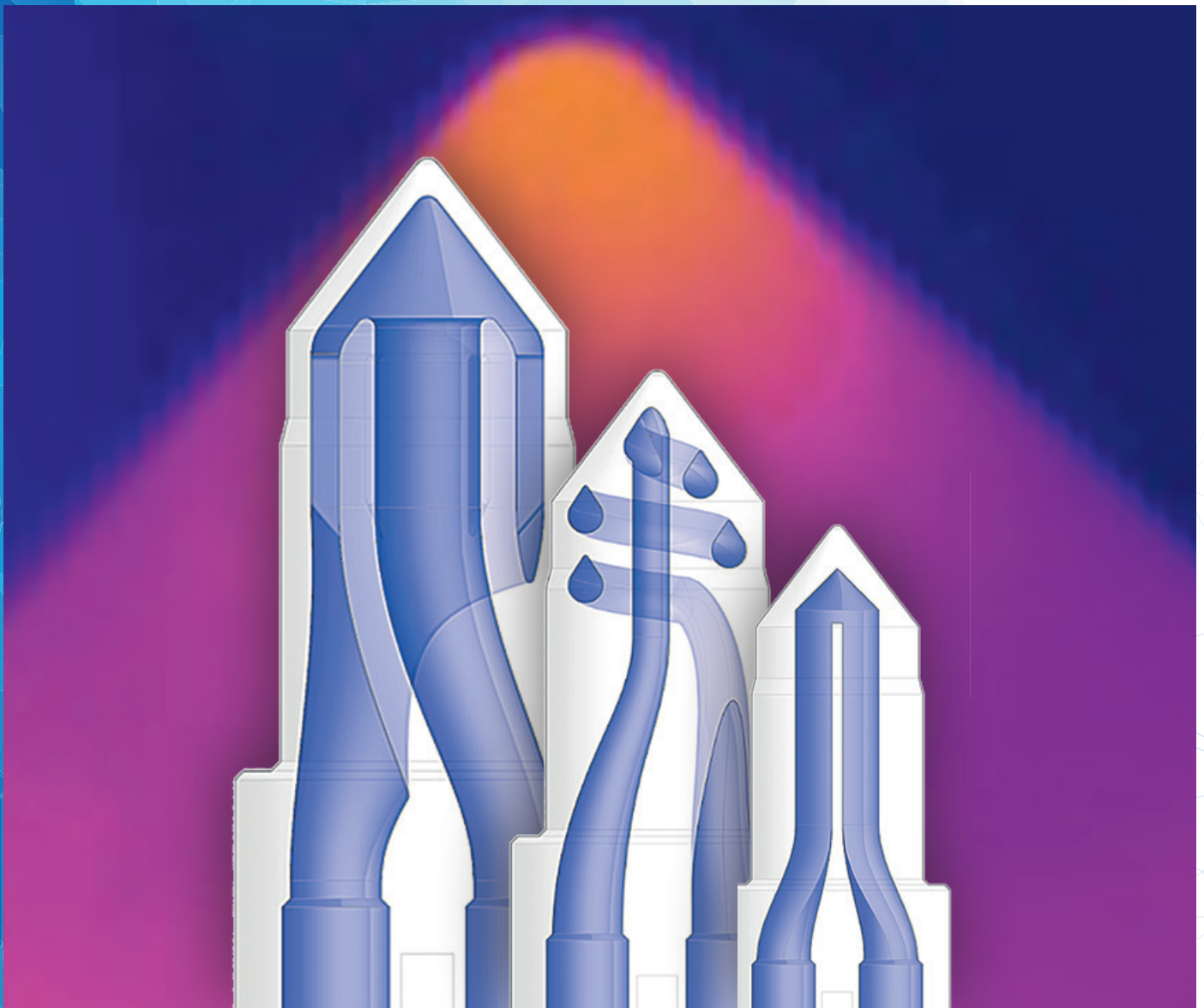


Case Report

Conformal Cooling for Tooling Inserts



3D-Printing of tooling parts with conformal cooling channels

Potential of additive manufacturing for tooling and molding at ABB

COMPANY PROFILE

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. In Finland the number of people working for ABB is around 5,400. The firm's shares are traded on the stock exchanges of Zurich, Stockholm and New York.

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



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CURRENT SITUATION / CHALLENGES

New solutions for the tooling industry

Selective Laser Melting, an additive manufacturing technology, can be used for the production of tooling parts with conformal cooling channels. ABB OY, Drives and Controls, was able to tremendously 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.

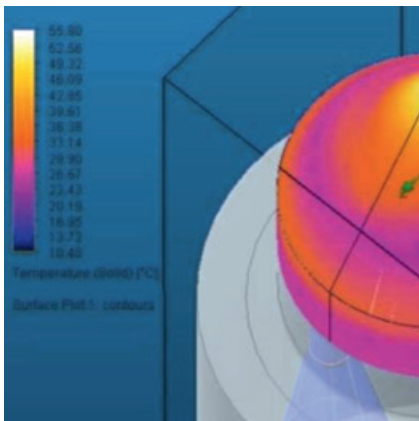
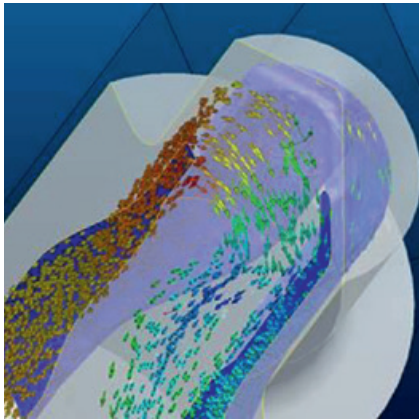


ABB produces millions of cabling grommets per year. The cabling grommet, which was used for this case study, is also a high volume component made of a thermoplastic elastomer (TPE). The injection molding tool used for production did not have any cooling inserts in the original design and a cycle time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







SLM® SOLUTION

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.

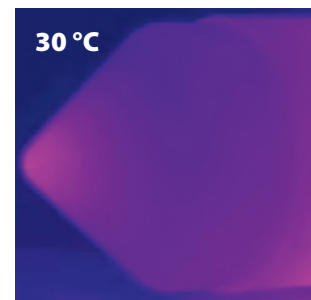
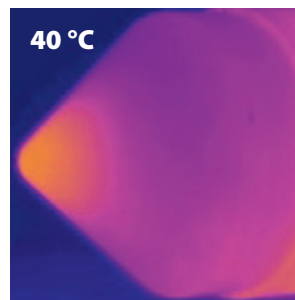
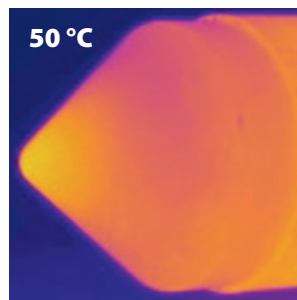
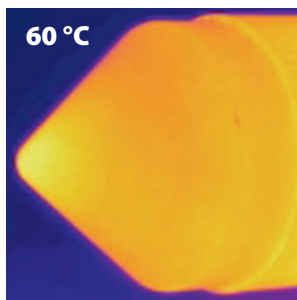
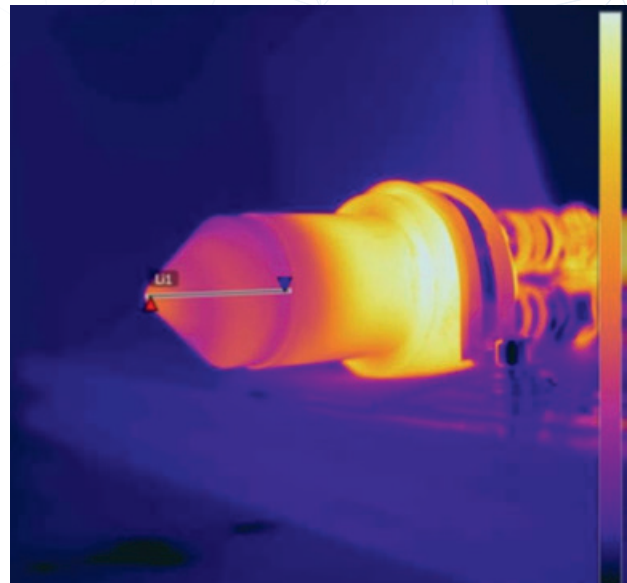
The tooling inserts were built by the Finnish company VTT on a SLM®125 machine in steel 1.2709. Heat treatment was then carried out to achieve the desired hardness of 54 HRC and the final outer shape was conventionally machined. The six cooling channel profiles built were:

Type 1:	Type 2:	Type 3:	Type 4:	Type 5:	Type 6:
Thin U-profile	Thick U-profile with turbulent ribs	Slim spiral profile	Robust spiral profile	Fountain profile	Conventional »drilled« profile
					
<ul style="list-style-type: none"> ▪ better reach towards the tip ▪ smaller cross section area ▪ water flow is entirely closer to the surface 	<ul style="list-style-type: none"> ▪ large ribs increasing turbulence ▪ larger cross section area ▪ more water volume flow 	<ul style="list-style-type: none"> ▪ smaller pitch ▪ smaller cross section area ▪ denser profile ▪ classic design 	<ul style="list-style-type: none"> ▪ larger pitch ▪ larger cross section area ▪ less dense profile ▪ more water volume flow ▪ classic design 	<ul style="list-style-type: none"> ▪ the largest and the most symmetric and coherent profile ▪ very experimental design 	<ul style="list-style-type: none"> ▪ internationally not optimized design ▪ represents classic solution which will be compared with optimized versions

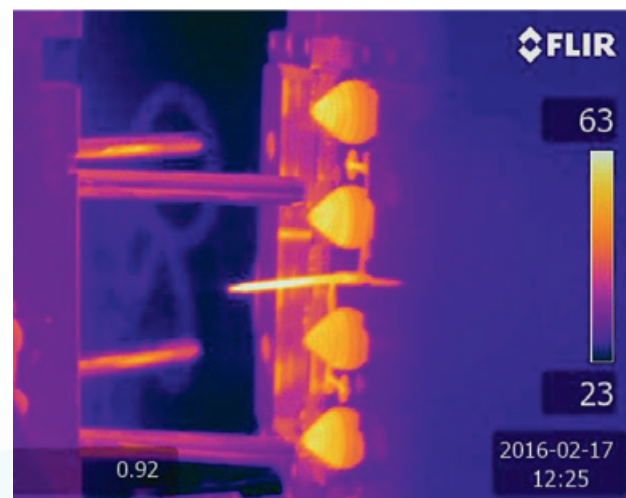
To test the cooling...

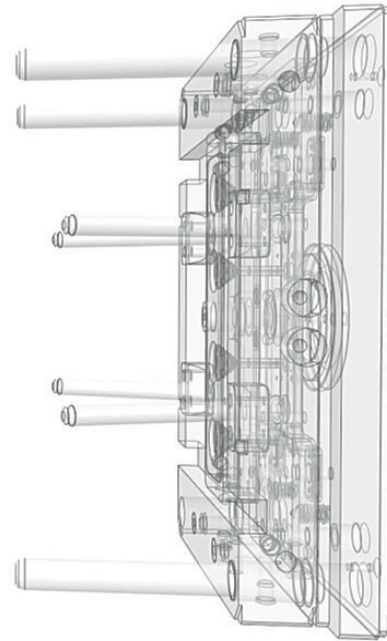
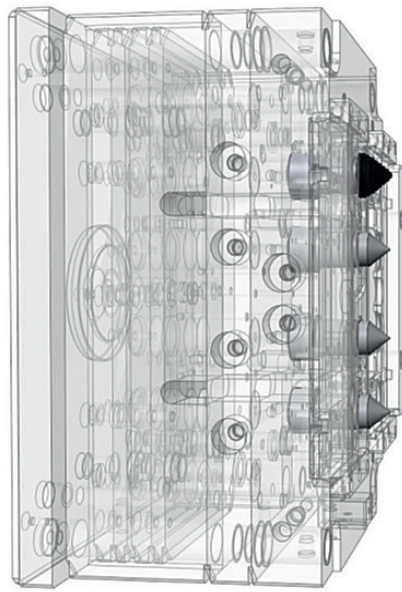
...the parts were heated to a temperature of 70°C with a tempering system and cooled to 20°C to resemble the cooling of the TPE in the injection molding process. The cooling phase was controlled by infrared scanning to compare the cooling behavior.

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.

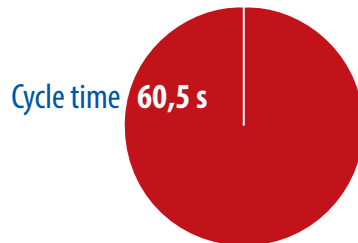




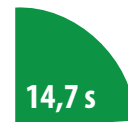
Conformal cooling for high volume injection molding components

The utilization of the SLM® technology 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.

Original part without cooling



Conformal cooling



SUMMARY

New potential from metal based additive manufacturing technology

- Tooling insert is equipped with conformal cooling channels
- Cooling time of TPE is reduced 80% than 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

About SLM Solutions

The Lübeck-based SLM Solutions Group AG is a leading provider of metal-based additive manufacturing technology. SLM Solutions focuses on the development, assembly and sale of machines and integrated system solutions in the field of selective laser melting.

SLM® technology offers diverse options in the metal-based additive manufacturing of parts, such as a new design and geometric freedom, lightweight construction through the reduction of metal part weight, significant advantages in terms of production speed and the manufacturing of internal undercut parts in low quantities.

Our products are utilized globally by customers from the most varied sectors, particularly in the aerospace, automotive, tooling, energy and healthcare industries, as well as in research and education.

They particularly value the following advantages of our technology partnership:

- Highest **productivity** using patented multi-laser technology
- Highest material density and **part quality** through our innovative gas stream management
- Completely closed **powder management** in an inert gas atmosphere
- Cutting-edge process monitoring using various **quality control modules**
- Multilingual open **software architecture** with customer adaptability
- Ultracompact **modular design**
- Long-term and **confidential customer relationships**
- **A technological leader and pioneer** in metal-based additive manufacturing with decades of market experience

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