A Tight Spot

Linde and Lüdenscheid Plastics Institute Developed a Technology to Spot-Cool Injection Molds

In injection molding, uniform temperature distribution across the surface of the mold wall has a significant impact on cycle times and product quality. However, production is often slowed by hot spots in areas that are difficult, or impossible, to reach with conventional water cooling. Spot cooling with liquid carbon dioxide can supplement water cooling to resolve these issues. As the following three case studies show, the results can be very impressive.

The plastic parts that Föhl manufactures for Kärcher have to look great and deliver outstanding performance, in the picture for example the gun for a high-pressure cleaner (© Linde)

The temperature of an injection mold is usually controlled by passing water through component-specific cooling channels. Sometimes, however, conventional water cooling cannot reach every area in a mold. Cooling long, thin cores, fillets and other difficult-to-reach areas can be a particular challenge for manufacturers. In areas like these, there is either no space for cooling channels or the thin channels quickly get clogged up with deposits. This all leads to excessive temperatures on the mold wall, which makes it difficult to remove parts from the mold. It can also lead to surface damage, warpage and long cooling times.

Supplementing water cooling with spot cooling can greatly increase the efficiency of injection molding. It enables plastics manufacturers to effectively cool hot spots such as very thin parts or sections with thicker walls. During the spot cooling process, liquid carbon dioxide (CO_2) is injected under high pressure with approximately 60 bar through narrow, flexible capillary tubes (outer diameter ≤ 1.6 mm) to the spot that needs cooling. The tubes are inserted through very narrow holes that are drilled or eroded into the mold. The CO_2 expands, creating a mix of snow and gas with a temperature of -79 °C and a very high cooling capacity (**Fig. 1**). Once the by now gaseous CO_2 has withdrawn the heat from the hot steel mold, it is drained via the annular gap between the hole and the capillary tube.

Spot cooling is becoming increasingly popular as a way to boost throughput and improve part quality. It can be integrated into new molds and also retrofitted to existing molds (**Fig. 2**). In most cases, only minimal modifications to the mold are required and costs for the cooling equipment are low. In general, the potential reductions in cycle time and improvements in quality far outweigh the supply costs for the CO_2 gas as the cooling agent.

A number of case studies from industry have shown that the solution developed by industrial gases specialist Linde and Lüdenscheid Plastics Institute is highly efficient and cost effective. It is also flexible in gas supply. Manufacturers who work with one or only a few molds that do not require much cooling can source their CO_2 from cylinder bundles. Customers who work with molds that have a lot of hot spots and/or who need to cool high production volumes can be supplied from a central CO_2 tank and the Presus C pressure-boosting station. Linde »

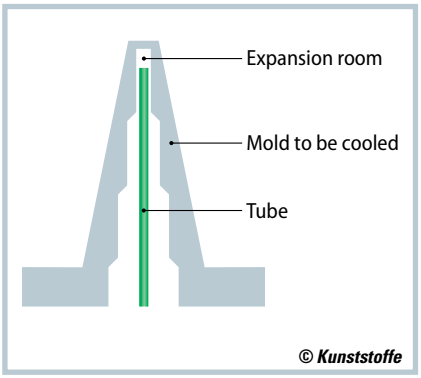

Fig. 1. Supplementing water cooling with spot cooling can significantly increase the efficiency of injection molding (source: Linde)

Fig. 2. The Plastinum Spot Cooling package includes control equipment, distributors and capillary tubes and can be used with new molds and also retrofitted to existing injection molds (© Linde)

markets this cooling solution under the name Plastinum Spot Cooling. Recently, three injection molding manufacturers implemented the technology in their process flow to resolve specific production challenges.

Kunststoff Christel: One Technology, Seven Cores

For the company Kunststoff Christel GmbH & Co. KG, reducing cycle times was the key driver for deploying Plastinum Spot Cooling. Headquartered in the town of Bad Dürrheim in Southern Germany, this medium-sized company has a wealth of experience as an all-round provider of thermoplastic solutions, for example pneumatic housings made of polyoxymethylene (POM) for the textile industry. In order to manufacture such a part, the company designed a single-cavity mold with seven thin cores.

In practice, however, the company soon realized that it would not be able to maintain the cycle times initially planned using conventional production methods due to the complex geometry of the part. The longer cycle times generated in this way also pushed up the budgeted component costs. To reduce the cooling and cycle times, Kunststoff Christel decided to use spot cooling with CO_2. Linde and Lüdenscheid Plastics Institute advised Kunststoff Christel on the application technologies needed to convert to this method. Working together, the experts offer an end-to-end service, extending from a precise analysis of the existing injection molding process through feasibility studies and tests on site to actual start-up.

The new technology was retrofitted to the mold at Kunststoff Christel subsequently and the seven mold cores are now cooled using CO_2. The conversion to CO_2 has had the desired effect, as Dirk Sauter, Design Project Manager at the plastics specialist, explains: "The spot cooling solution from Linde has reduced cycle times by 30 %, enabling us to meet the stringent quality and production efficiency demands of our customer." In actual figures, this means that the company has reduced the cycle time from 135 s to just 95 s – without compromising quality standards. Producing at full capacity with a three-shift rota, it has, thus, cut component costs significantly and firmly positioned them within the budgeted window.

Hörl Kunststofftechnik: On Track with Spot Cooling

Hörl Kunststofftechnik GmbH & Co. KG produces over 5.5 million high-precision components every day to exacting quality standards. Founded in 1991, the company specializes in the highly automated production of small and micro injection-molded parts (**Fig. 3**). The smallest component weighs just 0.02 g, the heaviest 50 g. Based in the German town of Laufen, near the Austrian border, Hörl Kunststofftechnik operates over 85 injection molding machines and has a zero-defect strategy in place.

A renowned domestic appliance manufacturer contacted the company to see if it could produce a complex fan wheel. The most important criteria were circular and axial concentricity plus an area without sink marks in the hub segment. To reliably manufacture a wheel such as this, Hörl instantly knew it would need a mold with an extremely sophisticated fixed core representing the central axis of the hub and – more importantly – that a special temperature control solution would be needed for that tool.

To manufacture the component to the required levels of precision, managers at Hörl decided to equip the mold with Plastinum Spot Cooling. The company designed the mold to support spot cool-

Recycling Carbon Dioxide – the Eco-Friendly Option

The carbon dioxide used in spot cooling is not produced specifically for this process. It is a by-product of chemical production processes. Once it has been carefully purified, dried and liquefied, the recycled CO_2 can be put to good use in the plastics industry.
In addition to spot cooling, Linde offers other CO_2-based process technologies for the plastics industry. Linde's Plastinum Gas Injection Molding with CO_2 solution is a relatively recent innovation that replaces nitrogen with carbon dioxide to considerably accelerate cycle times.

↘ www.linde-gas.com/plastinum

ing from the very outset after reading about the process in a trade journal.

CO_2 controls the temperature of the single-cavity mold very effectively as it ensures uniform temperature distribution. "The spot cooling solution from Linde enabled us to make a part that meets our customer's strict precision and service life requirements," explains Christian Tröster, Product Manager at Hörl. Investment in the new technology is paying dividends on two fronts – on the one hand, it increases quality levels and, on the other, reduces production cycle times.

Fig. 3. Hörl specializes in the highly automated production of small and micro injection-molded parts. Thanks to the spot cooling solution from Linde, the company has increased the quality of its parts and reduced cycle times (© Hörl)

Adolf Föhl: Working under Pressure for the Best Solution

Every day, Adolf Föhl GmbH + Co KG operates two fully electric and 25 hydraulic injection molding machines with clamping forces from 350 to 3000 kN to serve its customers. Headquartered in the southern German town of Rudersberg, the company produces around 300 million plastic parts per year. The company's customer base includes Kärcher, the world's leading provider of cleaning systems. Föhl manufactures plastic parts (**Title figure**) for its high-pressure cleaners. These components have to look great and deliver outstanding performance.

Looking at the mold geometry, with its long, thin core, the specialists at Föhl knew that they need more than conventional water cooling to fully meet the customer's strict specifications. Right from the start, the company decided to combine water cooling with CO_2 spot cooling to control the temperature of the mold. The solution was a resounding success, as Steffen Ammon, Head of Plastics Injection Molding at Föhl, explains: "Plastinum Spot Cooling enables us to drastically cut cycle times while at the same time guaranteeing the high quality levels required in the production of plastic parts for high-performance, high-pressure cleaners".

Conclusion

These real-life case studies from industry show that it pays to combine liquid carbon dioxide with conventional water-based methods to cool injection molds. Spot cooling can be used to produce extremely good results with much faster cycle times – up to 50 % faster in some cases. This technology can also be used to manufacture mold cores that are not realizable using water cooling. The Plastinum Spot Cooling solution developed by Linde and the Lüdenscheid Plastics Institute is suitable for new molds and can also be retrofitted to existing injection molds. The experts at Linde and the Plastics Institute offer an end-to-end application technology service to ensure the perfect, customized fit for each customers injection molding challenges. ■

The Author

Dipl.-Ing. Andreas Praller is as Senior Expert Plastics Industry responsible for the EMEA region at the Gas Division of Linde AG based in Unterschleissheim, Germany; Andreas.Praller@linde.com

Service

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