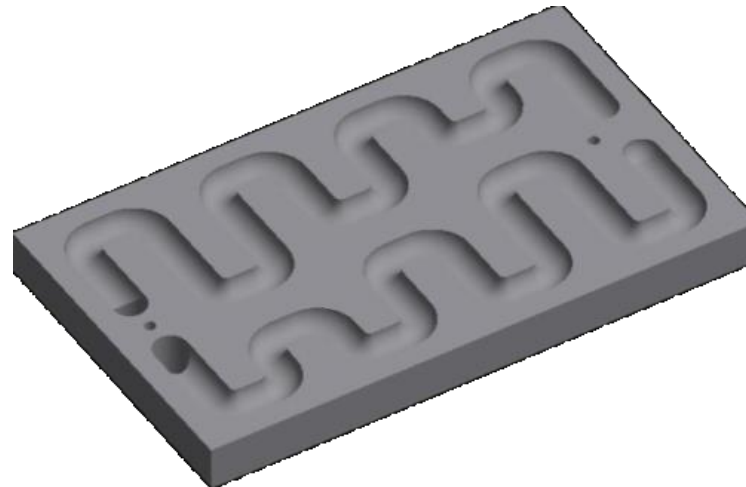
- Brazing is a thermal joining process where strong, metallurgical bonds are established between the base materials by the use of a braze filler metal.
- During joining the filler metal becomes liquid whereas the base material stays solid, in contrast to welding.
- In the interface area an alloying processes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

Classification of the brazing processes

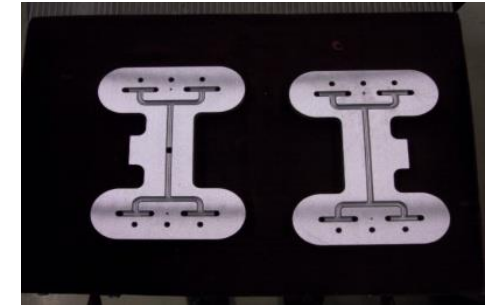
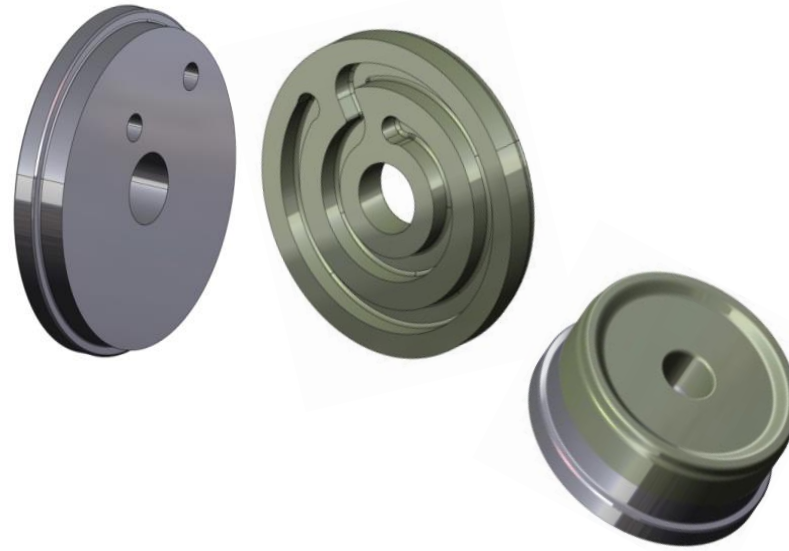
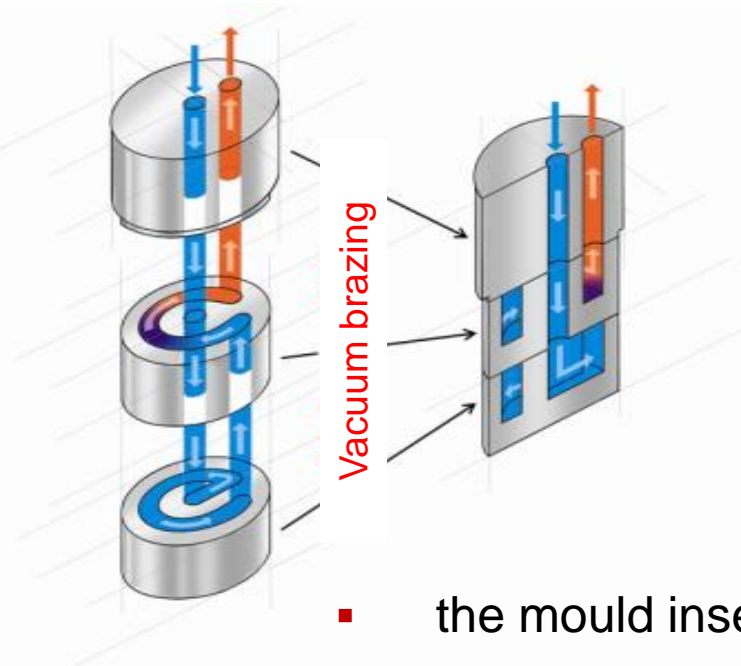


What is vacuum brazing?

- 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.

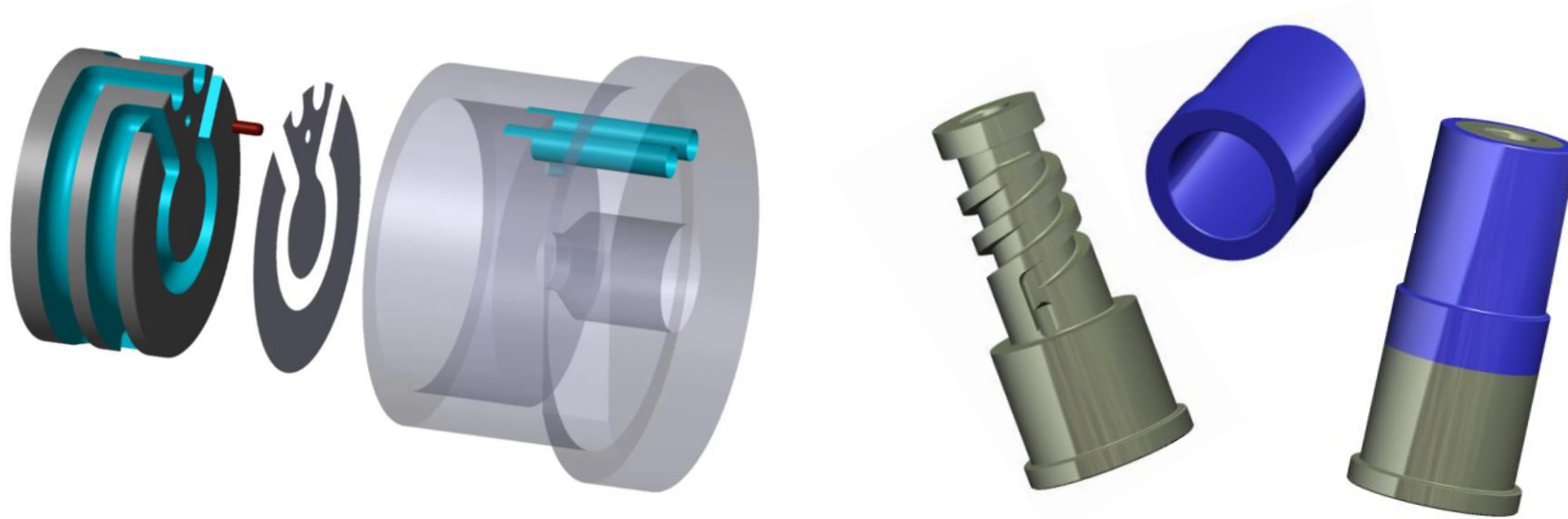


Component design for vacuum brazing

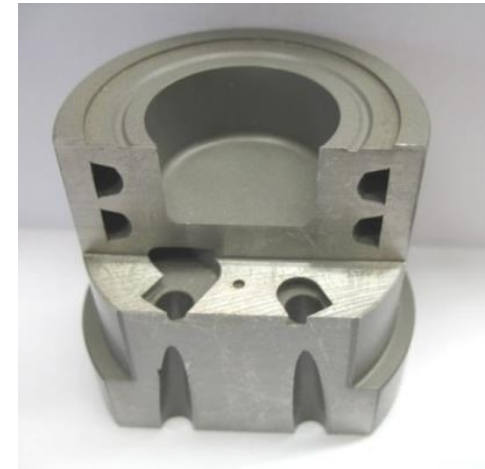


- the mould insert can be divided into several single components
- the cooling channels can be machined into the single parts easily
- with vacuum brazing the single parts are joined together with high strength and tightness
- hardening is integrated into the vacuum brazing process

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



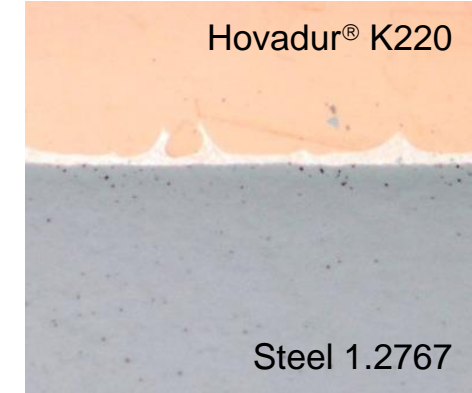
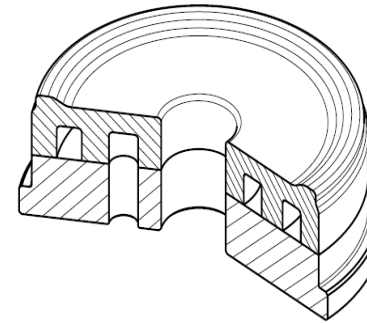
Component design for vacuum brazing



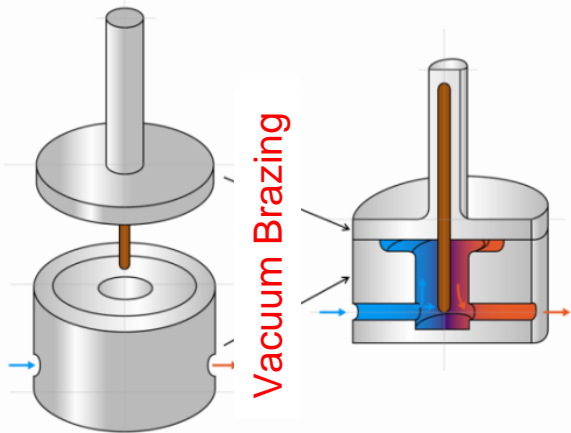
Hovadur / Ampcoloy



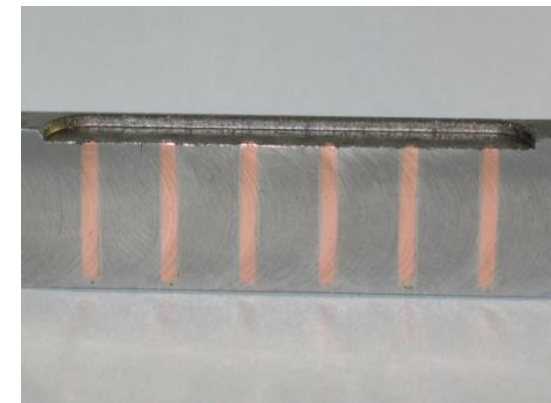
1.2714 / 1.2767



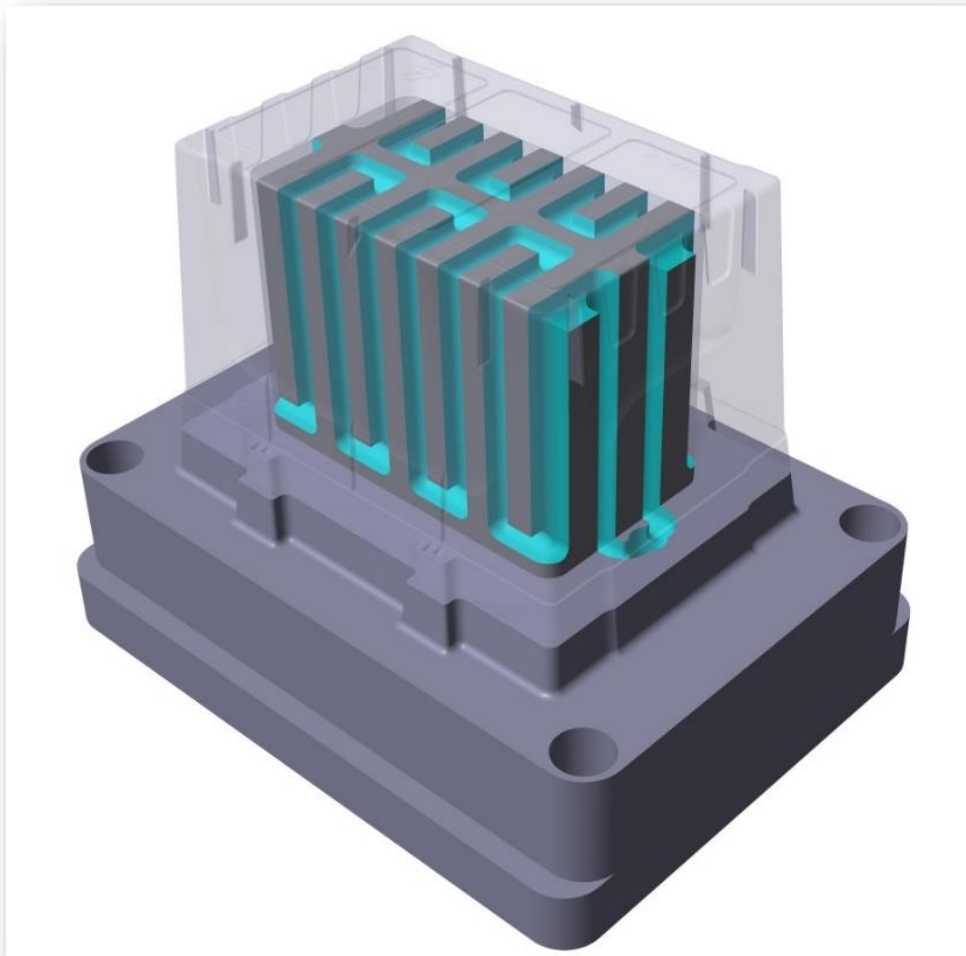
- expensive copper alloy can be used specifically
- superior thermal flow between copper and steel
- re-hardening of the copper alloy is possible



- 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



Example vacuum brazing:



INFORMATION:

Vacuum brazed insert from 1.2343

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

cooling channels $\varnothing 6\text{mm}$ parallel connected;
resulting cross section $\varnothing 8,5\text{ mm}$

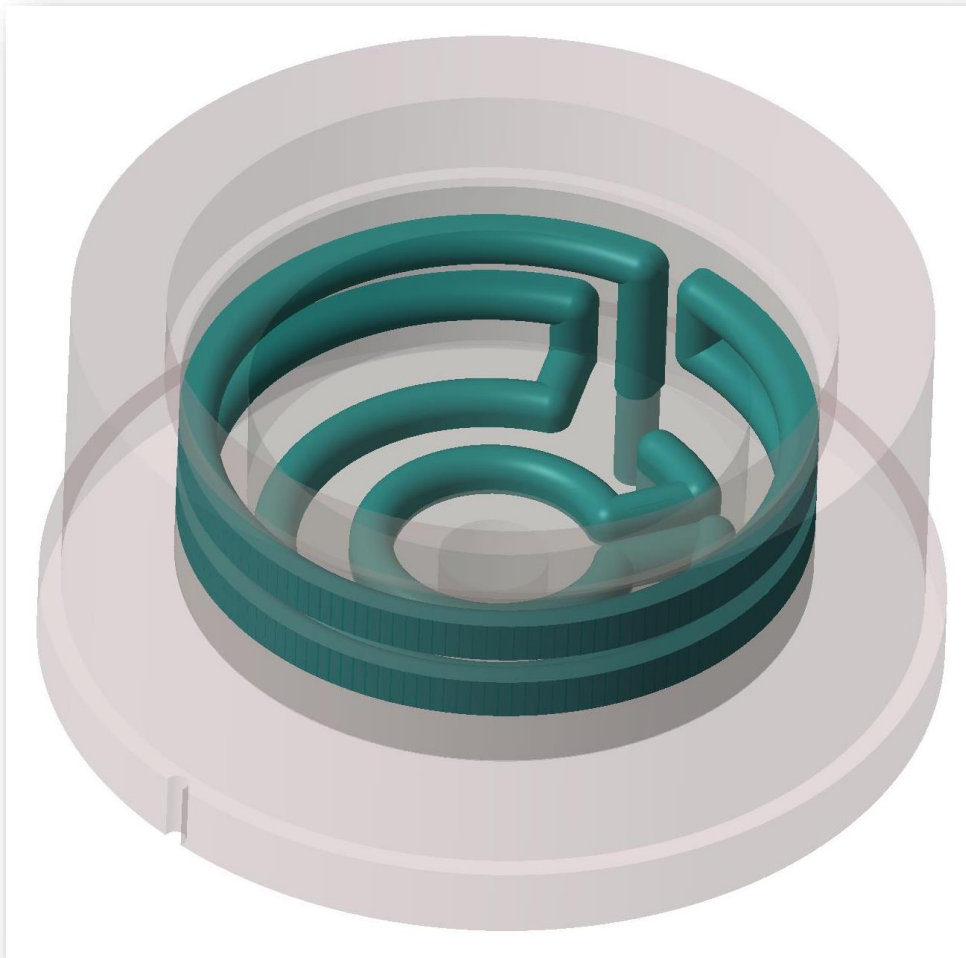
PROJECT FLOW:

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.

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.

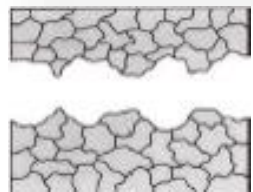
DIFFUSION WELDING – JOINTS AS IF FROM ONE CAST

- 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.

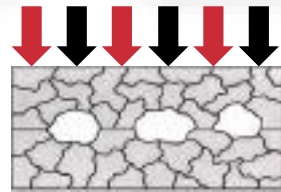


DIFFUSION WELDING – JOINTS AS IF FROM ONE CAST

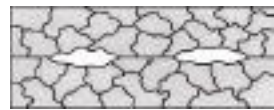
- Materially bonded and thus highly durable and temperature-resistant joints.
- High polishability of the components, as no joining zone is visible.
- Suitable for injection moulding of highly transparent parts.
- No oxidation of the components, as the process takes place in a high vacuum.
- Heat treatment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



component surfaces before welding



Pressure and temperature



Flattening the pores



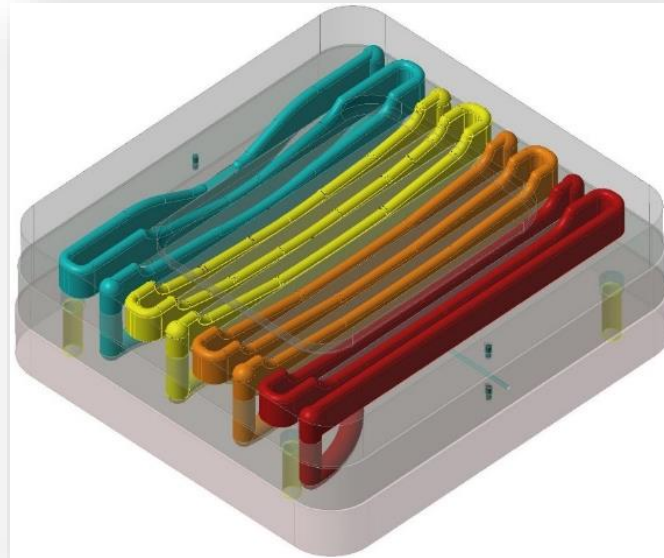
closing the pores



Part after welding

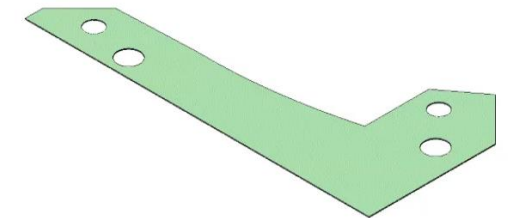
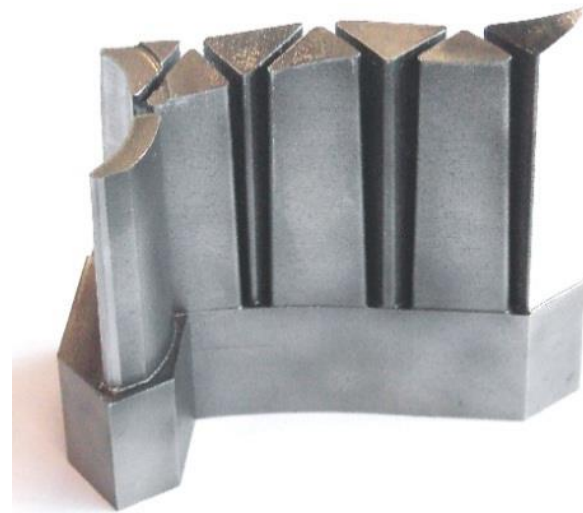
DIFFUSION WELDING – REQUIREMENTS

- 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?

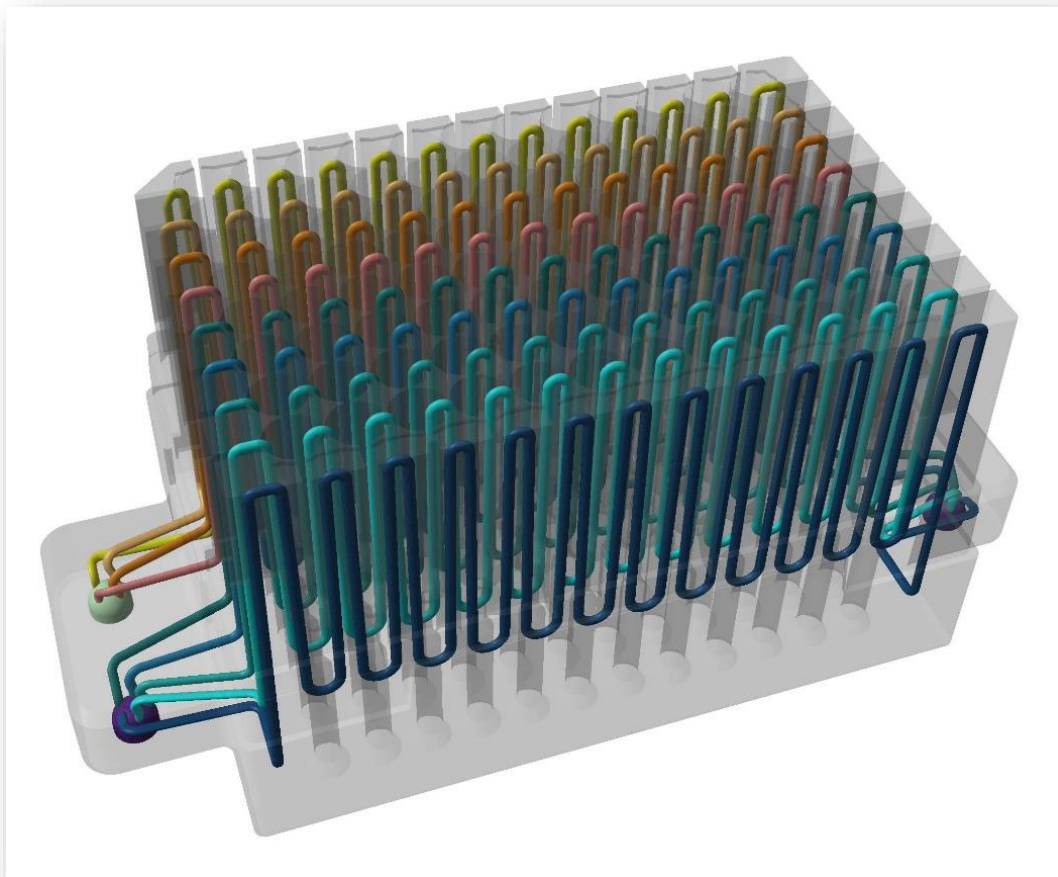
- AM (laser melting in a powder bed) or colloquially 3D printing is an additive manufacturing process in which a component is generated layer by layer from metal powder using a laser.
- The metal powder is applied in 40µm - 60µm thick layers by a coater (squeegee) on the base plate and homogeneously 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.



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 / dm ³ | 7,8 kg / dm ³ | 7,8 kg / dm ³ | 8,1 kg / dm ³ | 7,8 kg / dm ³ |
| 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 \varnothing 1,53 mm.

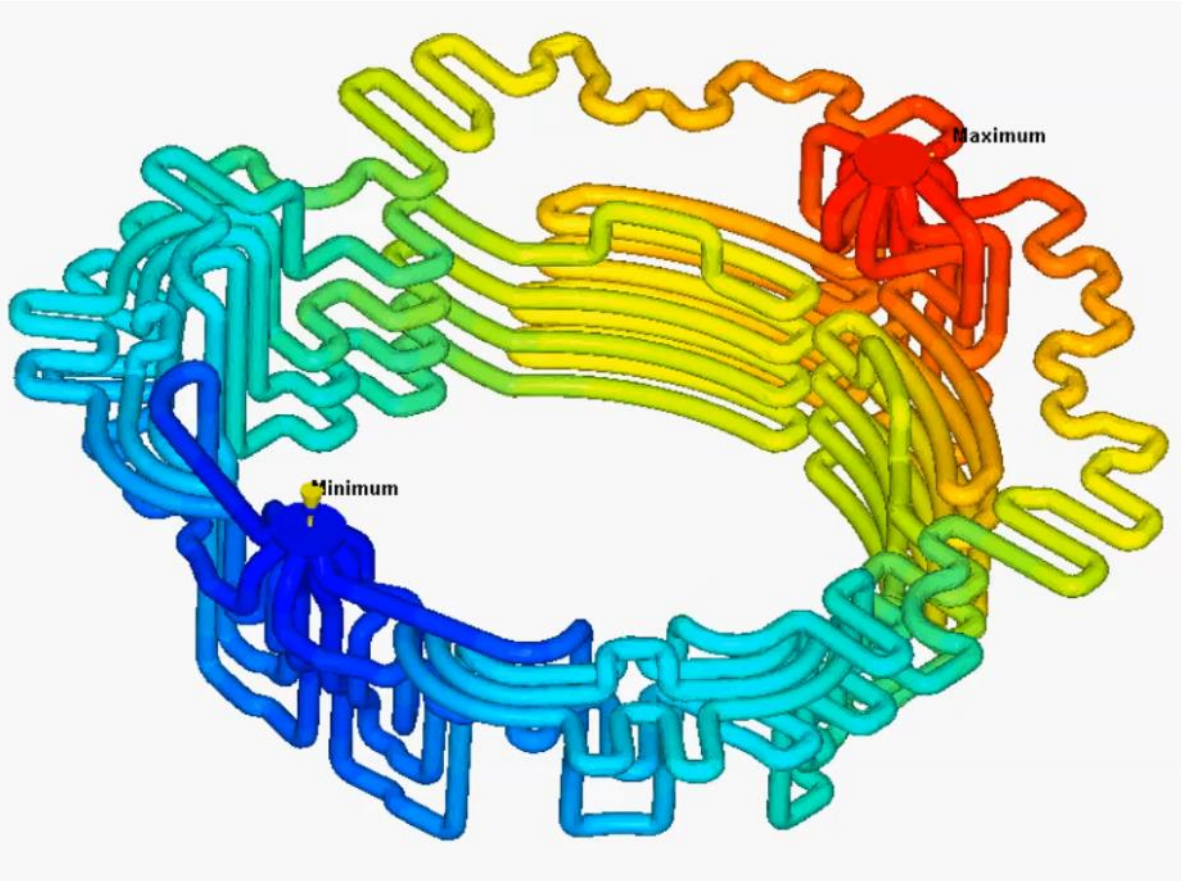
2 closed loops 1x 4-times parallel
 1x 5-times parallel

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:

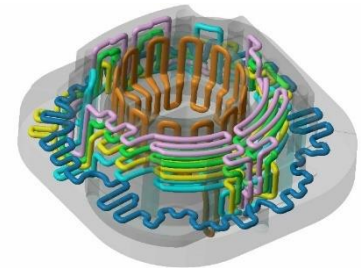
2-cavity 2C mold (electrical industry)

Cooling geometry:

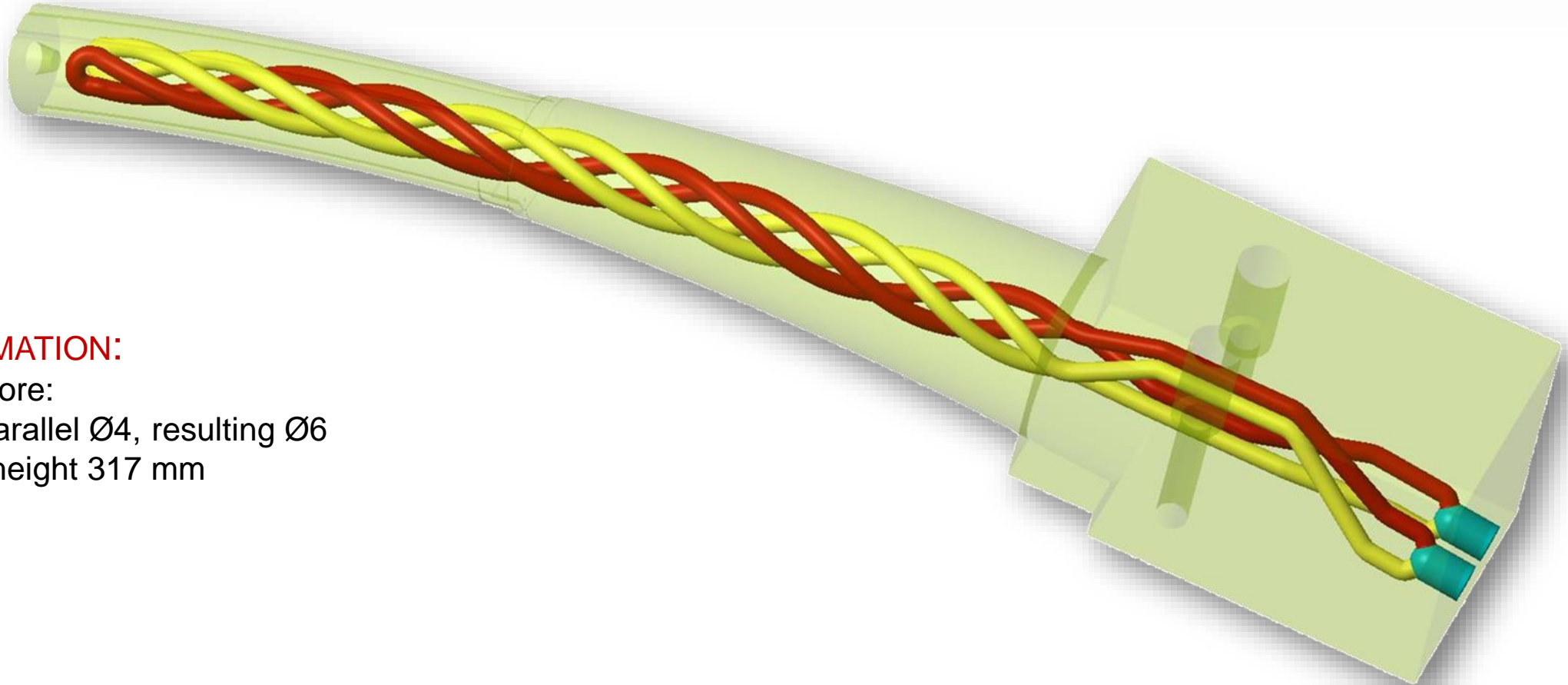
10-fold parallel connection $\varnothing 3$ corresponding $\varnothing 9,5$ mm perfectly balanced. Flow rate at 4 bar pressure 21 l/min

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



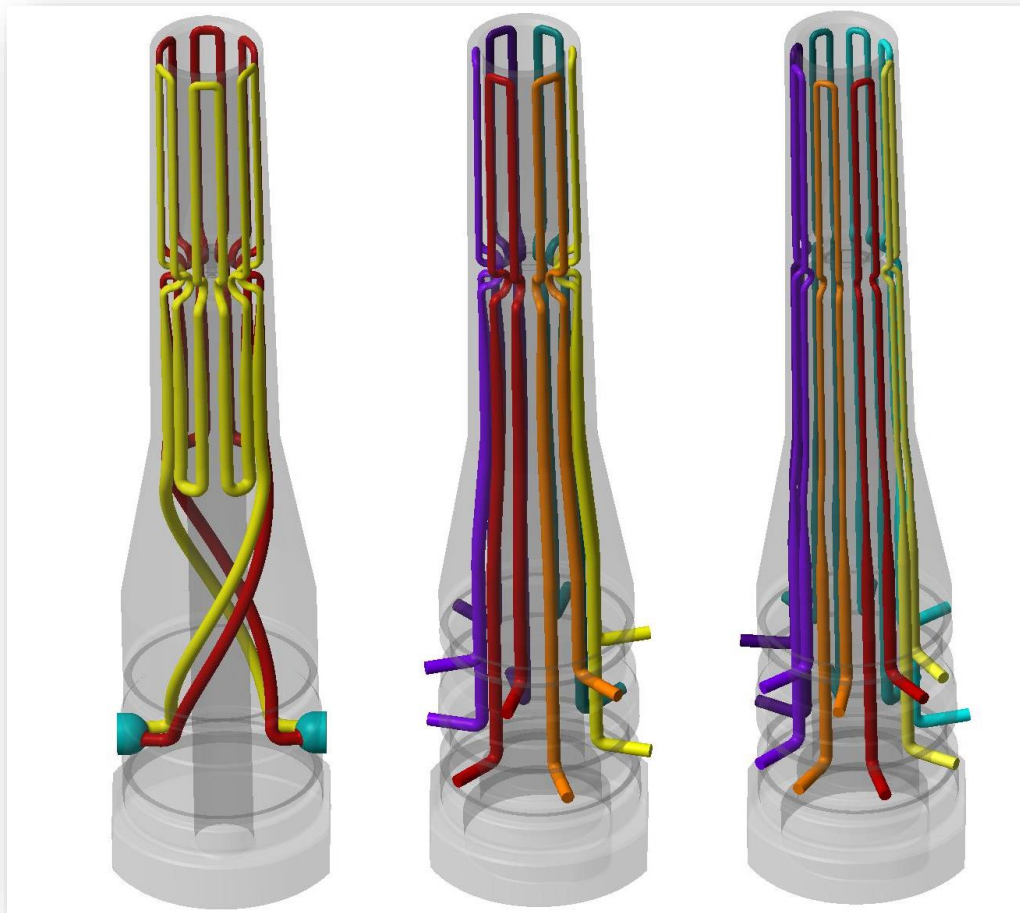
Example AM:



INFORMATION:

swivel core:
2-fold parallel $\text{\O}4$, resulting $\text{\O}6$
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

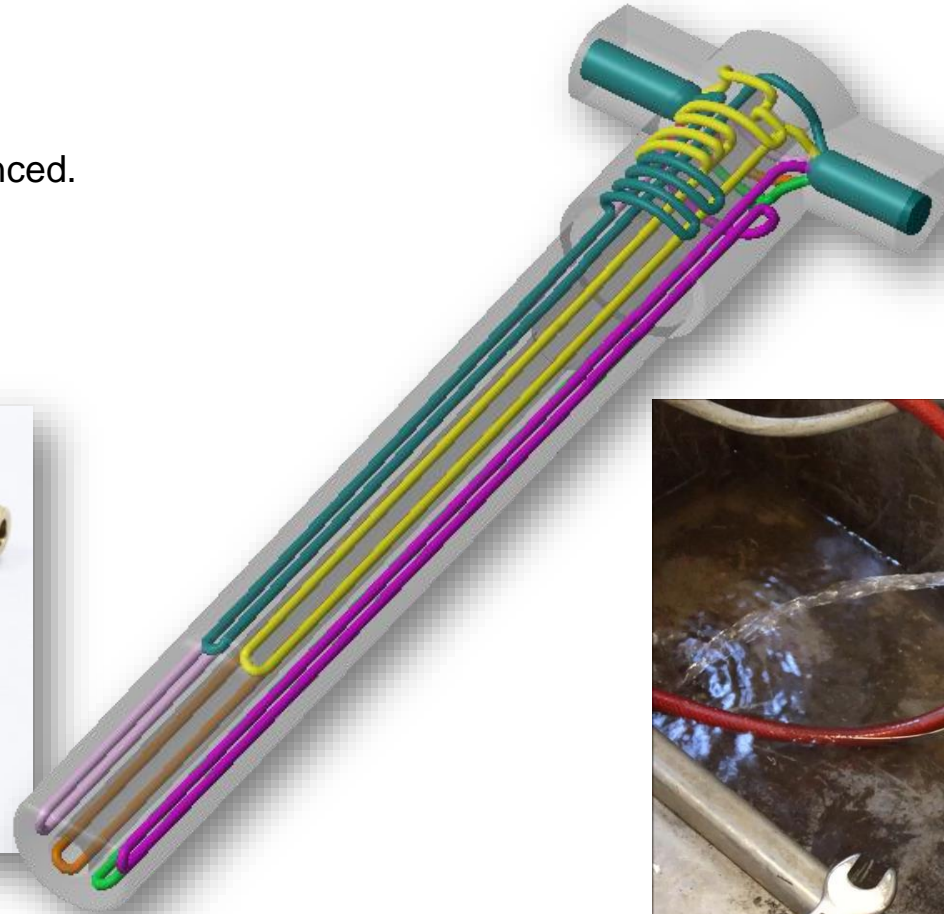
> 1,5 Mio Cycles 3. variant

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

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)

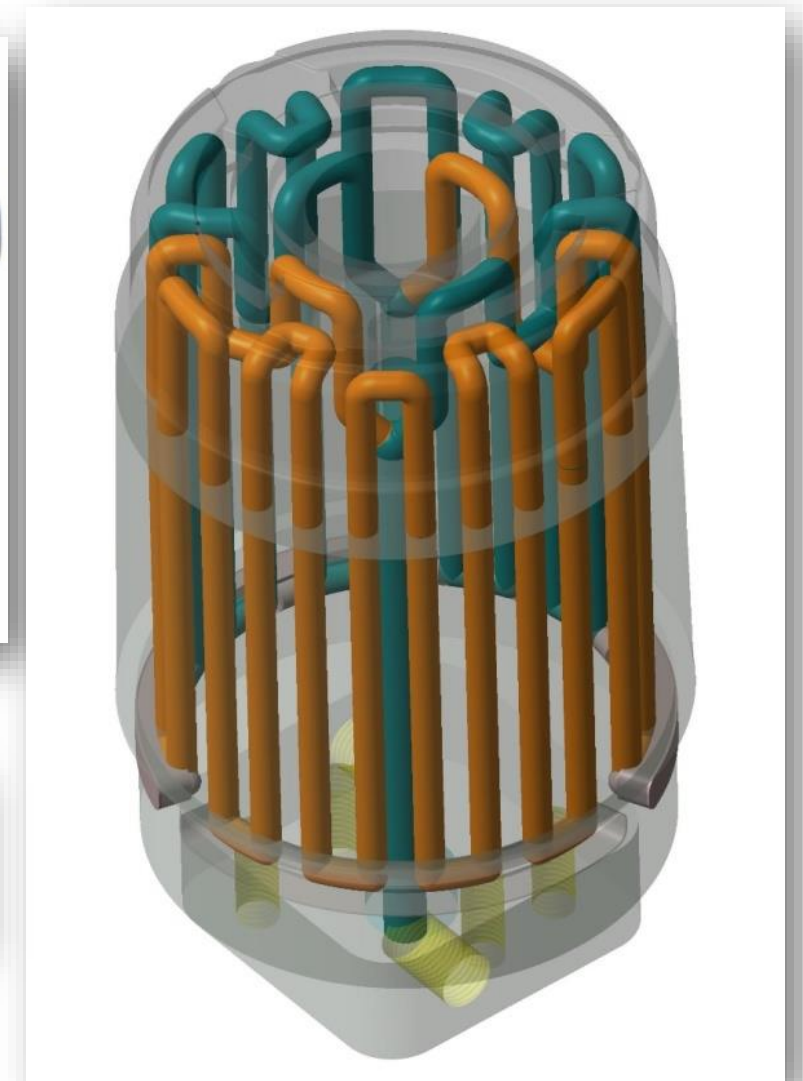
INFORMATION:

Conformal cooled die-casting insert built on a hybrid.

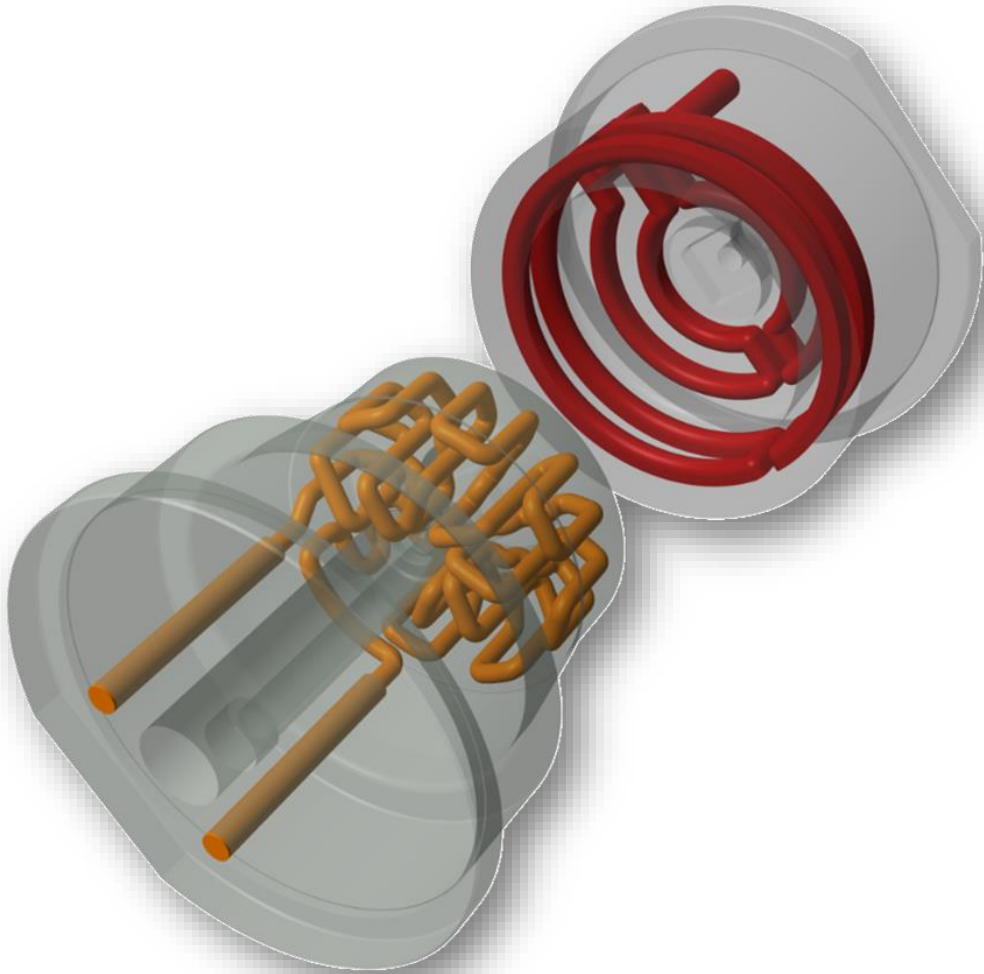
Weight 13,5 kg.

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

In order to ensure that the entire contour is conformally 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.

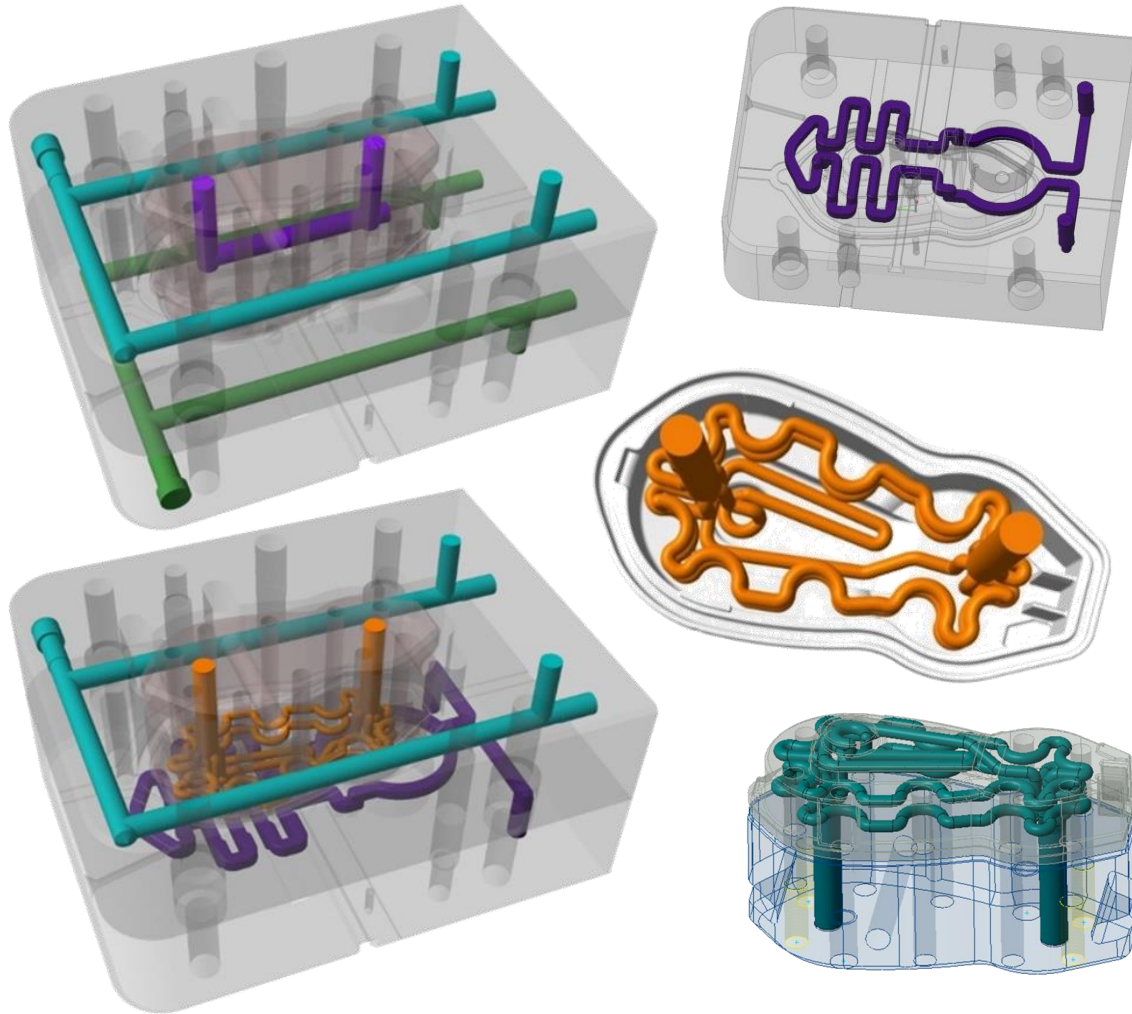
Cooling design by iQtemp GmbH.

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

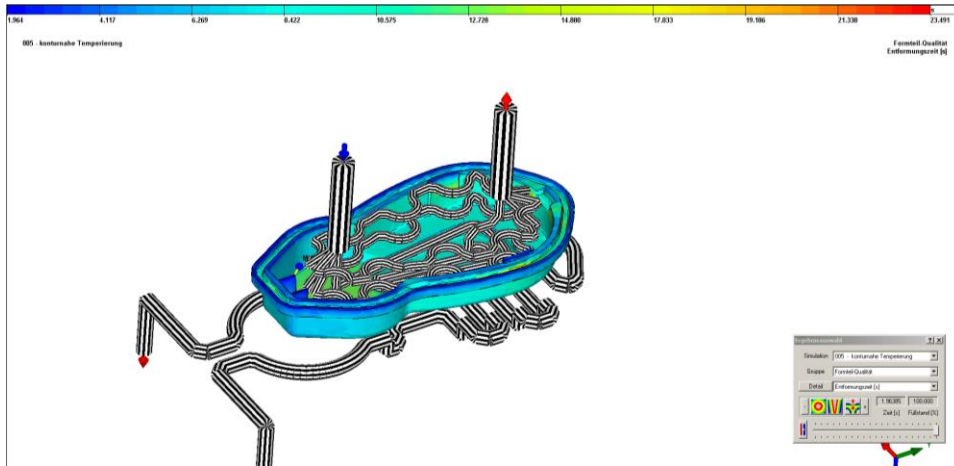
Mold insert FH (vacuum brazed) and core MH (additive manufactured) including conformal cooling.

Cycle time: 24,3 s

Cooling time: 9,5 sec

cooling time reduction: 48%

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.

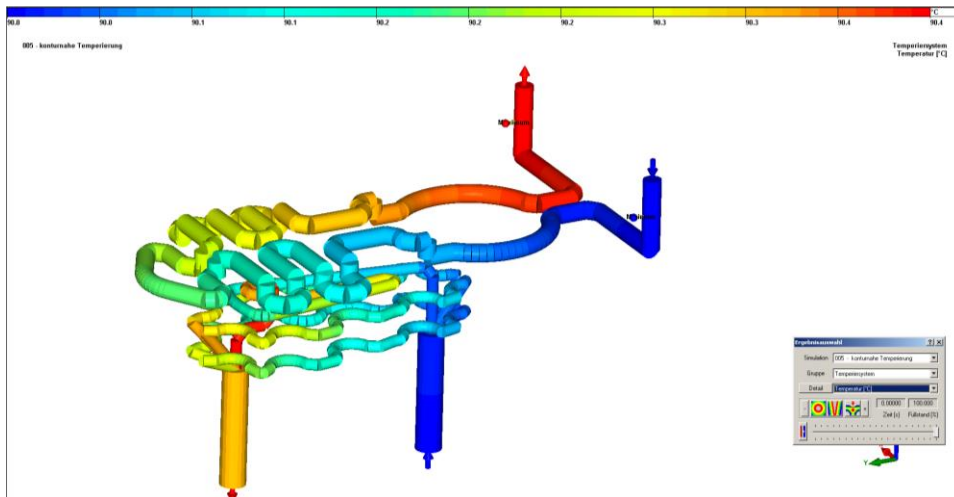
In consideration of injection time, holding pressure and secondary-time given by the process data sheet, the cooling time has been reduced from 18 s to 9,5 s.

Reduction of cooling time of 48%.

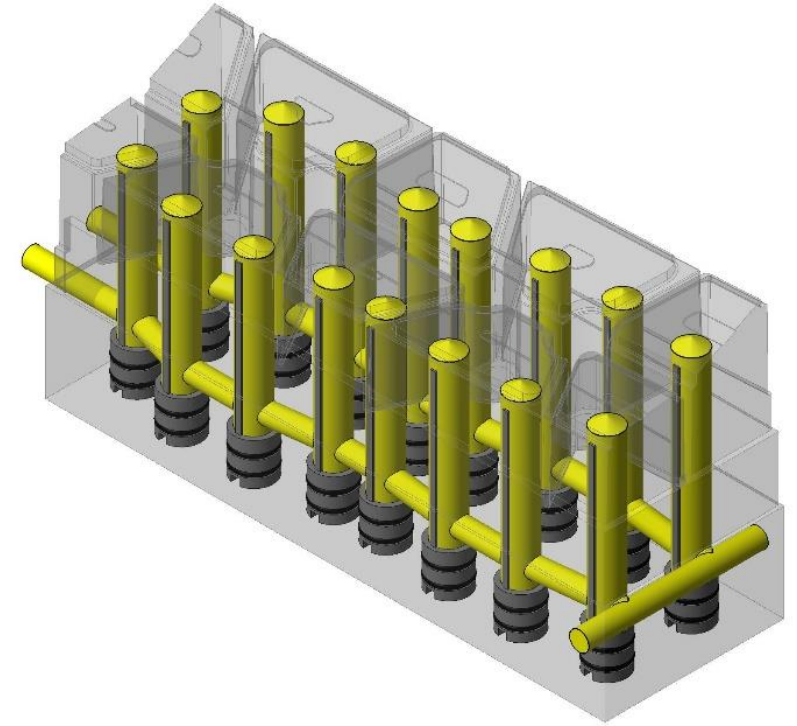
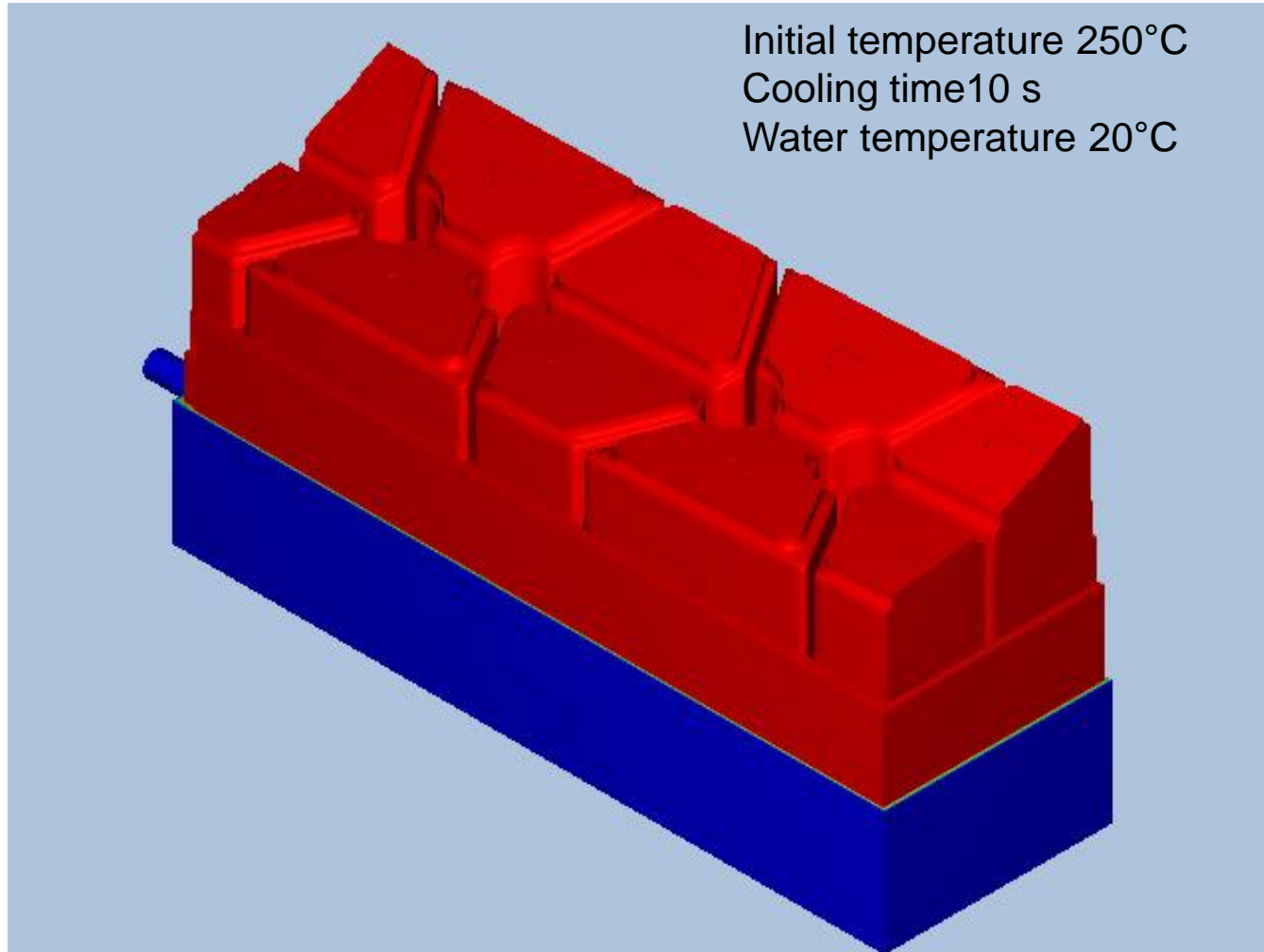
Maximum increase of the water temperature in the cooling circuit is only 0,4°K.

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.

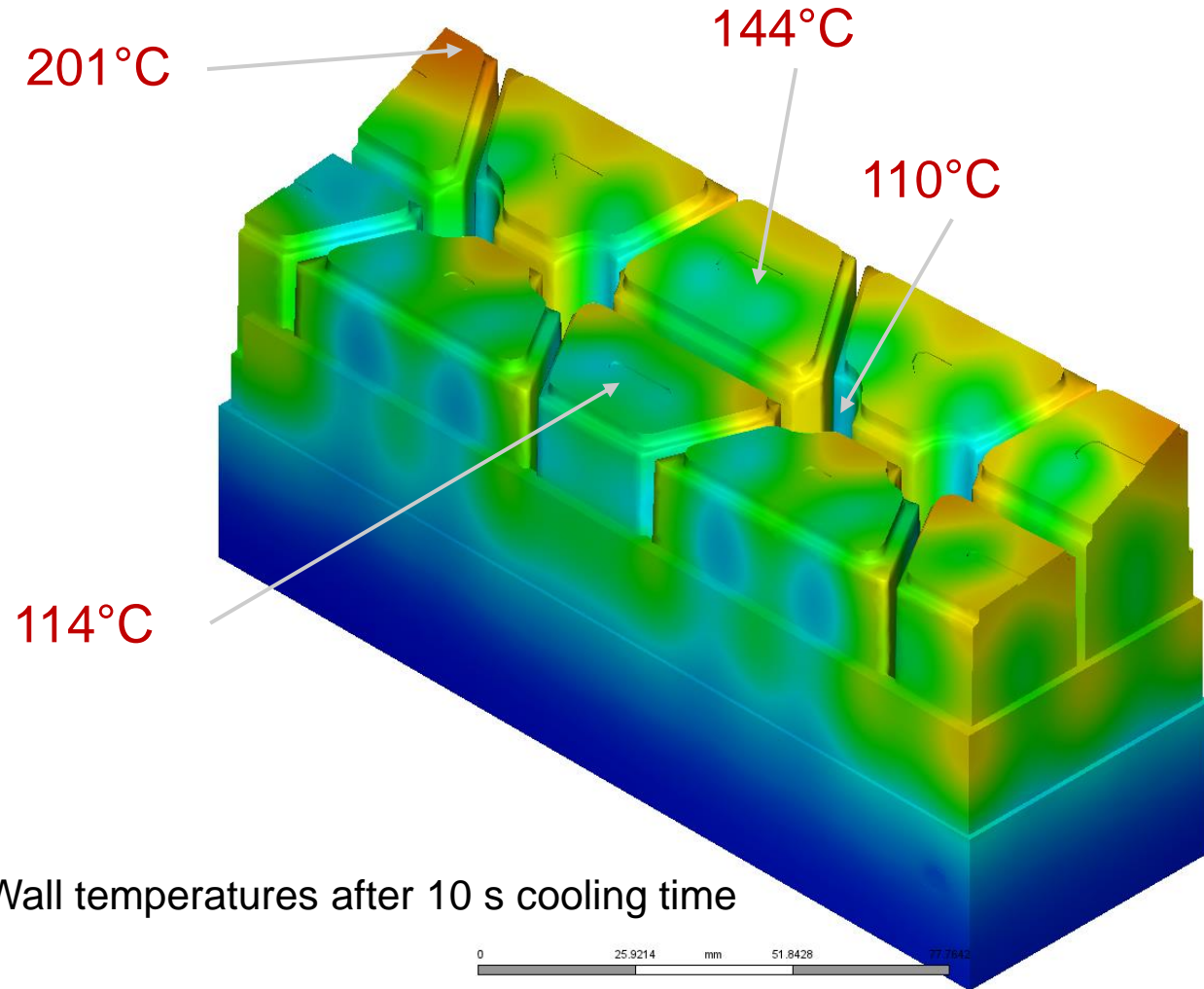


Optimised design – a comparison



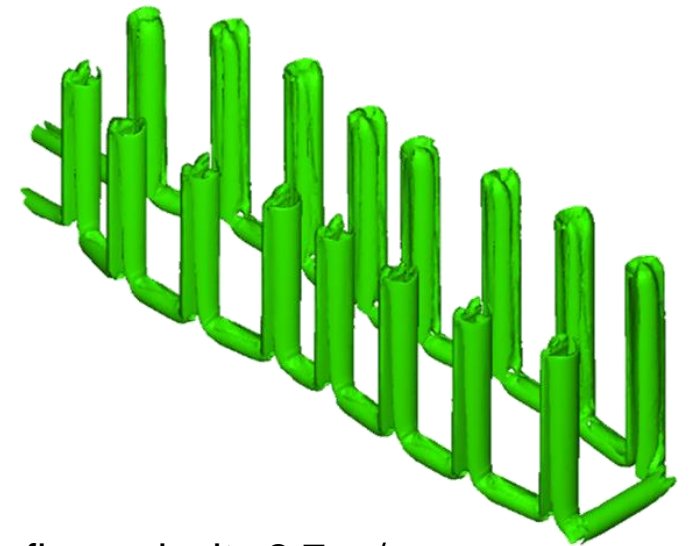
Conventional design with riser holes and baffles.

Optimised design – a comparison



Wall temperatures after 10 s cooling time

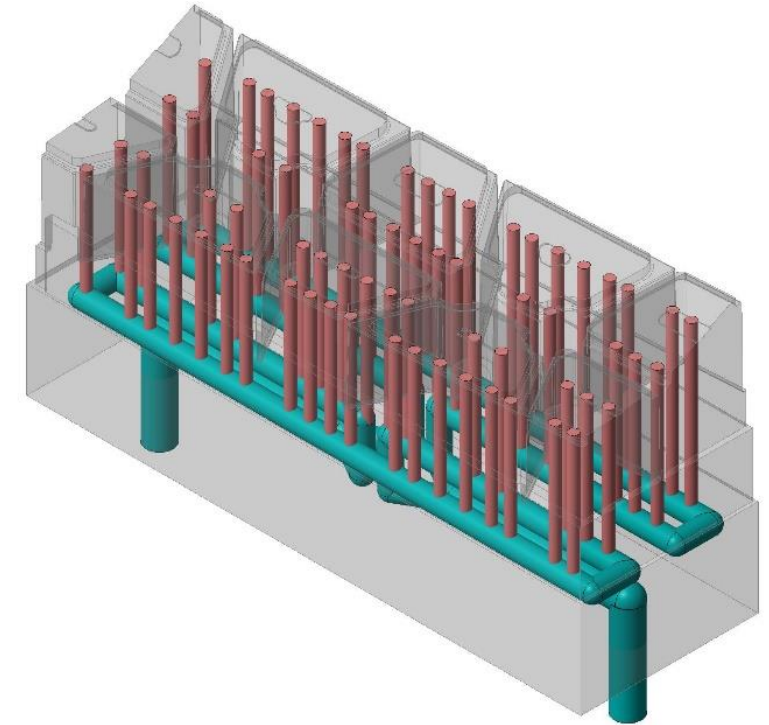
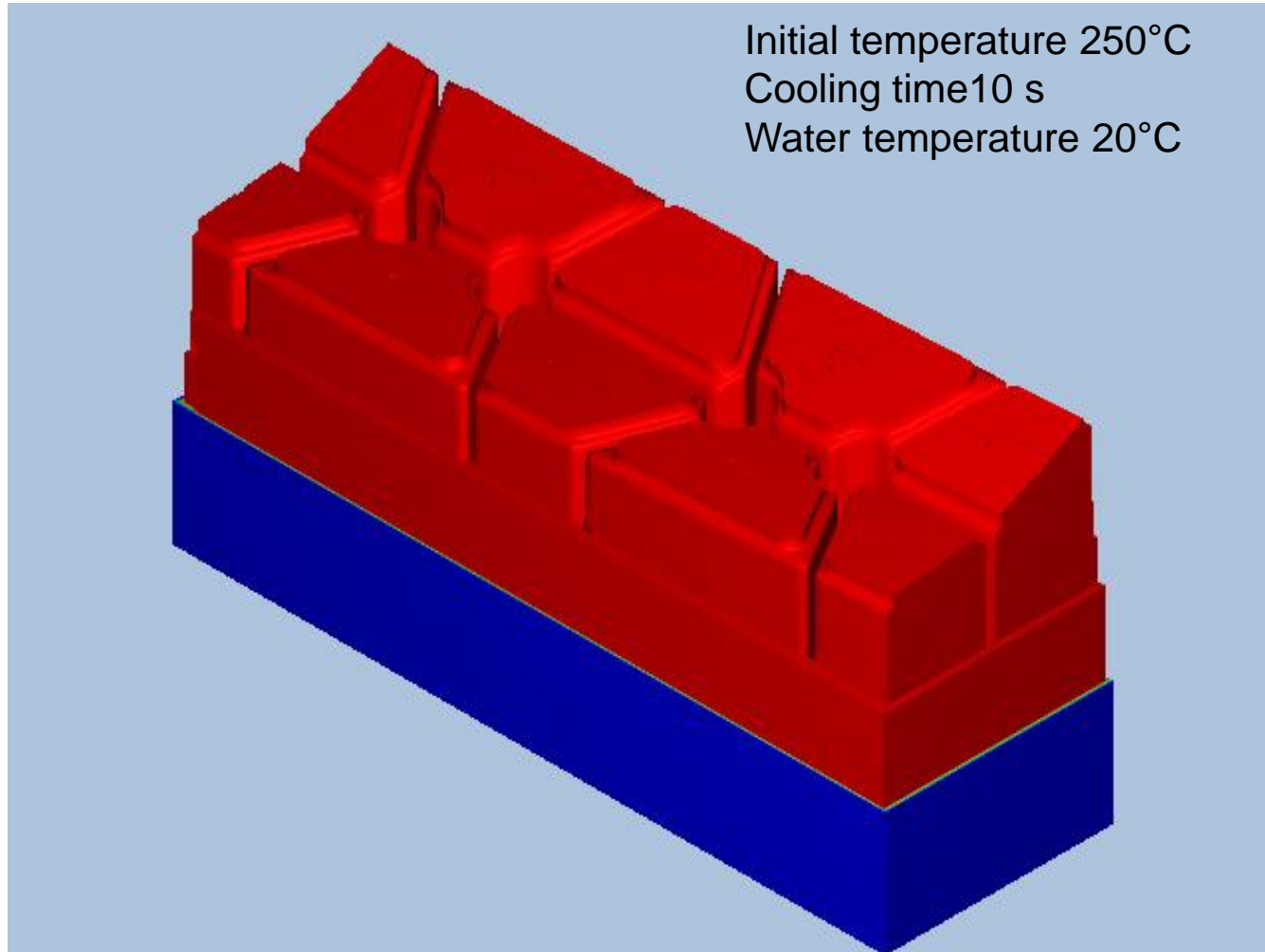
Conventional design with riser holes and baffles.



Average flow velocity 2.7 m/s

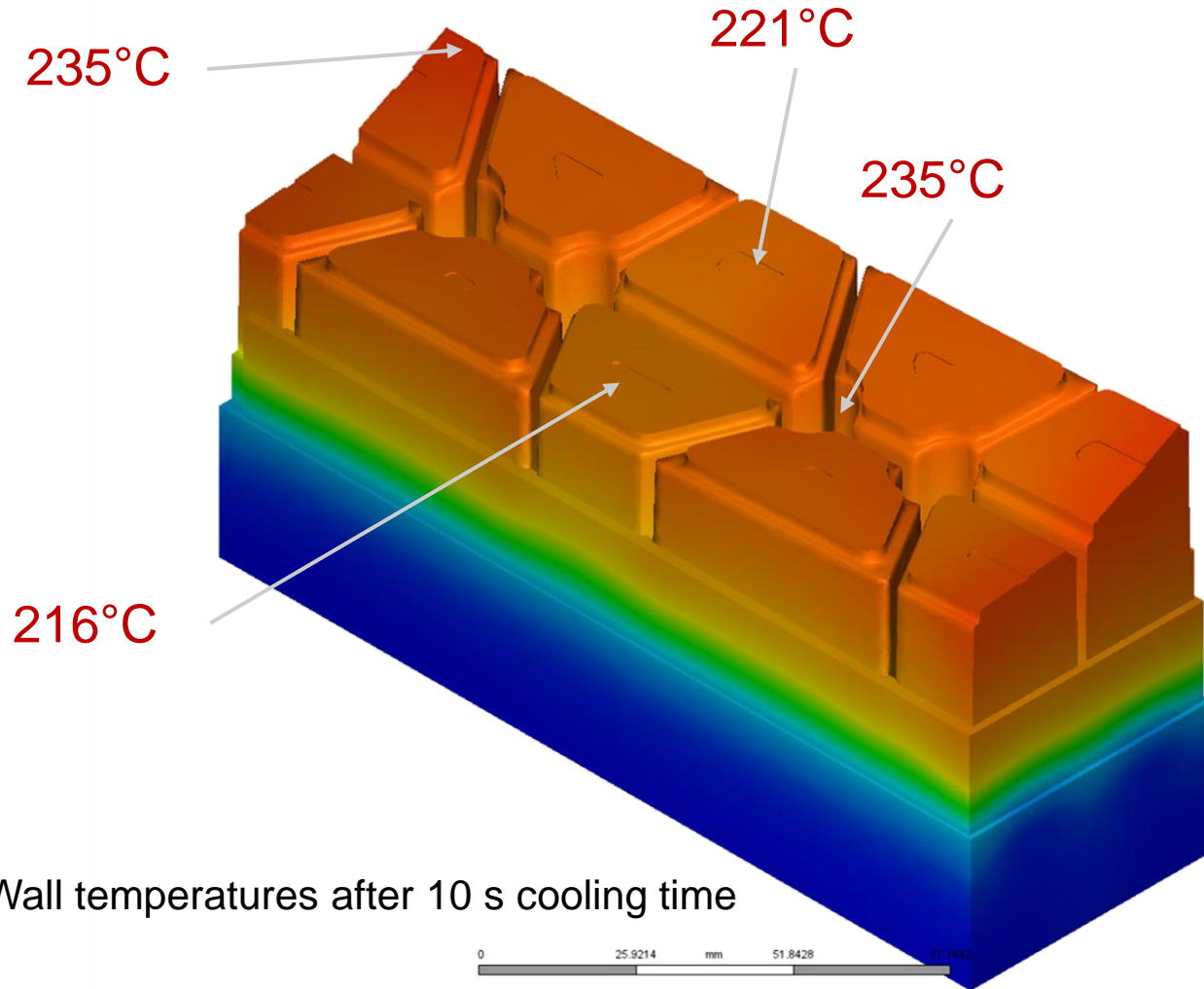
| | 3,5 bar | 6 bar |
|-----------------------|---------|-----------|
| Flow rate | 4 l/min | 5,2 l/min |
| Average flow velocity | 2,7 m/s | 3,5 m/s |
| Reynolds number | 9.800 | 12.740 |

Optimised design – a comparison

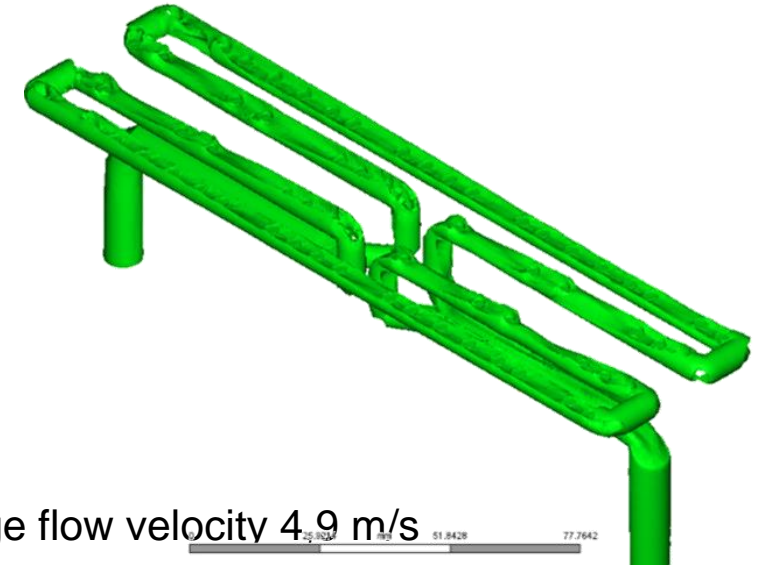


Vacuum-brazed version with many copper pins around which the water flows.

Optimised design – a comparison

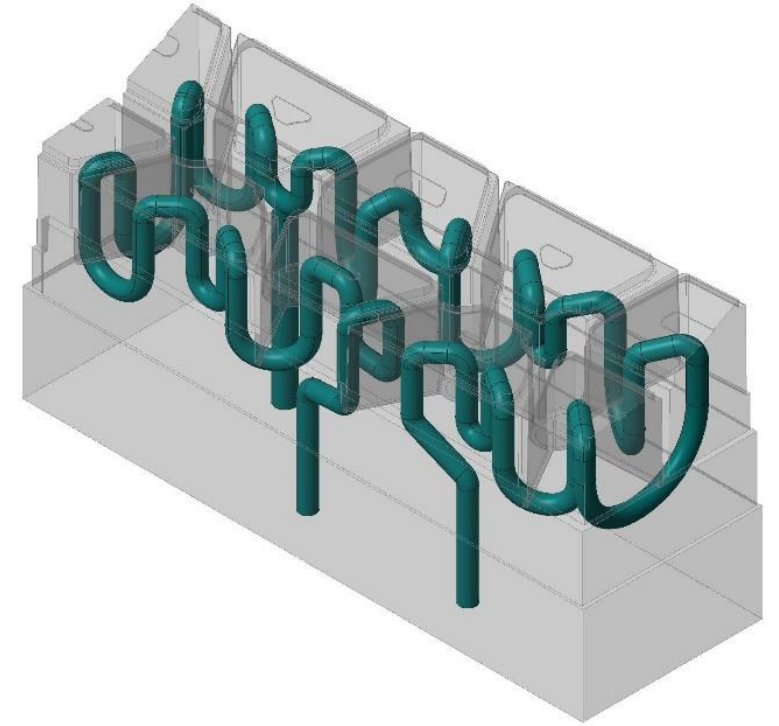
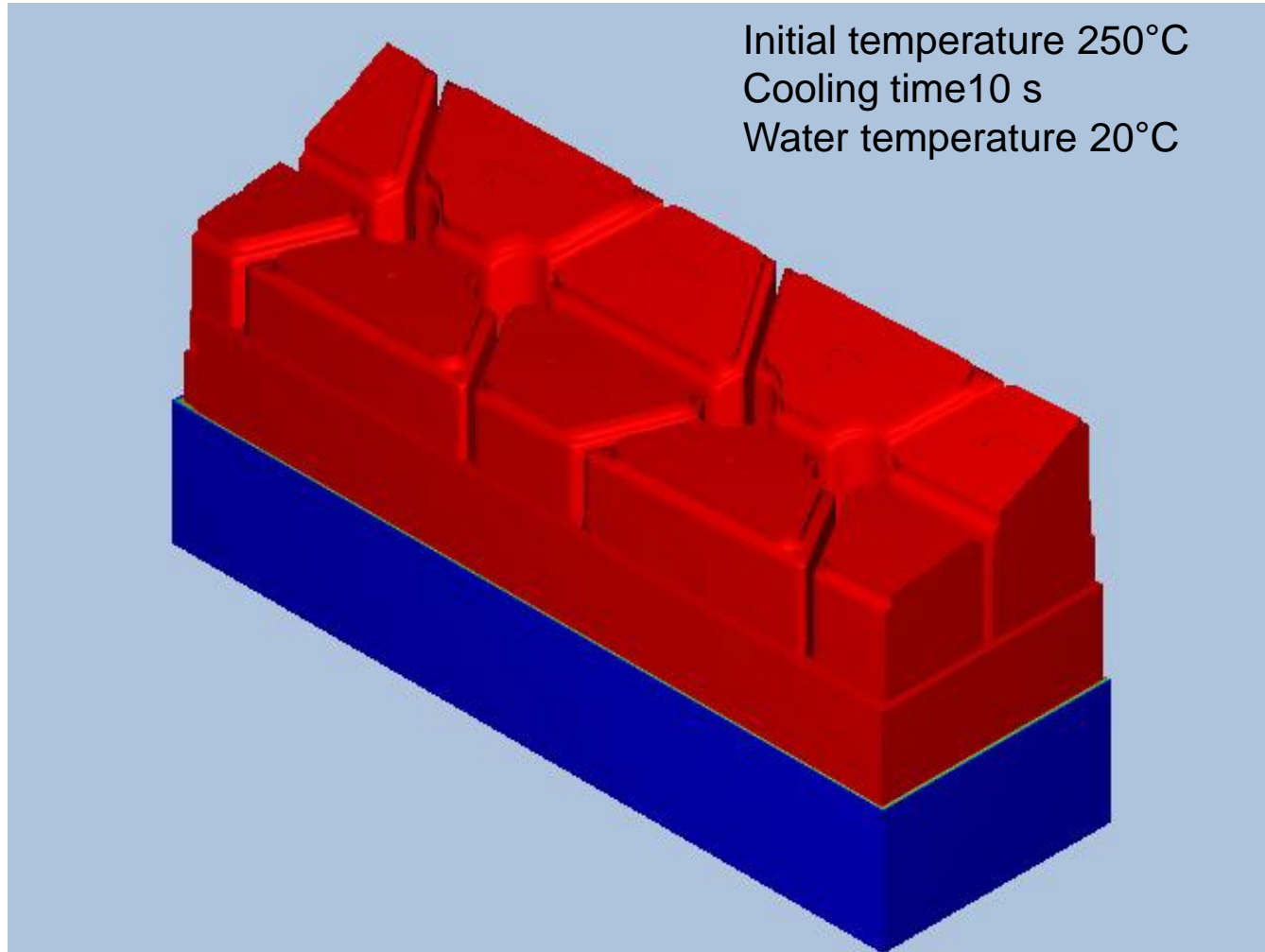


Vacuum-brazed version with many copper pins around which the water flows.



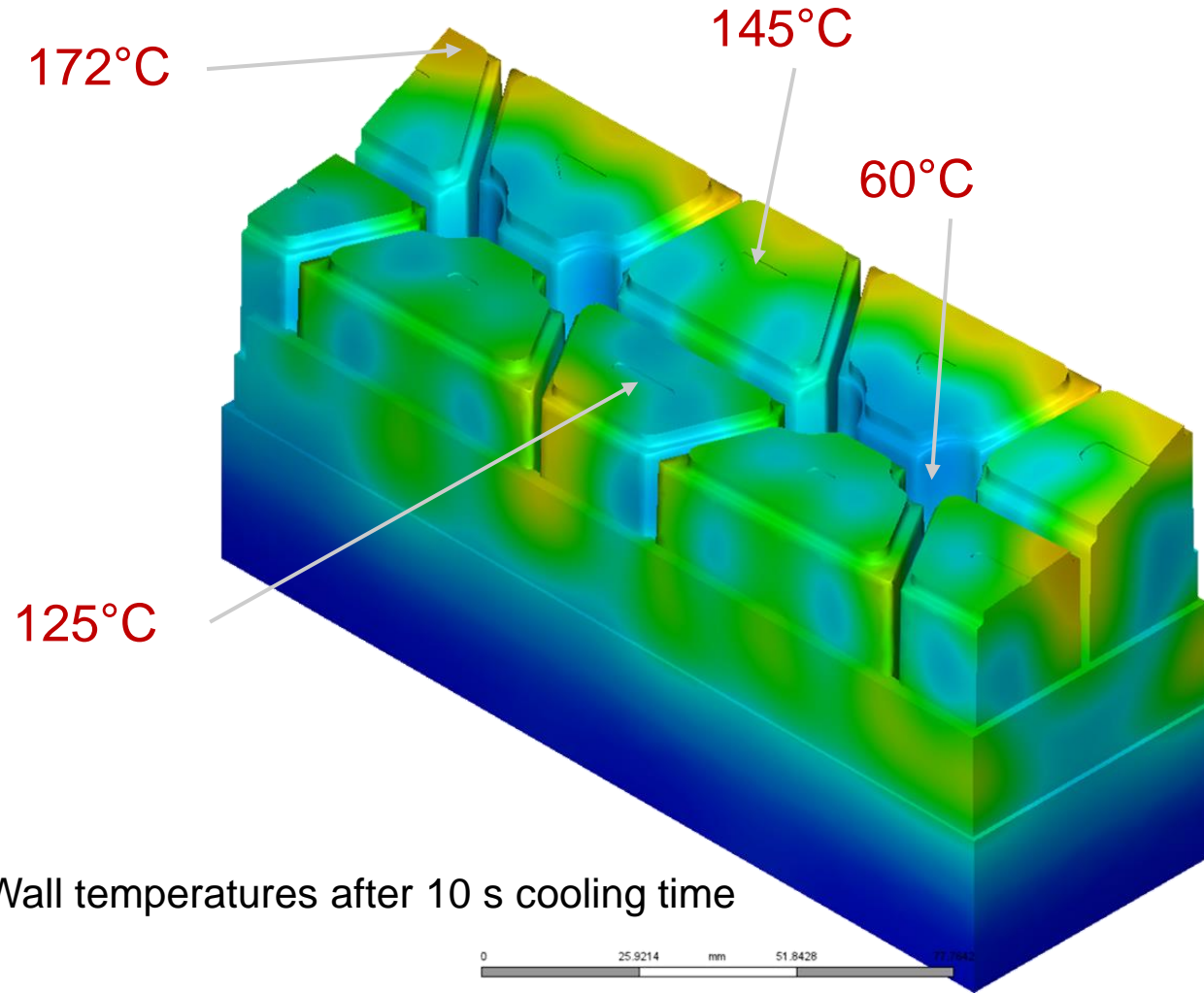
| | 3,5 bar | 6 bar |
|-----------------------|----------|------------|
| Flow rate | 16 l/min | 20,8 l/min |
| Average flow velocity | 4,9 m/s | 6,0 m/s |
| Reynolds number | 29.400 | 38.220 |

Optimised design – a comparison

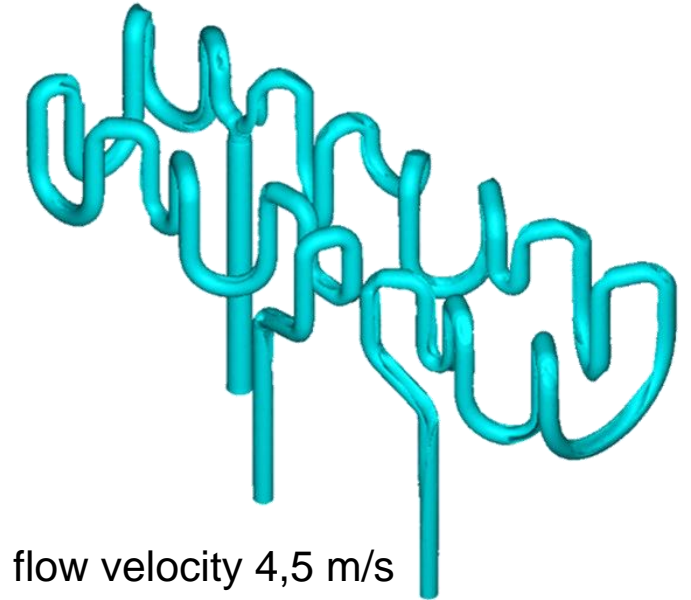


non-optimised, simple additive tempering.
(Customer design)

Optimised design – a comparison



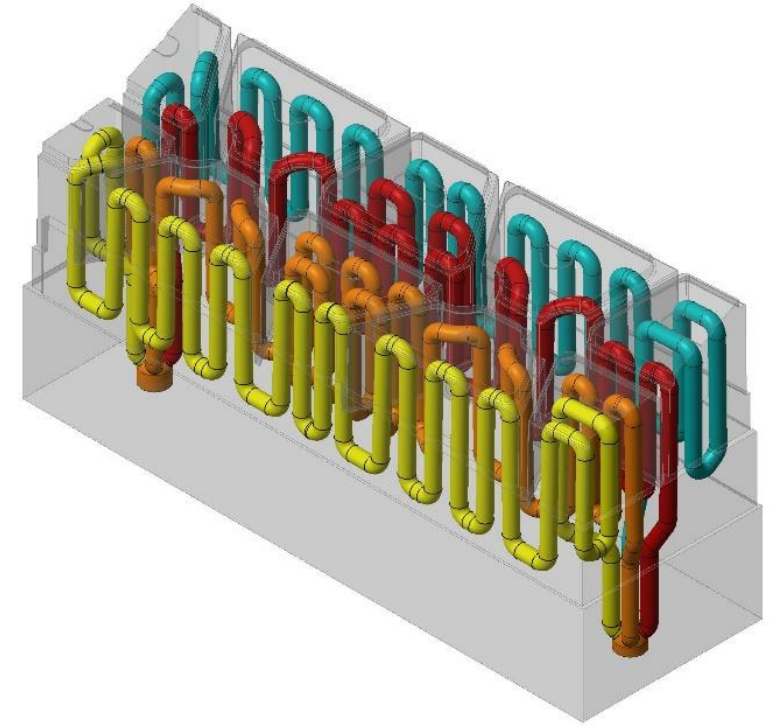
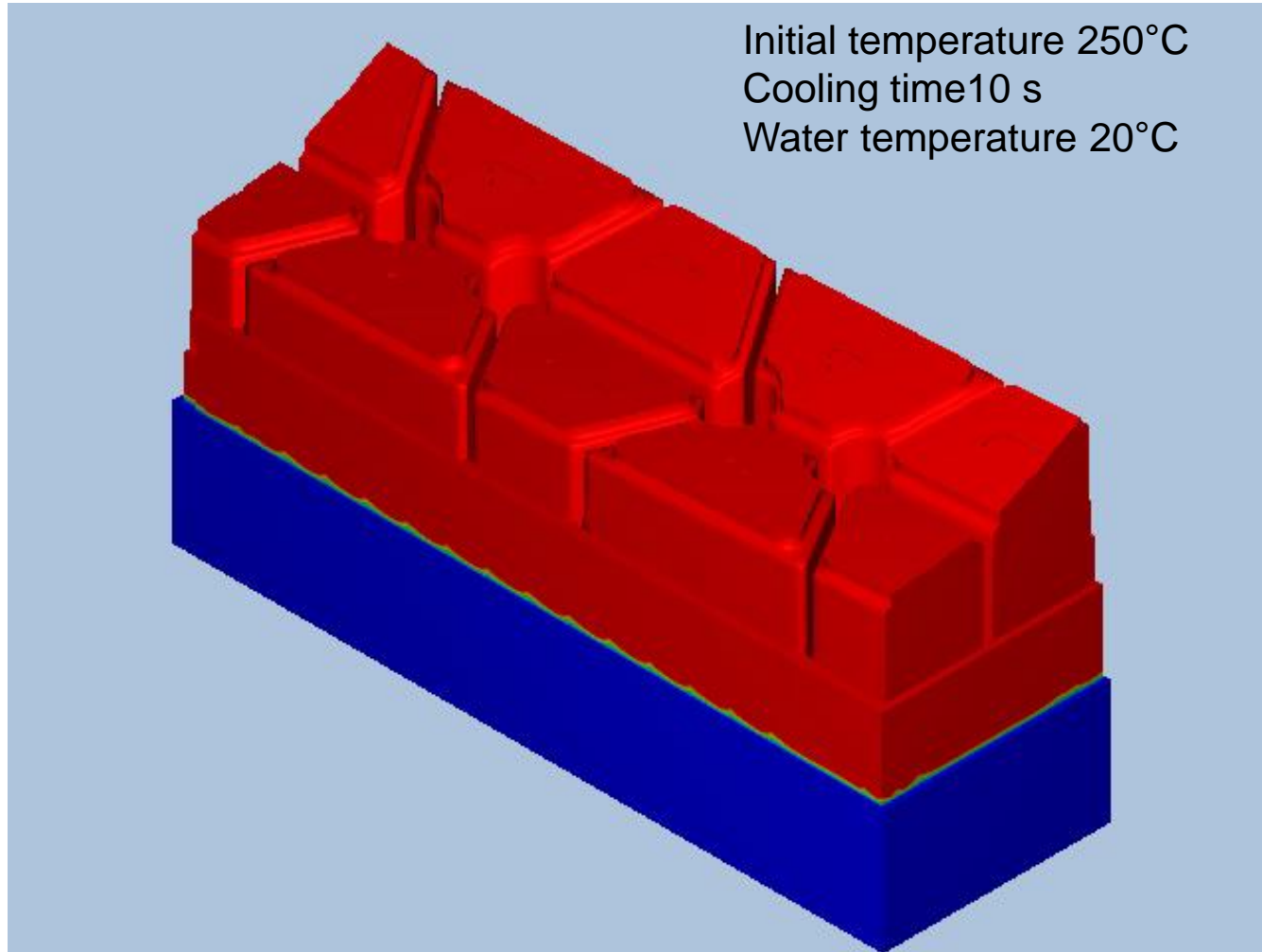
non-optimised, simple additive tempering.
(Customer design)



Average flow velocity 4,5 m/s

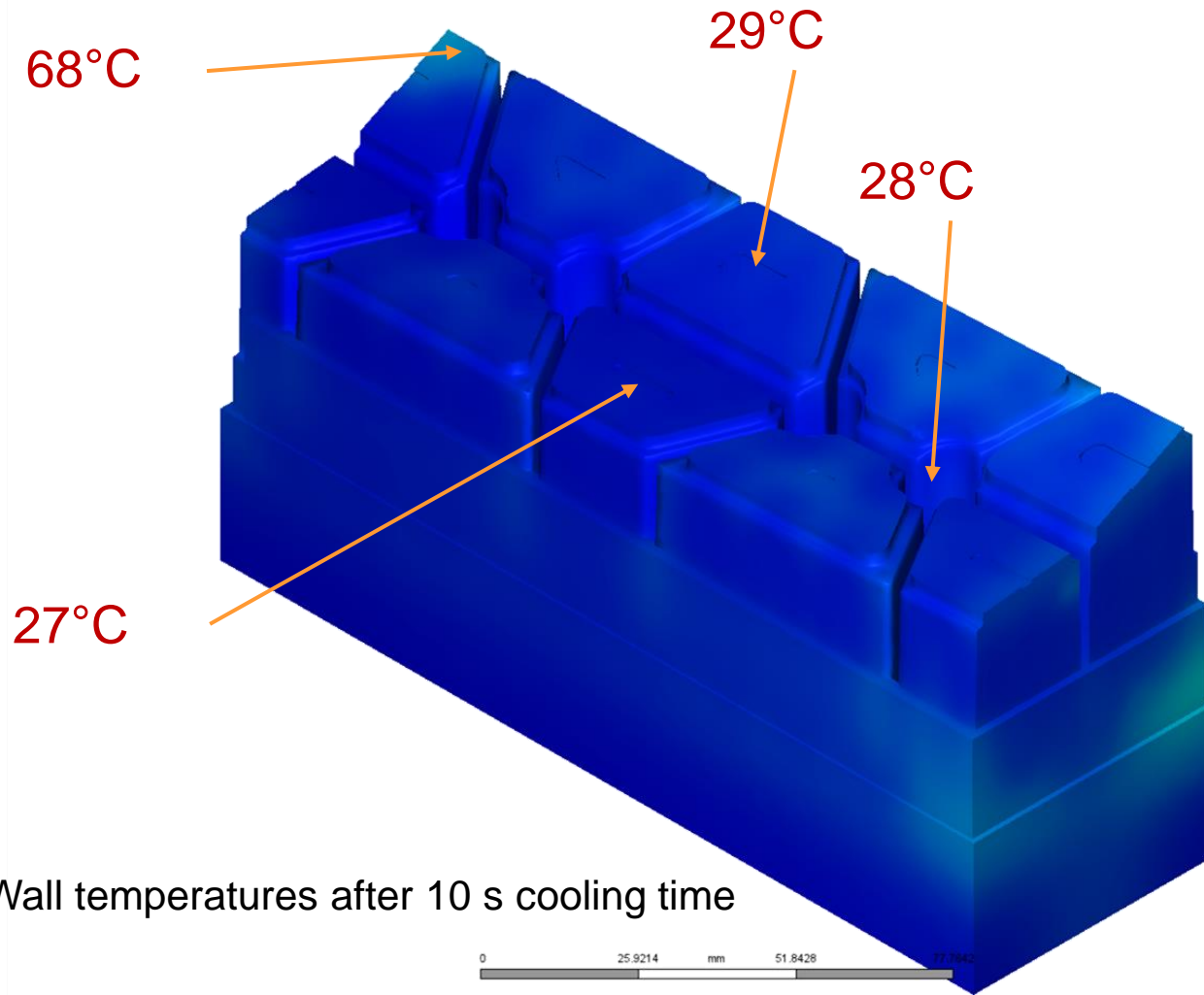
| | 3,5 bar | 6 bar |
|-----------------------|------------|------------|
| Flow rate | 10,5 l/min | 13,7 l/min |
| Average flow velocity | 4,5 m/s | 5,9 m/s |
| Reynolds number | 22.500 | 29.250 |

Optimised design – a comparison

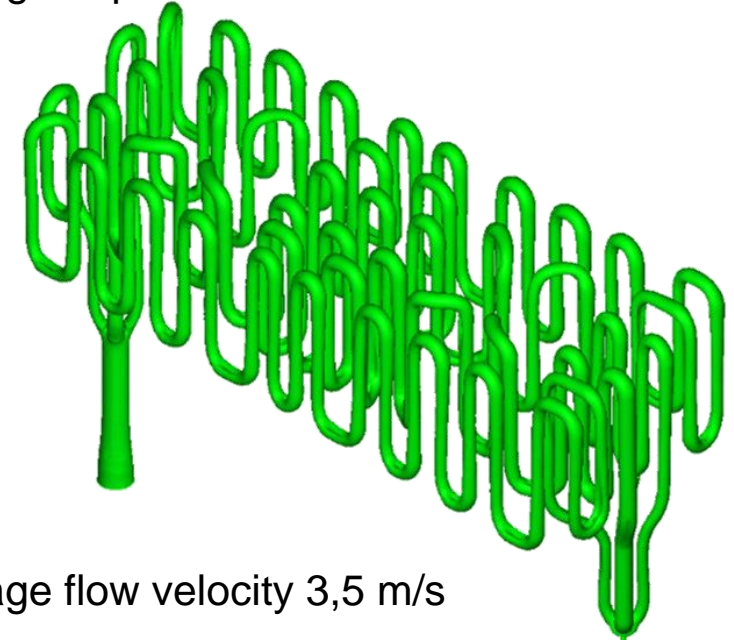


Optimized and balanced additive conformal cooling temperature control.

Optimised design – a comparison



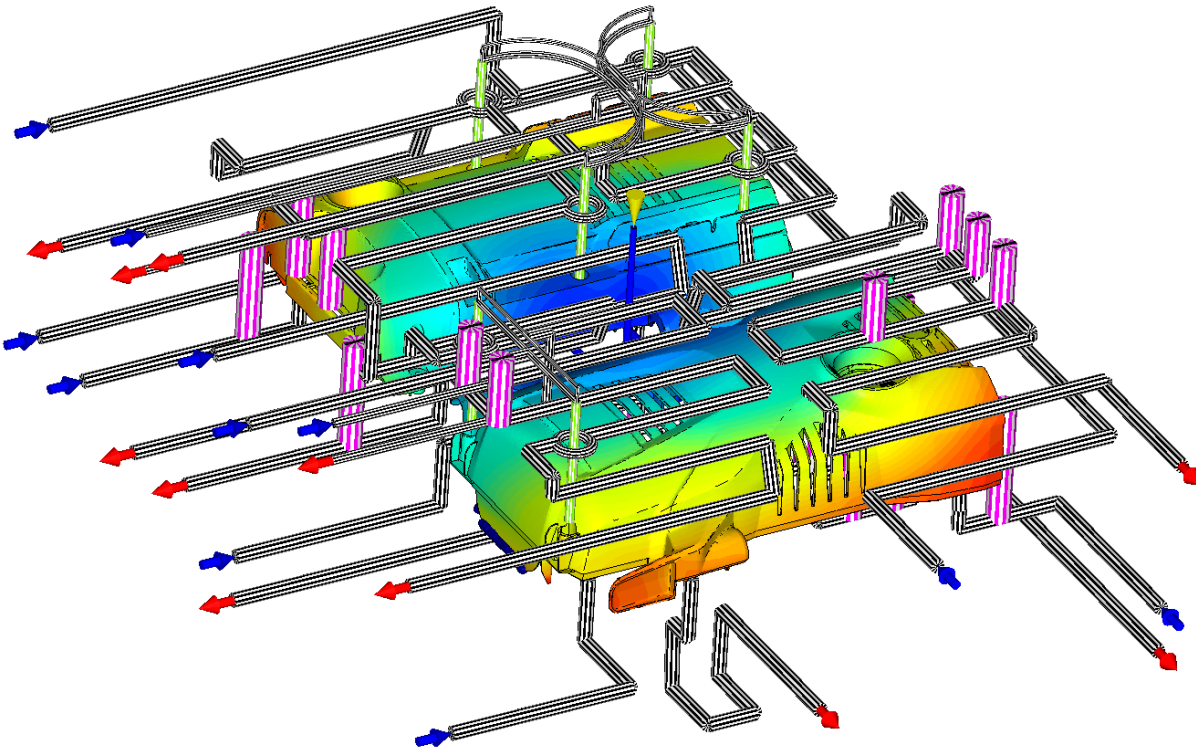
Optimized and balanced additive conformal cooling temperature control.



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 |

Simulation (injection moulding simulation)



INFORMATION:

A Simulation package consists of:

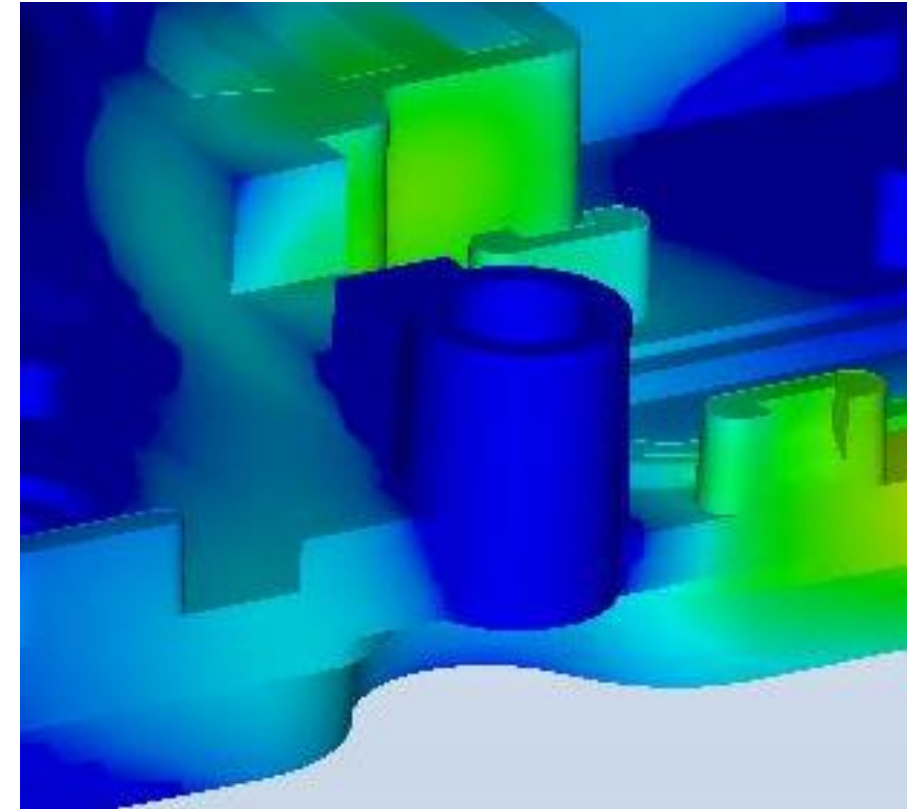
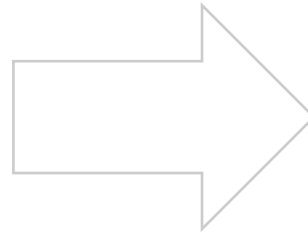
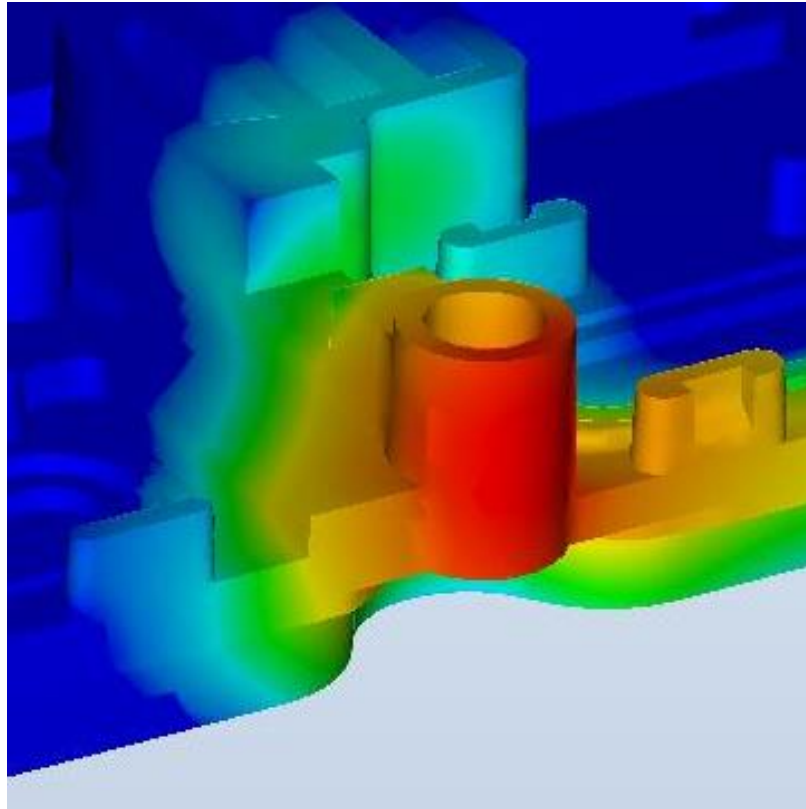
1. running the entire injection molding process of the existing mold in our simulation software with mapping of the real parameter.

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

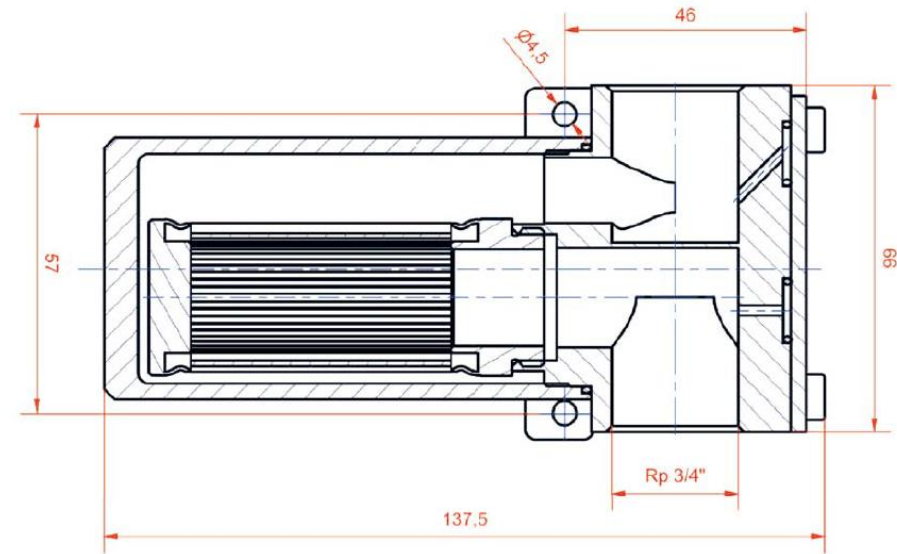
Simulation (CDF – heat transfer processes)

hot spot area before and after the optimization



Requirements for using conformal cooling

- Use of suitable filtering systems



Edelstahl-Leitungsfiter LF 80-200

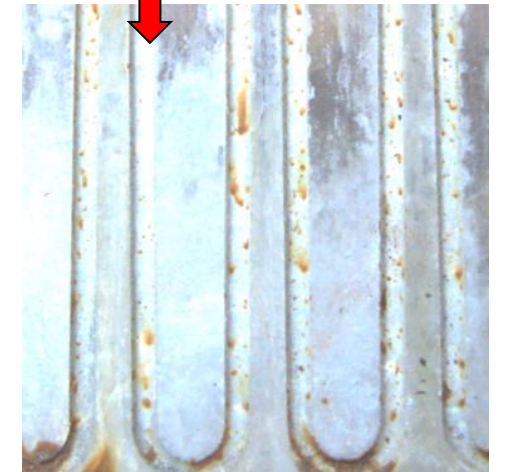
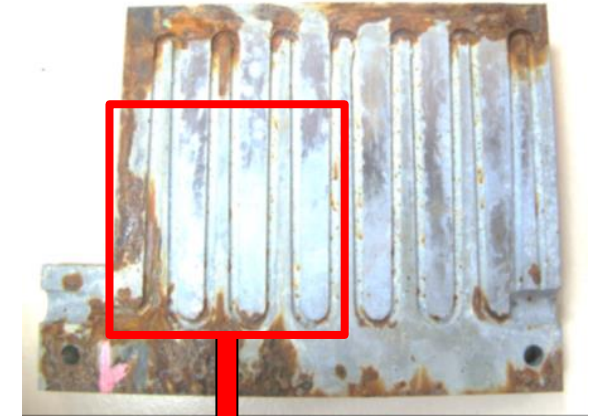
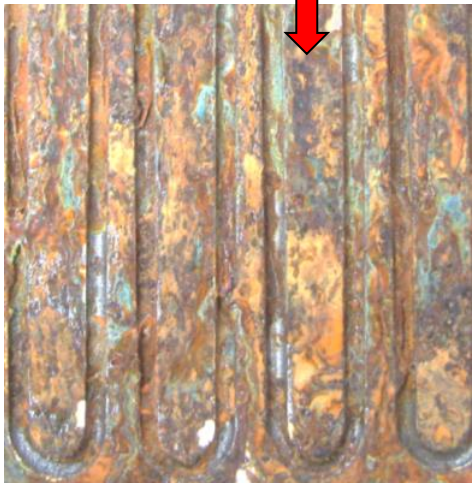
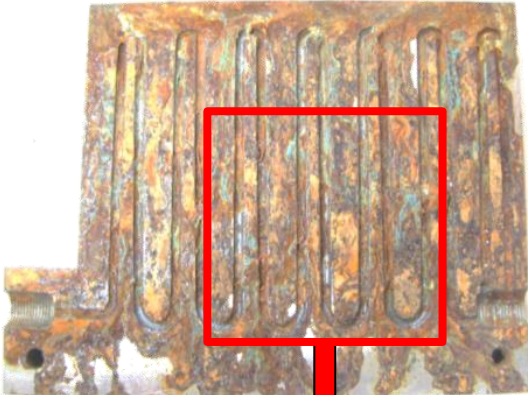
| | |
|--------------------|------------------------------|
| Material | Edelstahl 1.4305 |
| Anschlussgewinde | G 3/4" |
| Temperiermedium | Wasser / Öl |
| Druckbereich | PN 16 |
| Betriebstemperatur | -10°C / 260°C |
| Dichtung | PTFE |
| Abmessungen | 76 x 56 x 131 mm (L x B x H) |
| Gewicht | ca.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

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

uncoated

AnoxPro coated

- 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



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