3D printing for industrial applications: Melotte's conformal cooling for mold making

In this article two separate cases studies are cited in which solutions are provided to solve sprue bushing challenges of end-user companies. Through discussing production problems closely with their customers, Melotte's R&D and Design Departments were able to not only solve their clients' production concerns but also to produce workable solutions that were more cost effective and productive.

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In recent years, mold cooling methods have evolved considerably. For example, the use of heat conductive materials, like copper alloys in the core-side of a mold has improved cooling a great deal. Thermal management research, however, has shown that the highest temperatures concentrate around the hot runner, which is thus the most critical zone with the highest cooling requirements. Hot runners, as such, are the critical interface between the cavity and the melt delivery system.

Under certain circumstances quality issues during molding show that optimization of cooling is absolutely necessary. Further, with a better cooling, cycle times can often be reduced, thus increasing productivity. The sprue bushing is one of the most heavily loaded parts in a mold and, therefore, the most suitable part to be treated in order to solve these challenges. Melotte designed and developed a number of sprue bushings with 3D-printed integrated conformal cooling. The definition of the word 'conformal' signifies that the cooling acts conform the shape of the sprue bushing. 3D printings are exceptionally well suited to creating cooling channels with a complex geometric shape internally in the sprue bushing.

Case study sprue bushing 1

When describing this case study we are bound by an agreement not to disclose the customer's data. Effectively, we were only permitted to use test results. The customer in question, however, was a complete supplier of injection molding machines, which ran into quality issues and needed a significant shorter production cycle time.

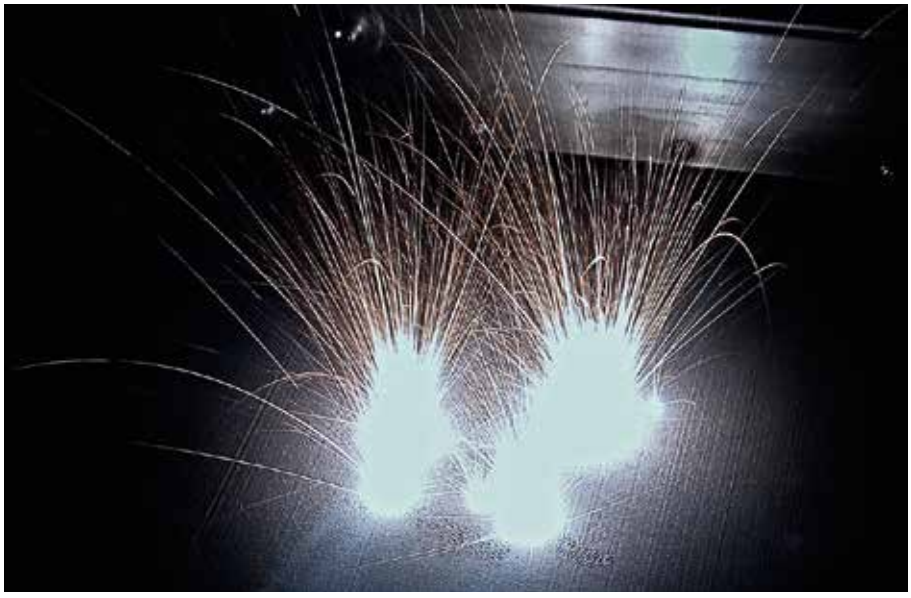

Fig. 1. Selective laser melting process.

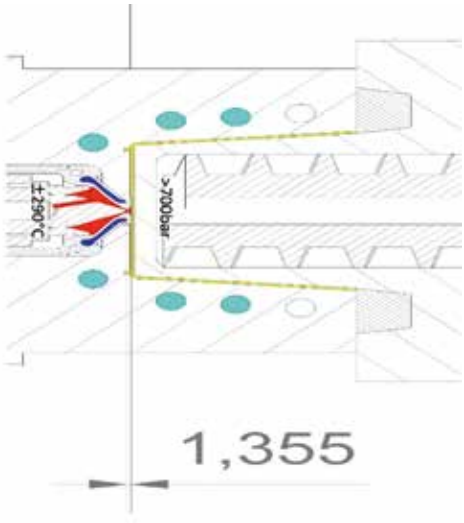

Fig. 2. Sprue bushing in front of the cavity.

After analyzing the challenges facing the customer, Melotte's engineering team managed to optimize the sprue bush cooling system without changing any of its external dimensions. In conventional manufacturing, temperature control or cooling channels can only be drilled in a straight line. As a result, critical hotspots often remain out of the reach of the coolant. However, conformal cooling brings the solution to the problem in that 3D print technology makes it possible to integrate cooling channels that follow the optimum cooling path, no matter how it twists and turns. As such we were able to integrate a very unique cooling con-

Fig. 3.

cept into the design. Only one channel is used to provide equality of coolant to the top circumference of the bushing, whilst the other channel immediately conducts the heat away.

This 3D-printed sprue bushing has been tested in two different situations: the first one was a mold with eight cavities for small cups, the second one was a mold with four cavities for bigger buckets. In both cases a sprue bushing with conformal cooling was used. Without conformal cooling, an extra cooling time of 0.7 seconds was required to achieve good product quality for the smaller cups. During the test with conformal cooling, the extra cooling time was reduced step by step, which only went on to prove that the extra cooling time was no longer required. As a result the cycle time could be reduced from 4.2 seconds to 3.5 seconds or a 17% decrease. In the other case, even more pronounced results were achieved. A cycle time reduction was achieved of 6 seconds as opposed to 8 seconds. Thus a 25% decrease proved possible. Rather noteworthy, this would mean something like 1,000,000 buckets could be finished in seventy days compared to ninety-three days without conformal cooling!

Case study sprue bushing 2

After hearing about Melotte's expertise in 3D-made conformal cooling solutions, CurTec (The Netherlands) contacted us with a specific problem they had with one of their existing products. They had experienced difficulties in filling a particular mold uniformly, which resulted in causing fill and flow lines in the product. Melotte's engineering team & additive manufacturing specialists analyzed CurTec's difficulties and proposed re-engineering the sprue bushing and sprue bush cooling systems. The team came up with a design of a larger injection opening and 3D printing of the re-engineered sprue bushing with conformal cooling. This became the perfect solution to solve the customer's problems.

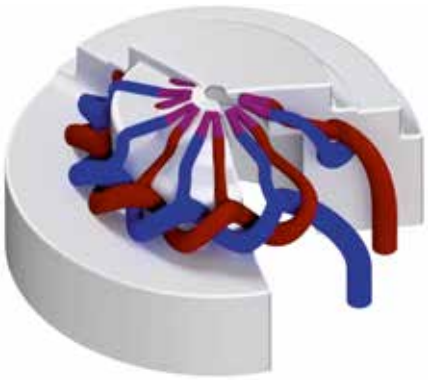

Fig. 4.

A more stable process was achieved and the quality problems no longer occurred. The optimized mold filling also resulted in a weight gain of 3%, which indicated a non-uniform wall thickness of the product without conformal cooling. The problem of gate stringing or drooling was mostly caused by excessive heat in the gate area. Because of the conformal cooling, a controllable turbulent flow in the gate area could be realized, which resulted in an injection point that was hardly visual. Last but not least, there was a cycle time reduction of 4.5 seconds but this was subordinate to solving the quality problems.

Conclusion

The above-mentioned types of innovative solutions can be delivered using the standard materials that are typical for mold making. Nevertheless, Melotte delivers additionally other materials such as titanium, tool steel, stainless steel, Inconel and cobalt chrome for 3D selective laser melting.

About Bram Grandjean

Bram Granjean has been a Mechanical Engineer at Melotte for the last eight years. He is currently the Sales & Project Manager.
Before this he held positions there as:
2010-2014: R&D and Project Manager 3d Metal Printing;
2009-2012: Optical Scanning & 3d Measurement Specialist;
and 2008-2009: Operator Automated Machining Center.

About Melotte

Melotte was founded in 1965 and focuses on the development and manufacture of high-precision engineered solutions for industrial (aeronautics & astronautics, nuclear, petrochemicals, pharmaceutical, and tools & dies) as well as medical and dental applications. Initially, its focus was on mold making. However, its experience with molds combined with more than ten years experience in 3D metal printing, made it a logical step to introduce 3D printed parts into the complex world of injection molding. The company supplies prototypes and small production series manufactured with conventional machining as well as metal 3D SLM printing (selective laser melting). It strives to bring added value by offering solutions for complex molds and tools. This is done by adding complex geomety and optimal cooling solutions for which 3D printing is particularly suited. It has in-house R&D and Design Departments, which discuss, design, and finalize with their customers parts suited for 3D printing using sophisticated CAD/CAM and specific software packages typical for this innovative technology.