Case Study
Conformal Cooling for Tooling Inserts

3D Printing of tooling parts with conformal cooling channels
Potential of additive manufacturing for tooling and molding
ABB Oy, Drives and Controls

ABB is a global leader in power and automation technologies. Based in Zurich, Switzerland, the company employs 145,000 people and operates in approximately 100 countries, with 5,400 employees in Finland. The firm’s shares are traded on the stock exchanges of Zurich, Stockholm and New York.

ABB Oy, Drives and Controls is the world’s leading manufacturer of drives and PLCs. It employs around 6,600 people in more than 80 countries. It has 12 factories to ensure customer needs around the world.

Offering:
- Low voltage drives, AC and DC
- Medium voltage drives
- Servo drives and motion control products
- PLCs and HMIs
- Software tools
- Services for the complete life cycle

Competences:
- Research and development of variable speed drives
- Product and service support
- Supplier selections and strategies
- Product and equipment assembling and testing

New Solutions for the Tooling Industry

Selective Laser Melting (SLM), an additive manufacturing technology, can be used for the production of tooling components with conformal cooling channels. ABB OY, Drives and Controls, was able to greatly reduce the cycle time for a cabling grommet due to a redesign and optimization of a tooling insert. The optimized geometry of the part not only reduces the cycle time but also leads to less scrap parts in production.

ABB produces millions of cabling grommets per year. The cabling grommet used for this case study is also a high volume component made of a thermoplastic elastomer (TPE). The injection molding tool used for production did not feature any cooling inserts in the original design and had a cycle time of around 60 seconds, including a cooling time of about 30 seconds.

The aim of the case study of implementing conformal cooling for this insert was to improve the efficiency of the production and to increase the product quality resulting in less defective products.
Redesign for Conformal Cooling

For the study, six different channel profiles were designed for the tooling insert, including one resembling a part with conventional cooling to provide a comparison to conventional manufacturing. The channel profiles were optimized for the SLM technology taking into account factors including the angles of surfaces facing down to reduce the need of supports, a minimum wall thickness between channels and the dimensions and shapes of the channels. Before building all the various cooling channel profiles, simulations for water flow and thermal conductivity were carried out and the parts already showed slightly different cooling behavior in the simulations.

The tooling inserts were built by the Finnish company VTT on an SLM 125HL in steel 1.2709. Heat treatment was then carried out to achieve the desired hardness of 54 HRC and the final outer shape was conventionally machined. The six cooling channel profiles built were:

- **Type 1:** Thin U-profile
  - better reach towards the tip
  - smaller cross section area
  - water flow is entirely closer to the surface

- **Type 2:** Thick U-profile with turbulent ribs
  - large ribs increasing turbulence
  - larger cross section area
  - more water volume flow

- **Type 3:** Slim spiral profile
  - smaller pitch
  - smaller cross section area
  - denser profile
  - classic design

- **Type 4:** Robust spiral profile
  - larger pitch
  - larger cross section area
  - less dense profile
  - more water volume flow
  - classic design

- **Type 5:** Fountain profile
  - the largest and the most symmetric and coherent profile
  - very experimental design

- **Type 6:** Conventional «drilled» profile
  - internationally not optimized design
  - represents classic solution which will be compared with optimized versions
Testing the Cooling

To test the cooling, the parts were heated to a temperature of 70°C with a tempering system and cooled to 20°C to resemble the cooling of the TPE in the injection molding process. The cooling phase was controlled by infrared scanning to compare the cooling behavior.

With cooling times under 10 seconds, the best cooling behavior was obtained from the fountain, thin U and the thick spiral profiles. These feature relatively small cross sections for rapid and turbulent water flow as well as conformal water flow close to the insert surface. The tip area cooled slower on all inserts. The fountain and thin U-profile were identified for the most potential for production with other parameter and ease of manufacturability considerations.
The parts with conformal cooling were used in the injection molding tool and no evident insert-dependent performance differences between the cavities could be found. A cooling time of the TPE of approximately six seconds was achieved, resulting in a cycle time of 14.7 seconds.
Conformal Cooling for High Volume Injection Molding Components

The utilization of SLM leads to drastic reduction of cycle time and production cost. Achieving a reduction of the cooling time from around 30 seconds to approximately six seconds was able to reduce the cycle time from 60.5 seconds to 14.7 seconds by using the conformal cooling insert in the injection molding tool.

New potential from metal based additive manufacturing technology

- Tooling insert is equipped with conformal cooling channels
- Cooling time of TPE is reduced 80% compared with original insert
- Cycle time is more than 75% shorter than with original insert
- Savings in production time and cost
- Less defective products due to more equal cooling on surface
- Cooling channels can be used for tempering according to application