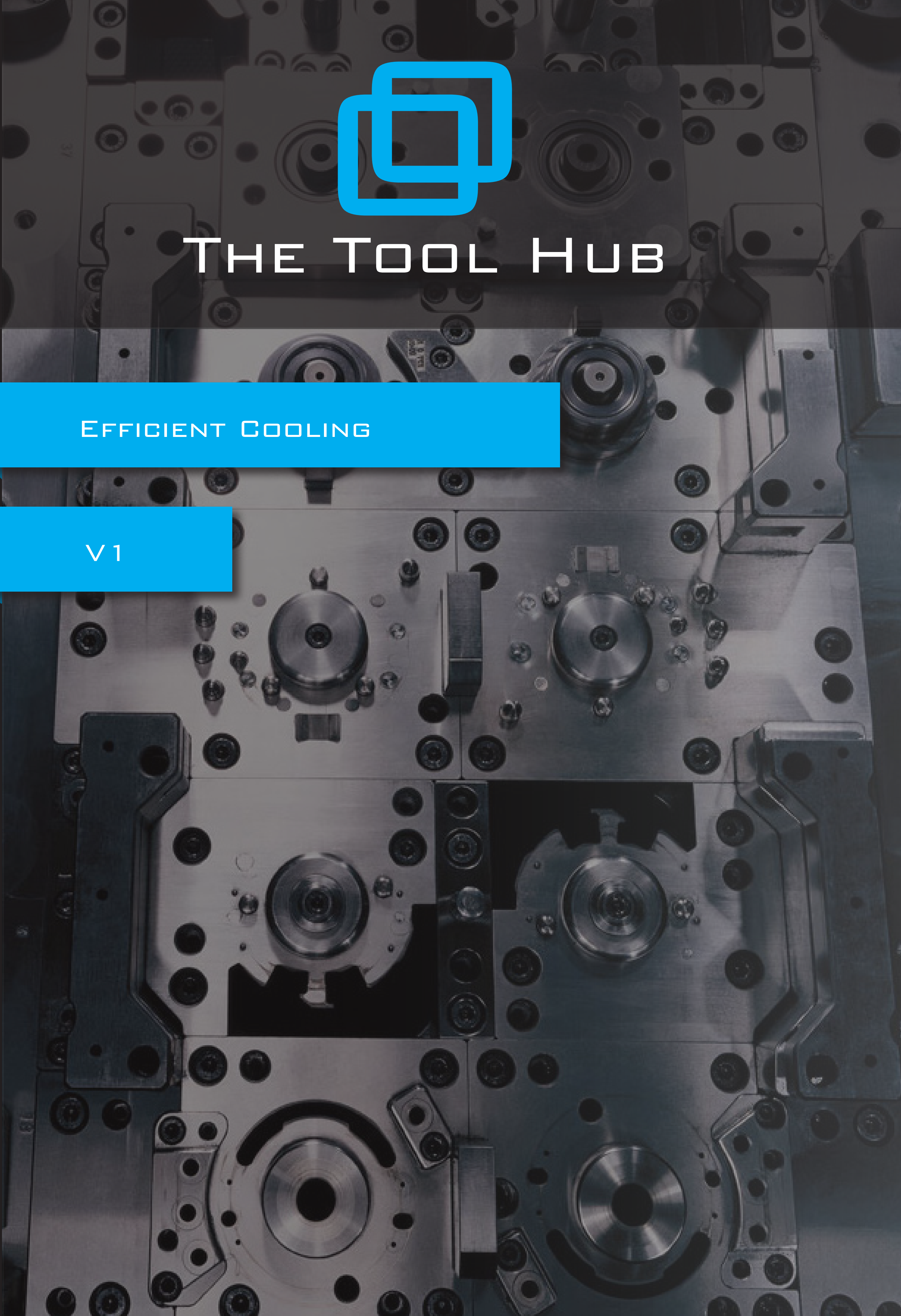
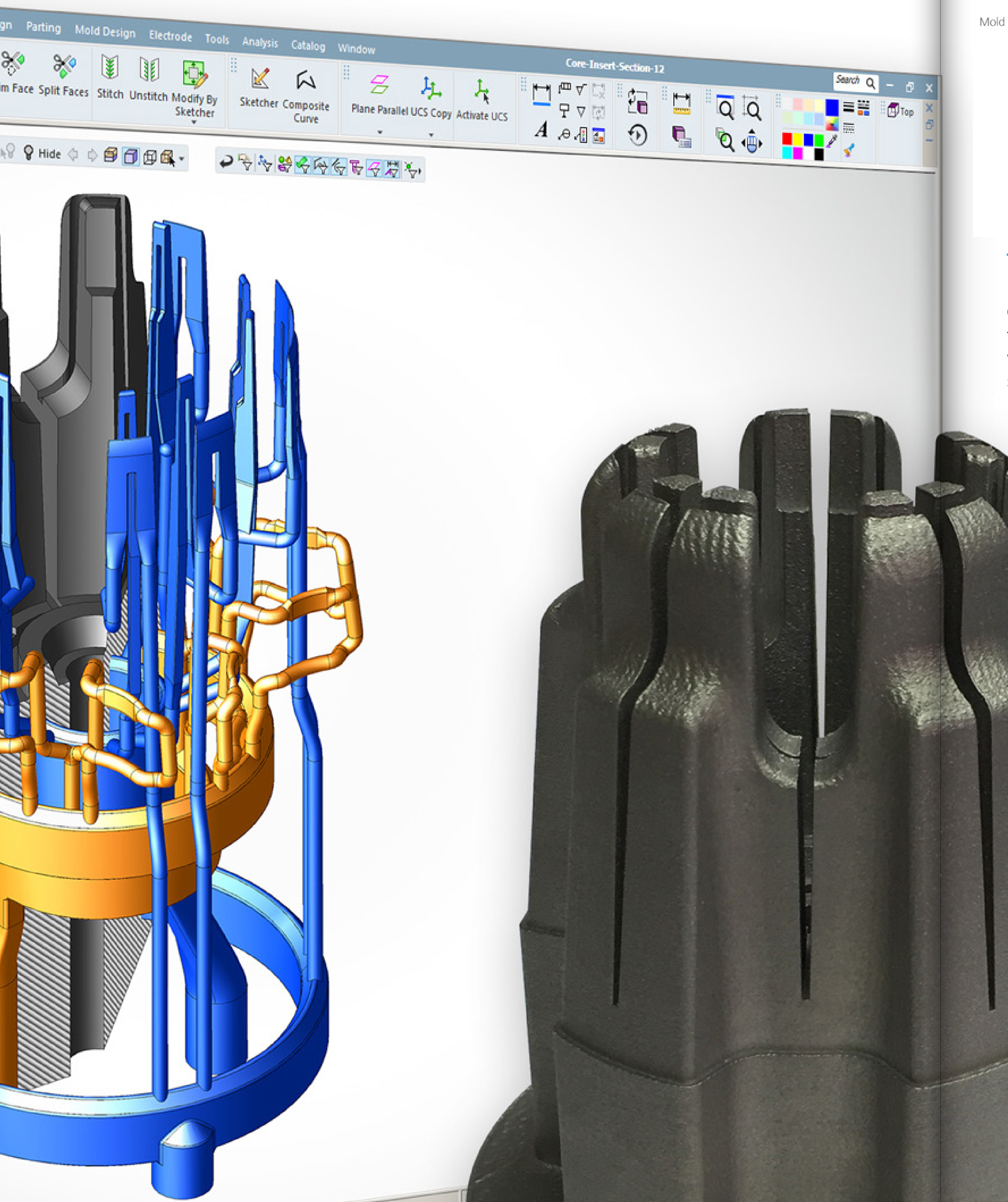
The Tool Hub

Efficient Cooling

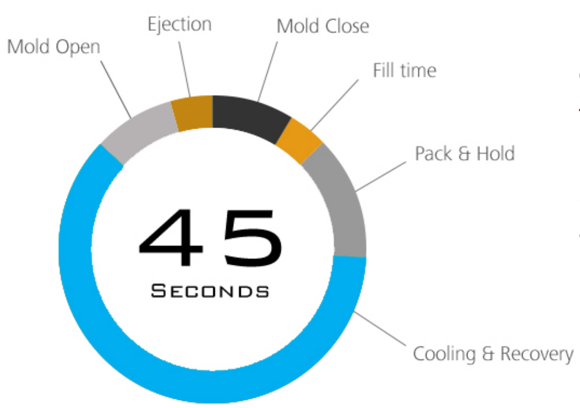
V1



Conformal cooling channels is a good way to decrease deformation and increase productivity.
Below is a core ready for final machining.



Efficient Cooling



Injection moulding process is cyclic in characteristic. Cooling time is 50 to 75% of the total cycle time. Therefore, optimizing cooling for best performance is very important from quality and productivity point of view. A 30% improvement in cooling efficiency can give as much as 22% in increased production output.

The first step is to optimize the part design.

Cost savings are highest when components have a minimum wall thickness, as long as that thickness is consistent with the part's function and meets all mold filling considerations. As would be expected, parts cool faster with thin wall thicknesses, which means that cycle times are shorter, resulting in more parts per hour. Further, thin parts weigh less, using less plastic per part.

The best cooling system in the world won't take away heat any faster than the molded part will give it up. Most unfilled resins transfer heat at a rate 1/10 to 1/25 that of steel. The outer walls of a thick part insulate the mold from the heat trapped in the center of the part. The message here is that for very thick part, the cooling system will have relatively little effect on cycle time.

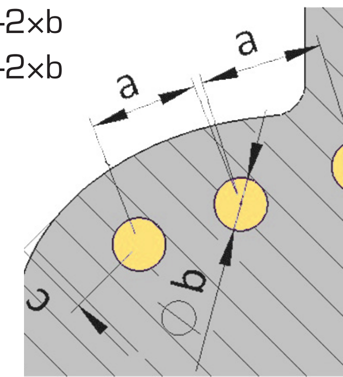
The second step is to optimize the mould design.

Cooling channel design – location and size and type – should ensure that melt freezes uniformly inside the mould.
Cooling channel design must be analyzed with the help of a Mold flow report.

The difference between the inlet and outlet water temperature should be less than 2 to 5 degrees C.
However, for precision moulding, it should be 1 degree C or even 0.5 degree C.

Our view on optimal placement and distribution can be seen below

Wall thickness of moulded product (mm)	Hole diameter, b (mm)	Centreline distance between holes, a (mm)	Distance between centre of holes and cavity, c (mm)
0.3-2	4-8	2-3xb	1.5-2xb
>2-4	>8-12	2-3xb	1.5-2xb
>4-6	>12-14	2-3xb	1.5-2xb



The third step is to add material with high thermal conductivity.

BeCu Alloys high thermal conductivity, 3 to 4 times better than steel, ensures uniform, rapid heat removal, minimizing part distortion, warpage, poor replication of detail and similar defects. In many cases it can significantly reduce cycle times, even when used in a steel mold just for selected cores and inserts.

Heat pipes or "iso pipes" can also be used in areas where it is difficult to use conventional cooling.

The Isopipe uses very high thermal conductivity to transport heat from one end of the pipe to the other, cooling (or heating) mold tools. Heat picked up from the mold is dissipated by cooling water passed over the exposed end of the Isopipe, allowing vapor inside the pipe to condense. The liquid/vapor phase changes within the Isopipe allow thermal energy to be absorbed, transferred and rejected with a maximum temperature difference of only 5° C along the outer sheath.

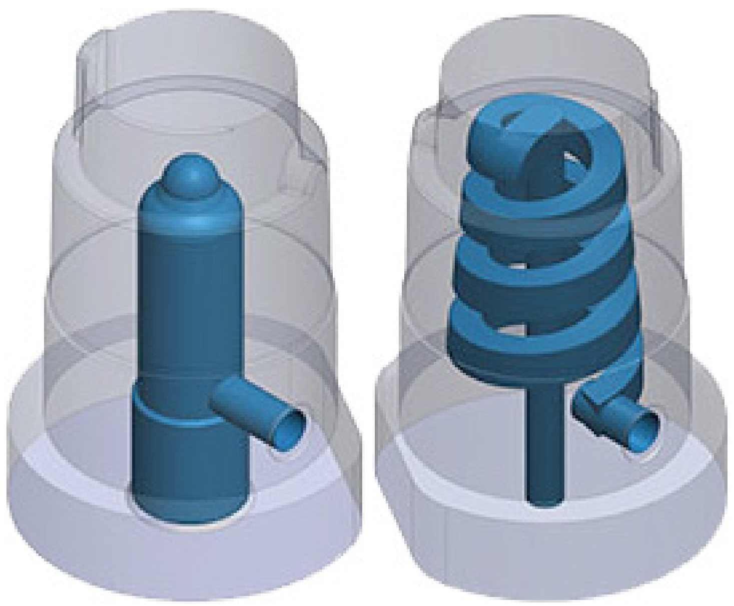
The fourth step is to add conformal cooling.

To add conformal cooling we work with 3 methods.

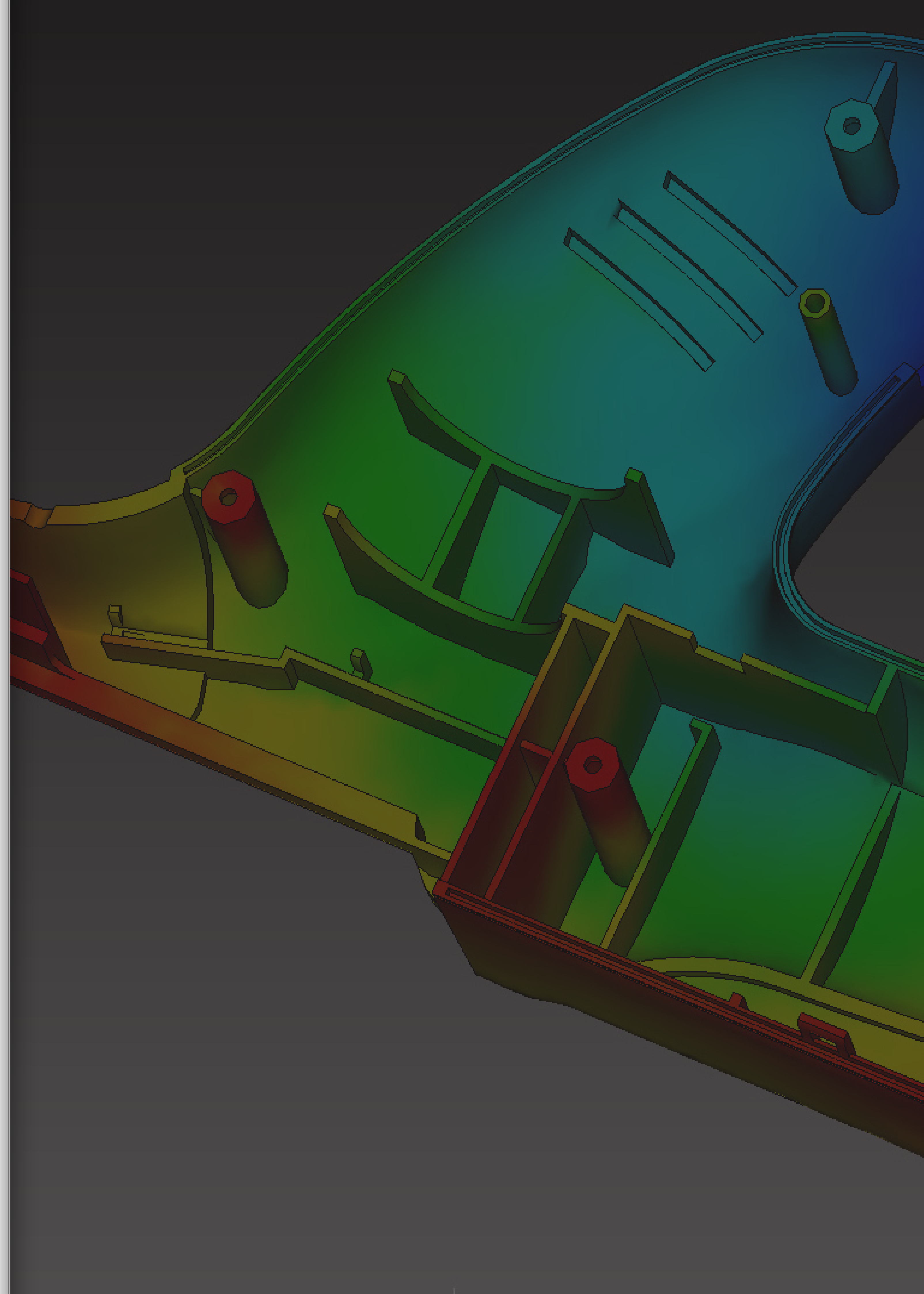
Hybrid Direct Metal Laser Sintering (DMLS)
By using DMLS we are able to build core and cavity inserts with cooling channels added in the process. This can be done in a number of steels such as: Stainless steel 17-4, Stainless steel 15-5, Stainless steel 316L and Steel DIN 2709 (50-54 HRC)

Diffusion Bonding (DB)
A special fabrication technology is developed that is based on fusion of different pre-machined parts to a single part "monoblock". Such part contains at its interior specially engineered thermal regulation circuit.

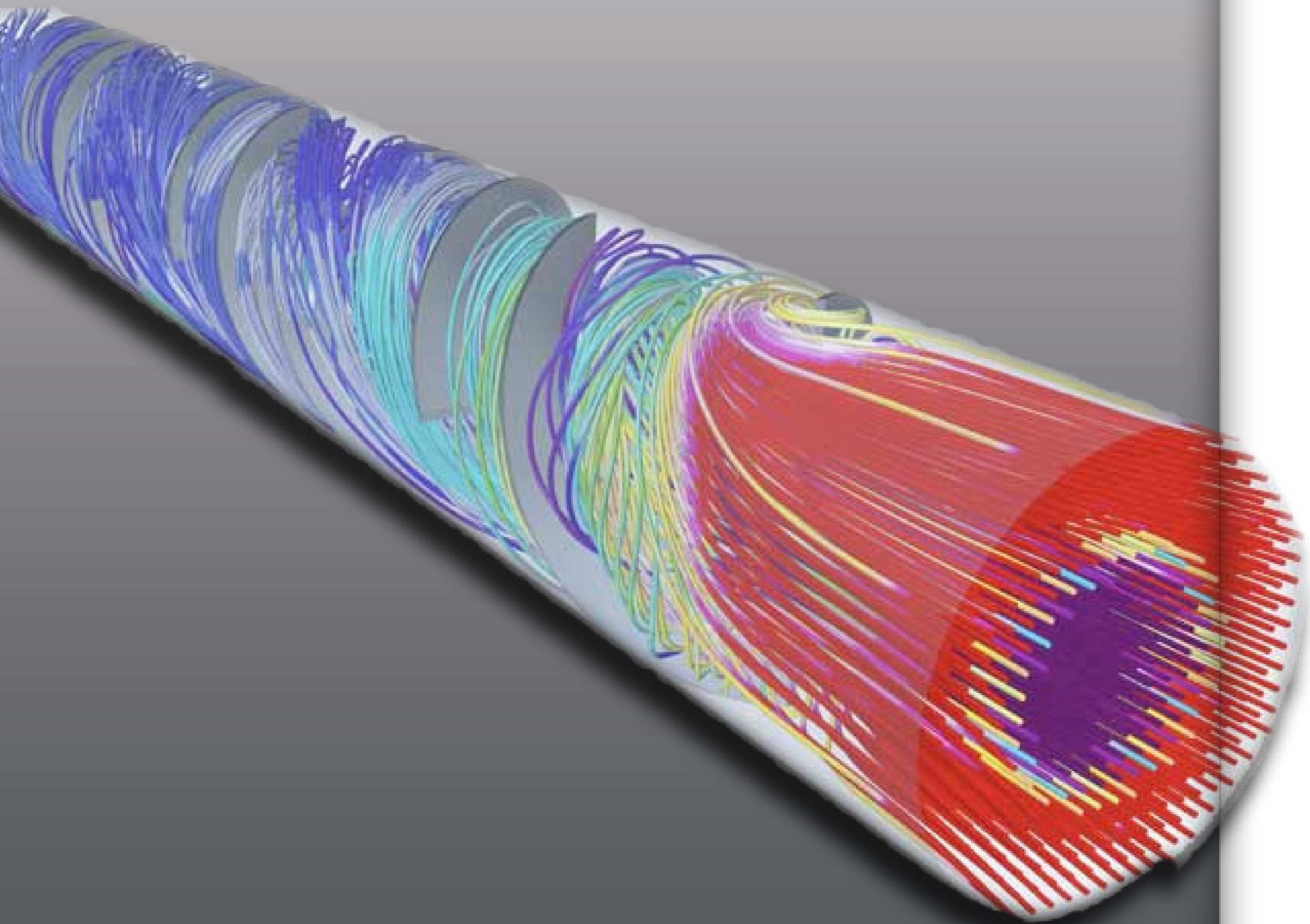
Thermal Brazing & Coating (TBC)
Used for larger inserts, it is a thermal joining process in which a molten brazing filler metal is drawn into a capillary gap between the metals being joined.



Before After



Studies have shown that for the same net flow through a cooling channel a turbulent flow can transfer as much as 150-500% more heat from the tool steel



The fifth step is to introduce turbulent flow.

Achieving a turbulent flow is a good way to increase the heat transfer without having to alter anything in an existing tool.

Turbulent flow begins when the velocity of fluid in a channel increases to a critical level. Above this critical velocity, vigorous internal mixing of the fluid occurs as it flows. This improves heat transfer by mixing warmer fluid near the wall of the cooling passage with the relatively cooler interior fluid.
The precise velocity for turbulent flow depends on several variables, including the cooling passage geometry, fluid viscosity, and roughness of the pipe walls. The formula for a ratio known as Reynold's number includes these variables.

A Reynold's number greater than 4000 denotes turbulent flow.

Boundary Layer

The boundary layer is defined as the area of the flow that has shear stress forces induced by the solid wall of the cooling channel.
What this basically means is that the boundary layer is the part of the moving water that is feeling the friction of the wall.

The molecules of water that are closest to and touching the water block wall are not moving at all, but are stationary.
As the distance from the wall increases, the molecules pick up speed until they are far enough away that the flow feels no effects from the wall.

The problem with having a boundary layer for heat transfer in a cooling channel is that it is actually insulating the inner most layers of flow from being able to pick up the heat from the tool steel.
This is especially true of laminar flow because the boundary layer is very thick. However, in turbulent flow the random action of the water molecules breaks up the boundary layer and disperses the majority of it, thus increasing the ability of all the water molecules to pick up heat from the water block wall.

Flow rate needed to achieve turbulent flow:

ID of drilled passage (mm)	Min. flow rate for turbulent flow (L/min)
6.5	1.25
9	1.66
11	2.08
15	2.8
18	3.4

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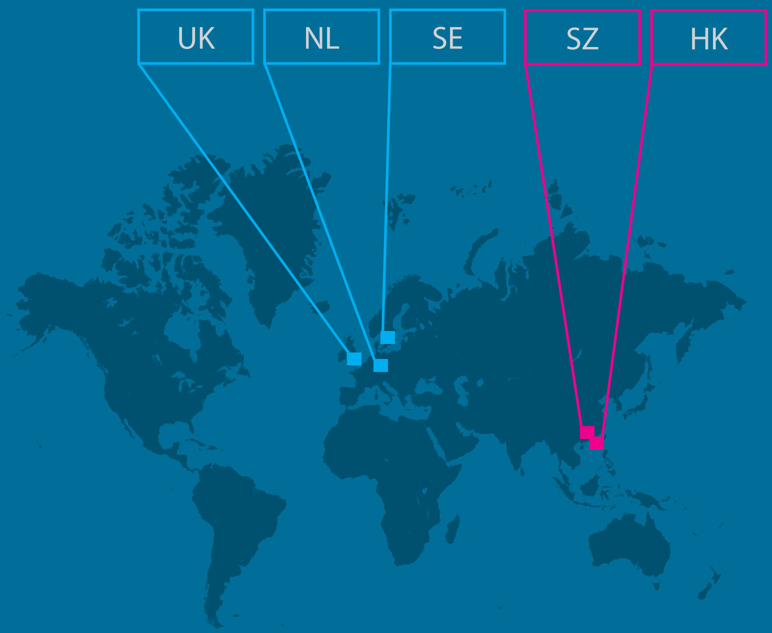
Production Centres
Shenzhen, Hong Kong



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