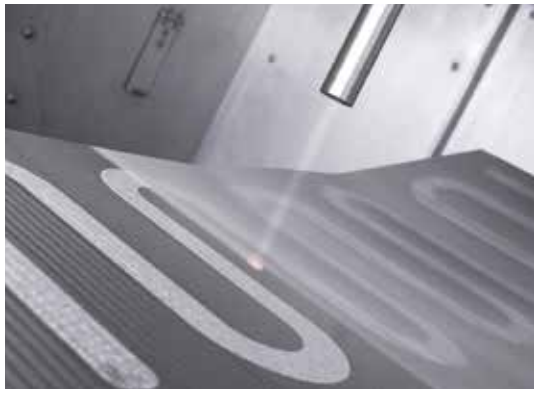
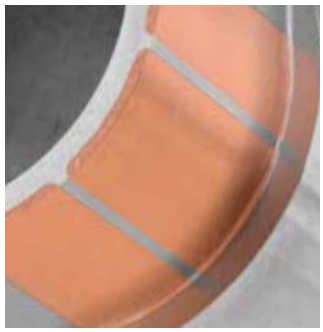
Hermle MPA

Additive manufacturing





HERMLE
generativ fertigen

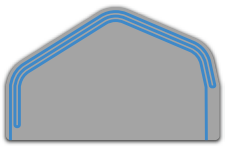
Additive manufacturing.

Using Hermle MPA technology.

The thermal spray process (Metal Powder Application or MPA), which is the result of more than 15 years of intensive research and development by Hermle, is the only one of its kind on the market and opens up completely new opportunities in the field of additive manufacturing. This process unites the idea of additive manufacturing and milling at its best, since the combination of material build-up and machining in a single machine offers hitherto undreamed-of possibilities, especially when it comes to producing large metal components. From the integration of efficient cooling channels to ingenious material combinations – experience the exceptional features of this new additive manufacturing technology for yourself.

ADVANTAGES

- *High application rates (steels 250ccm/h, copper 900ccm/h)*
- *Layer formation due to plastic deformation, therefore no material melt*
- *Reduced stress within the component even with solid material build-up*
- *Combination of various materials possible*



Close-to-contour cooling

Build free forms

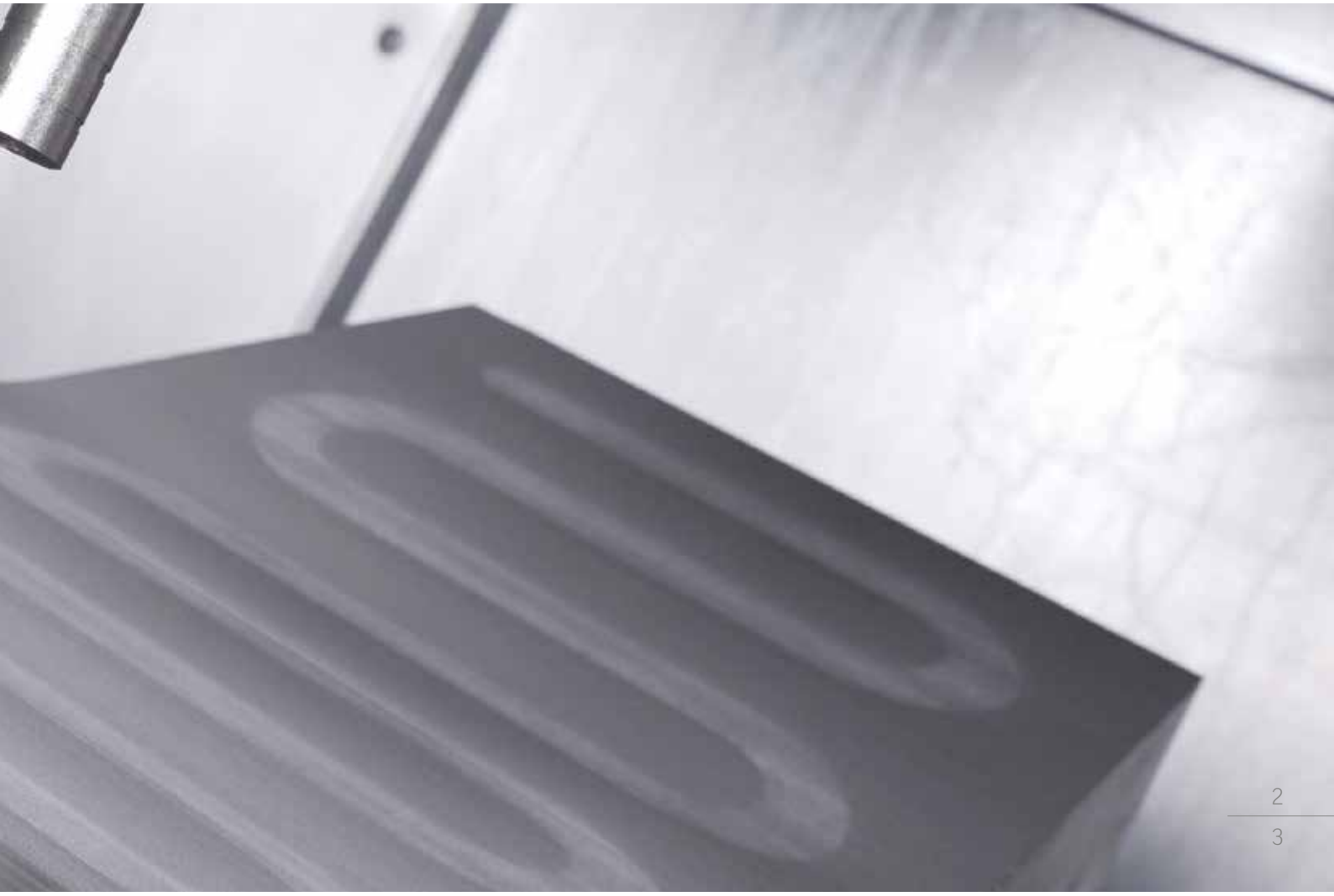
Combine materials

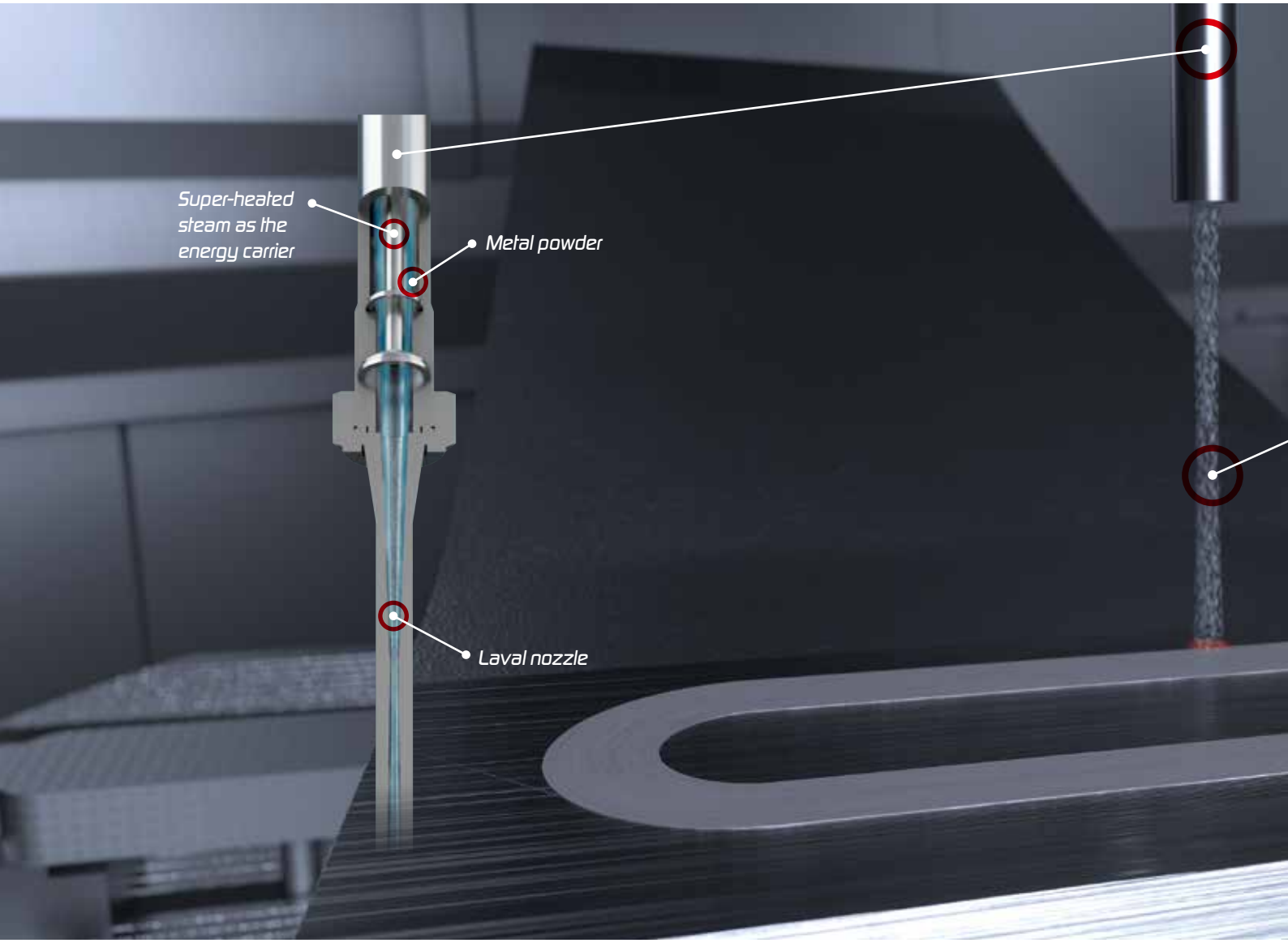
Optimise heat transport

The opportunities of MPA technology.

Successful completion of a significant number of customer projects has led to the emergence of a range of key applications that make Hermle's MPA technology particularly attractive. They include, for example, the integration of conformal channels for cooling surfaces.

Hermle is breaking new ground with its MPA technology by combining several materials – e.g. with varying hardness or thermal conductivity – in one component. Combined with cooling channels or heating elements integrated into the component, for instance, this ensures homogeneous and optimised heat transfer.





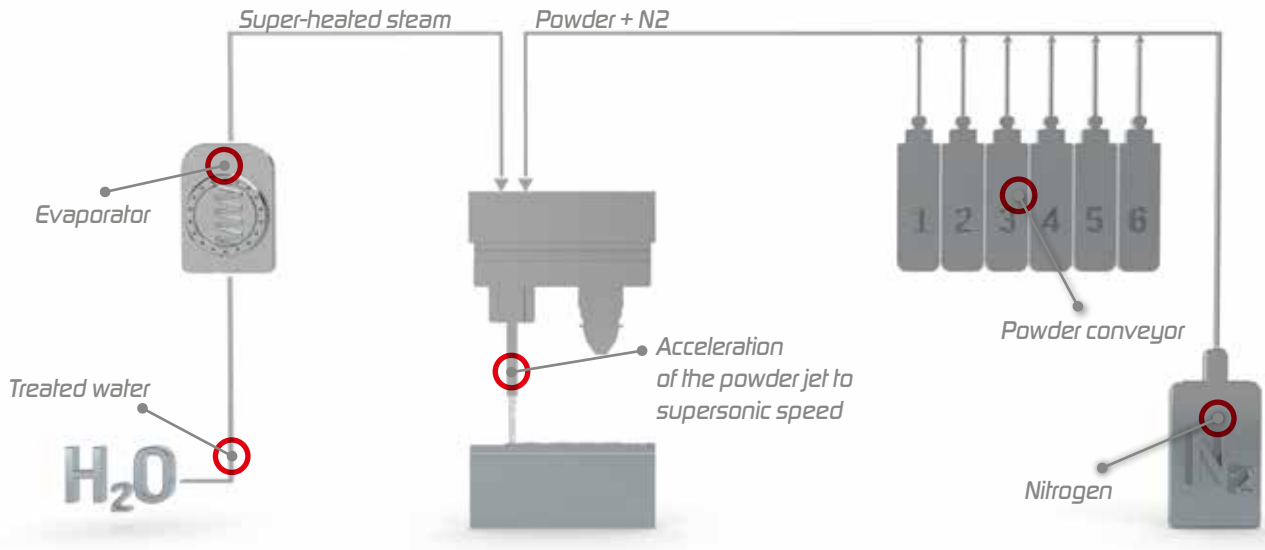
This is how Hermle's MPA technology works

A fascinating and ingenious approach to additive manufacturing technology.

MPA is an additive manufacturing process that is used to build up solid components layer by layer – simply by accelerating metal powder inside a nozzle. To do so, powder particles are accelerated to supersonic speed by means of a carrier gas and then deposited on the substrate via a nozzle. Build-up rates exceeding 900 cm^3 per hour and a powder jet comprising several millimetres qualify MPA technology for a comparatively rapid volume build-up on small to large component surfaces.

MPA = METAL POWDER APPLICATION

- Additive manufacturing process – without lasers
- Solid components are built up layer by layer
- By accelerating metal powder inside a nozzle (thermal spray process)



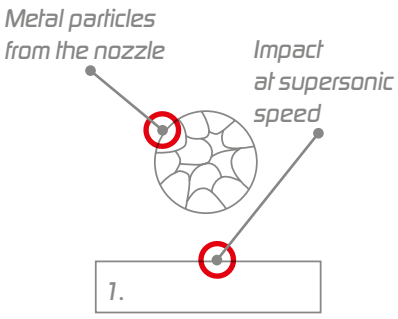
Layer formation.

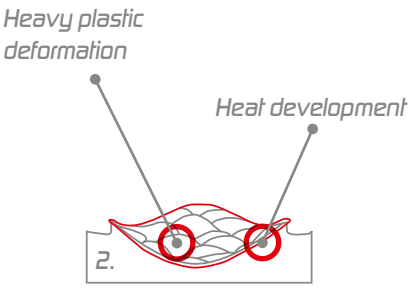
Material application through plastic deformation

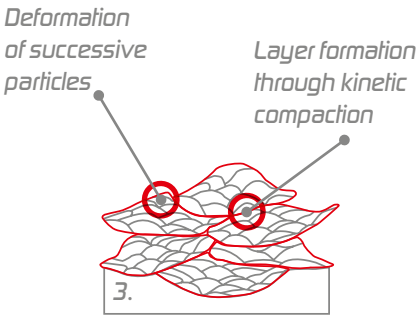
In contrast to many other additive manufacturing processes, the materials are not melted but only plastically deformed during layer build-up. This creates a binding contact surface between the particle and the substrate. The level of stress within the component remains comparatively low. This process is therefore ideal for solid material build-up on large component surfaces.

PROCESSIBLE MATERIALS

- *Hot-working steels (1.2343, 1.2344, 1.2083, 1.2367)*
- *Cold-working steels (1.2333, 1.2379)*
- *Stainless steels (1.4404, 1.4313)*
- *Invar (1.3912)*
- *Pure iron, pure copper, bronze and others*
- *High-carbon steels*







When impacting with the substrate, the metal particles carry a vast amount of kinetic energy which is converted into plastic deformation of the material.

A binding contact surface is created between the powder particle and the substrate.

A dense material layer is thus formed by the rapid succession of particle impact.

A video explaining the process in detail can be found at:
www.hermle.de/generativ_fertigen

Additive manufacturing and better milling come together.

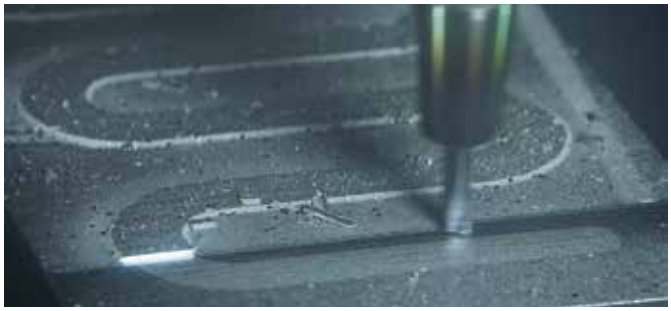
A hybrid machine concept for a hybrid manufacturing process

Material application and machining can be combined to create a versatile hybrid manufacturing process. By integrating the MPA deposition unit into a Hermle 5-axis machining centre, the milling machine is enhanced by the opportunities provided by additive manufacturing.

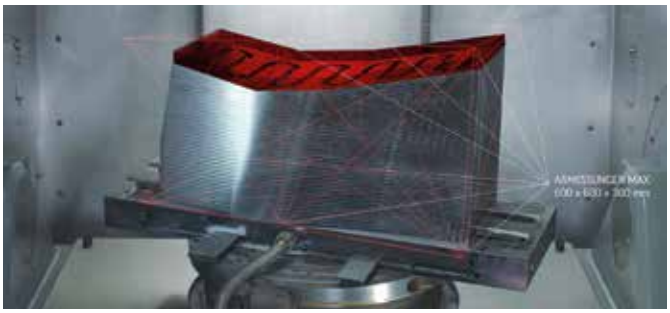
The deposition nozzle is mounted parallel to the tool spindle on the Z slide of the machine. The complete 5-axis dynamics of the machine can also be fully utilised via the swivelling

ADVANTAGES

- *Material build-up and machining in a single setup*
- *Fully flexible thanks to 5-axis technology*
- *Large working area for components measuring up to 600 x 600 mm*
- *Material application also on free-form surfaces*



Combined manufacturing process: A milling tool removes excess filler material from the channel geometry, thereby preparing the surface for the next application of material.



The large working area allows additive material build-up even on solid components.

rotary table and the components can be oriented to the nozzle as required. Material can therefore even be applied to curved free-form surfaces.

Thanks to its large working area, the MPA machine sets standards, as it allows the additive manufacture of large-volume components weighing several hundred kilograms and measuring up to 600 x 600 mm.

Close-to-contour cooling.

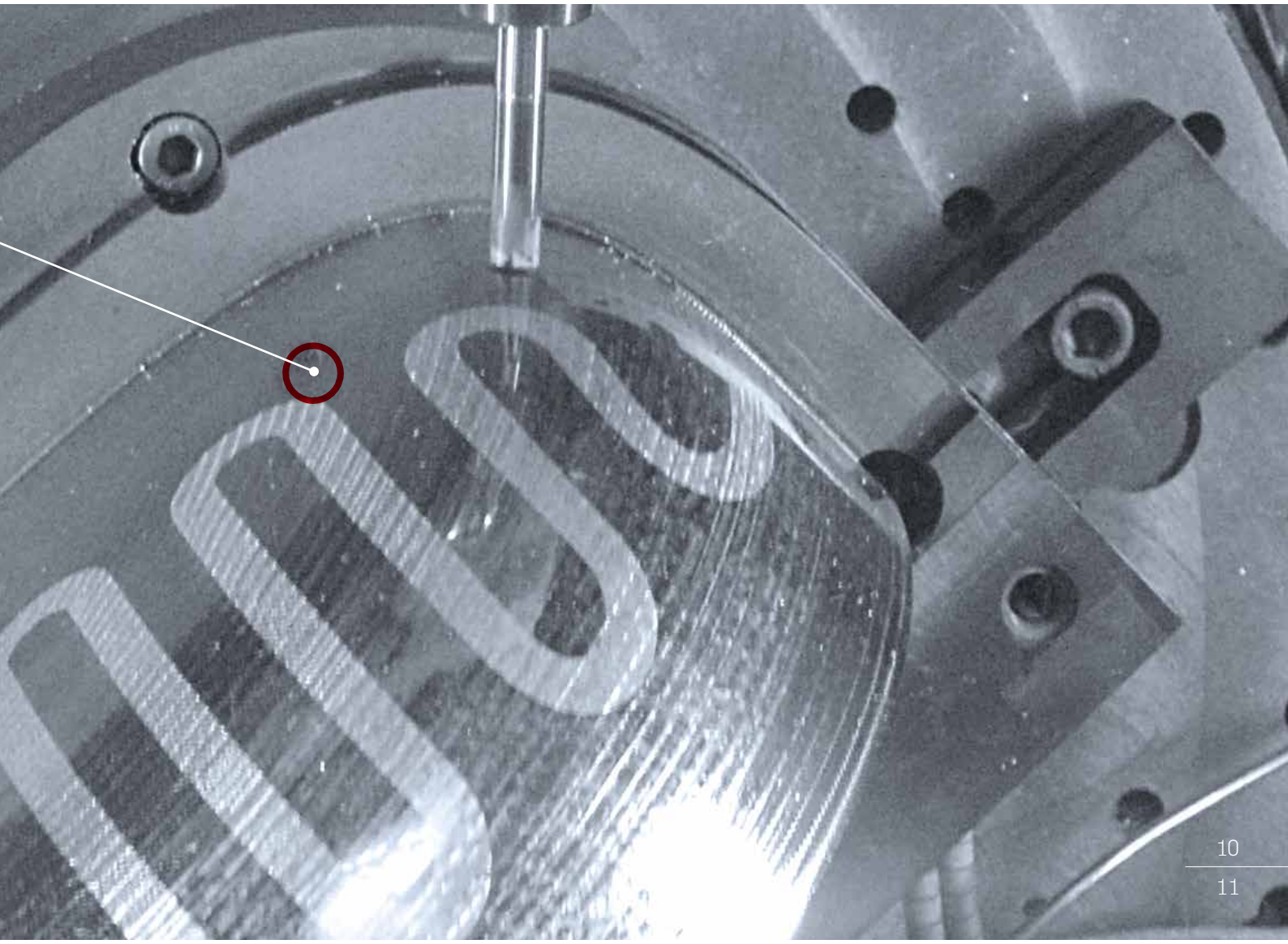
Conformal channels for optimum cooling.

One focus when using MPA is on tool and mould making for injection moulding and die casting processes. Additive manufacturing allows the continuous cooling of component surfaces, something that cannot be implemented or is very difficult to achieve with conventional manufacturing processes. Experience with customer components has shown that additively manufactured components with near-contour cooling channel guidance have enormous potential for reducing cycle times in injection moulding processes. The actual time required can be cut by up to 45% compared to tools without efficient cooling. For particularly high demands on tool surfaces, even high-gloss polishing is possible. Due to the very low porosity in the applied material, it can be offered, for example, for components made of 1.2344 hot-working steel.

CLOSE-TO-CONTOUR COOLING – THE ADVANTAGES

- *Large channel diameters in any spatial orientation*
- *Cooling channels with excellent surface properties due to the machining process*
- *Very long cooling channels possible*
- *Components whose thermal properties are profitable in their further use can be produced. For instance in injection moulding tools, forming tools or also die casting tools*

The pre-milled cooling channel in the blank is first filled with a water-soluble material via MPA. Excess filling material is then removed with a milling tool and the surface contour prepared for material application. Subsequently, the steel coat is applied. The filling material in the channel can now be removed. After heat treatment, the component is milled to its final shape.



Build free forms

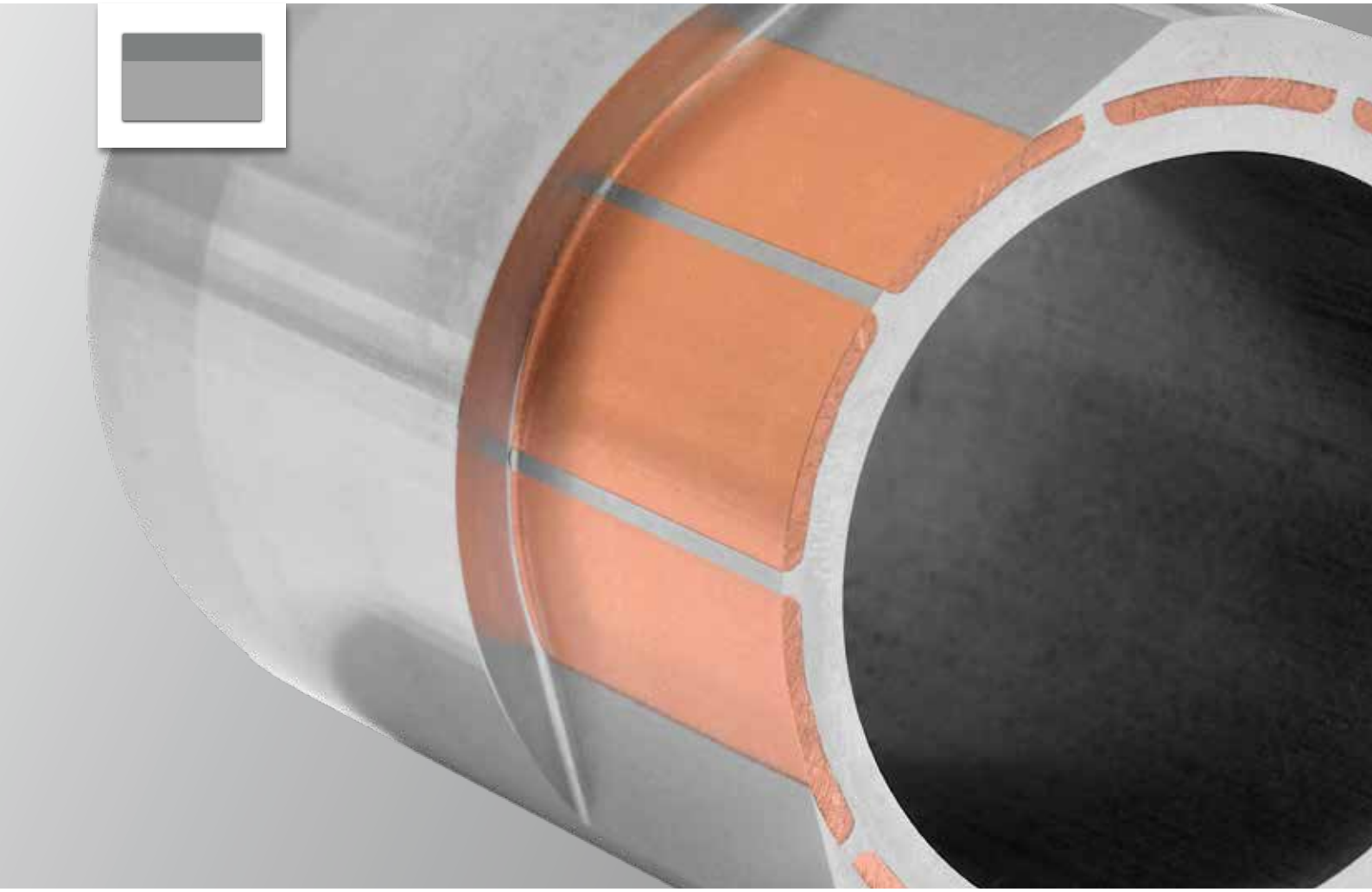
The free orientation of the nozzle to the component allows greater freedom of design and efficiency.

Especially with large components, it is not economical to build up the entire volume additively. Quite often it is sufficient to add a partial area to an existing component. This is where the flexibility of the 5-axis machine comes into play: The machine can align the component to the powder jet of the nozzle at any time, thereby allowing material application even on curved surfaces. Within the framework of machine dynamics (which limits the radius of curvature), it is thus possible to build additive components on almost any free-form surface of a prefabricated blank. For many components, the proportion of the component volume built up by additives is 10 – 20%, while the underlying blank is prefabricated cost-effectively using conventional methods.

BUILD FREE FORMS – THE ADVANTAGES

- *Thanks to the 5-axis kinematics, material build-up on any workpiece geometry is possible*
- *Material build-up on any substrate or on already existing components*
- *Large-volume components measuring up to 600 x 600 mm and weighing 500 kg can be processed*
- *Due to 5-axis simultaneous machining, it is also possible to build up material on rotationally symmetrical and cylindrical components*
- *Economical manufacturing due to a high application rate*

Demonstration component for Volkswagen.
Tool for press hardening sheet metal. The proportion of additive manufacturing is limited to the filling of the channels and the subsequent application of the steel top layer. To illustrate this, the coat applied on top of the cooling channels was milled open in places (areas shown in red).
Total weight approx. 620 kg, applied material approx. 50 kg.

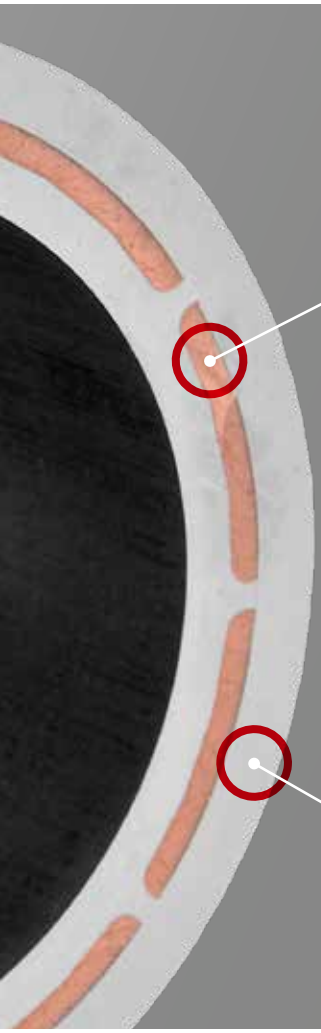


Combine materials

New component functions by combining various material properties

The MPA process allows the combination of multiple materials in one component. An outstanding example of this are components designed as a copper-steel combination. Here, the dimensional stability and durability of a hardened steel are combined with the excellent thermal conductivity of pure copper. Near-surface copper elements integrated into a steel body can distribute and dissipate heat very efficiently, even in places that are inaccessible to a cooling channel.

For the manufacture of such components, prefabricated pockets in a steel blank are usually filled with copper using MPA and then closed with an applied steel coat. A direct thermal contact is created between the copper and the steel body.



COMBINE MATERIALS – THE ADVANTAGES

- *Various material combinations are possible, limited by physical boundary conditions*
- *Combining different materials means combining different material properties*
- *Processing of pure copper for maximum thermal conductivity*
- *Optimum heat transport due to copper-steel connections (Cu + 1.4404 / 1.2344 / 1.2083) or a copper-aluminium combination*
- *Material gradients with a smooth transition are also possible*

Flat copper elements in a hollow cylinder. Cylindrical components can be produced by using the rotary axes of the machine. As the component rotates, the nozzle radially applies new layers of material.

Manufacturing stages of a tool with copper cores.
In a steel blank, pockets are defined and then filled with copper via MPA. After milling the cone surface, a steel cover is applied. Ultimately, the final component contours are milled.

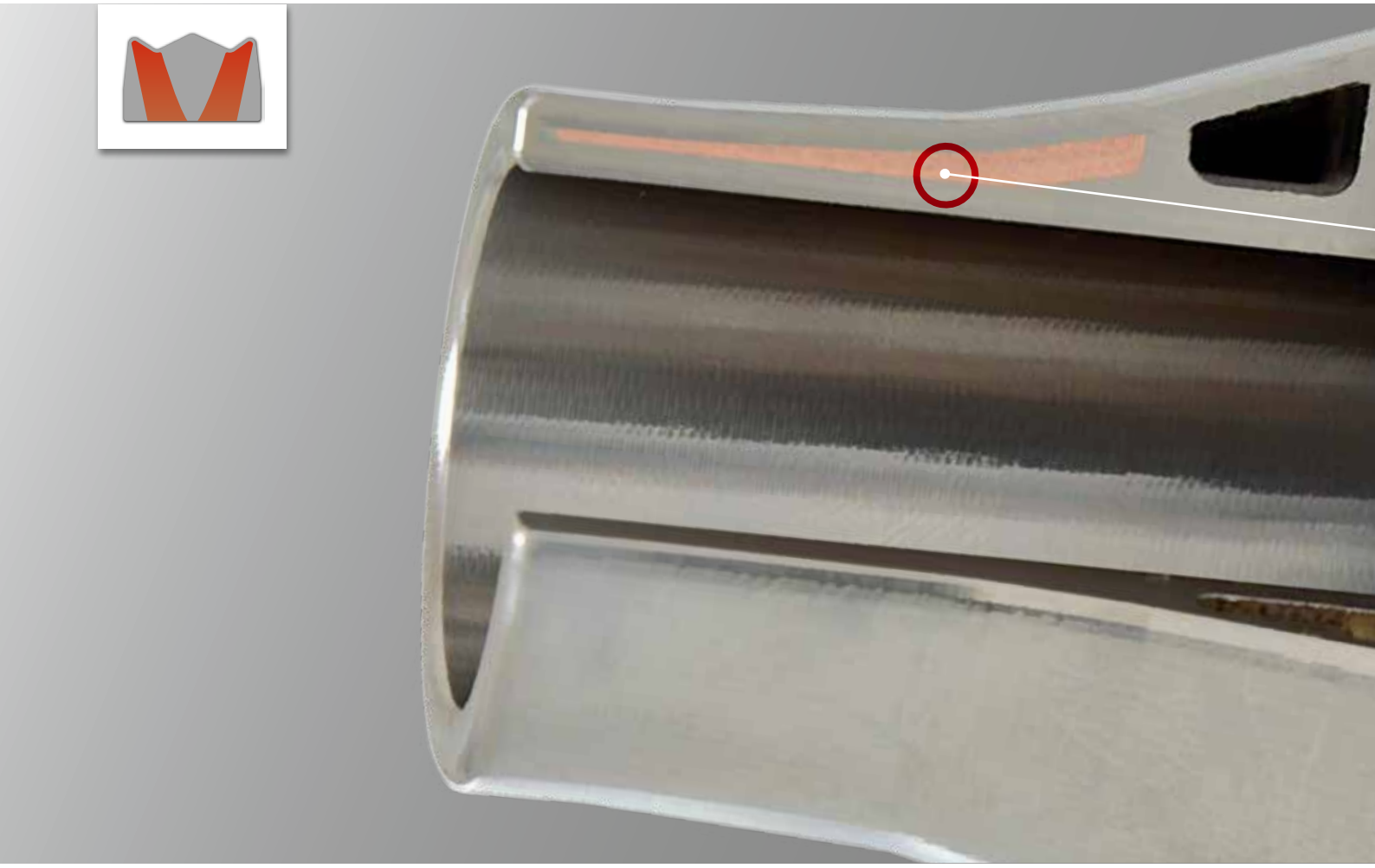
Optimise heat transport.

Cooling, heating, conducting heat – there are many ways to control the component temperature.

The creation of near-contour cooling channels and the integration of heat-conducting copper elements can be combined. Together with the temporarily introduced filler material for the cooling channel, three materials are then used in the manufacturing process. For example, heat generated at local component bottlenecks can be dissipated via copper elements and transported further inside the component by an efficient cooling channel with a comparatively large cross-section.

Direct local heating of components is also possible by integrating prefabricated electrical heating elements as well as thermal sensors. To do so, the heating conductors are pressed into channels prepared for this purpose in the blank and then closed by applying steel powder. The direct connection to the applied material provides excellent heat conduction far beyond that of a press contact. Here, too, copper elements can be combined for heat conduction. All in all, this results in a modular system that offers a wide range of possibilities for component temperature control.

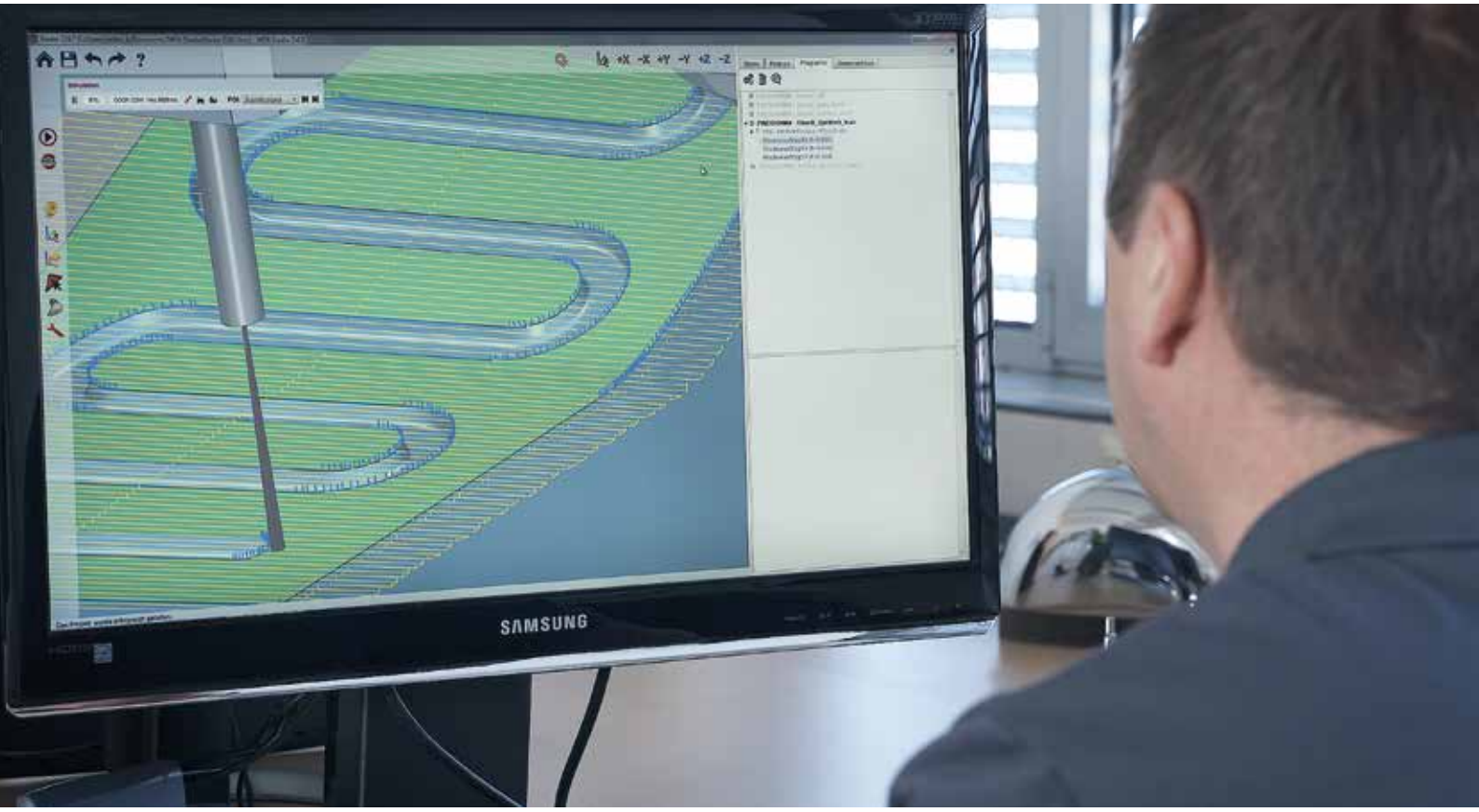
Sprue bush for plastic injection moulding. The embedded copper conducts the resulting heat to the cooling channel.



Injection mould with optimised cooling. Copper elements in the extremities which are not accessible to a channel dissipate the heat to the lower cooling channel.

OPTIMISE HEAT TRANSPORT – THE ADVANTAGES

- *Combination of cooling channels and copper elements for optimum heat transfer*
- *Integration of active heating elements in a near-contour design*
- *Combination of heating and cooling functions in one component*
- *Integration of functional elements (e.g. thermal sensors for temperature control)*

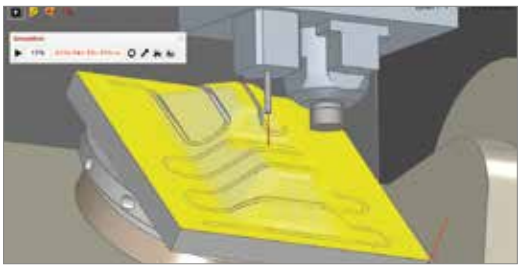


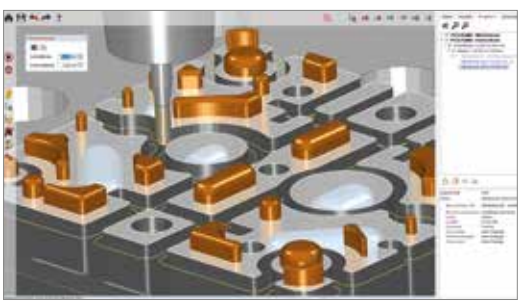
Process planning with MPA Studio.

The CAM software for the MPA process maps the complete manufacturing process.

Additive manufacturing with MPA technology places specific demands on path planning strategies and tool paths for the deposition nozzle. In order to meet the geometric, physical and technical boundary conditions, we have developed MPA Studio, an independent CAD/CAM software specially tailored to the MPA process. It can be used to calculate all the required tool paths for material application as well as for preparatory machining.

Furthermore, it enables the analysis and adaptation of the component geometry with regard to the planned material structure and the subsequent simulation of the process flow. This makes MPA Studio an essential and versatile tool when using MPA technology.





MPA Studio calculates and simulates application paths as well as machining paths for the MPA process.

Maschinenfabrik Berthold Hermle AG, Gosheim

Tradition meets additive manufacturing.

Milling and additive manufacturing from a single source.

Maschinenfabrik Berthold Hermle AG is one of the world's leading manufacturers of milling machines and machining centres, known for its high precision, efficiency, reliability and perfect service. Another focus of the company is on product automation.

In addition to the production of machining centres, its subsidiary Hermle Maschinenbau GmbH has more than 15 years of experience in the development and application of additive manufacturing. With this in mind, Hermle now offers MPA technology as an innovative and versatile additive manufacturing process that can fully exploit its strengths, especially in tool and mould making but also in other sectors.

Hermle Maschinenbau GmbH, Ottobrunn

Maschinenfabrik
Berthold Hermle AG
Industriestrasse 8-12
D-78559 Gosheim

Phone +49 (0)7426 95-0
Fax +49 (0)7426 95-1309

info@hermle.de
www.hermle.de

Hermle Maschinenbau GmbH
Daimlerstrasse 6
D-85521 Ottobrunn

Phone +49 (0) 89 2152540-20

sales.hmg@hermle.de
www.hermle.de

Subject to technical modifications. 01/20/MPA/1000/EN/ST

HERMLE
generativ fertigen