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Engel Formenbau und Spritzguss GmbH.

Gas injection moulding with carbon dioxide.

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Engel Formenbau und Spritzguss GmbH achieves leap in productivity in series production.

Gas injection moulding with nitrogen offers a number of technical benefits over conventional injection moulding methods in the manufacture of high-quality moulded plastic parts. Now for the first time, a German company has replaced nitrogen with carbon dioxide as injection fluid. In series production, this new injection solution, developed by Linde in collaboration with Maximator, has reduced the cycle time for a refrigerator handle by 36%.

Based in Sinsheim, Germany, the mid-sized company Engel Formenbau und Spritzguss GmbH operates in a global, price-driven market. “For us, as a comparatively small company, innovation is the key success factor in such a competitive environment,” says Dietmar Engel, Managing Director, when asked about the company’s market strategy. In addition to conventional injection moulding methods, the company also specialises in new and highly efficient production technologies. It has, for example, become a recognised expert in the processing of high-temperature plastics. For over 25 years, the Engel brothers have been focusing on the gas injection moulding (GIM) process technology, and are considered industry pioneers in this sector.

The GIM method is particularly beneficial for thick-walled components, complex contours and glossy surfaces. With this method, gas is injected under high pressure into the polymer melt, forcing the melt out of the centre of the mould and pressing it outwards to the walls of the mould. This creates a hollow core within the component. Once the plastic has solidified, the gas is released from the component.

General advantages of gas injection moulding

Plastic components produced in this way have several advantages over solid components. Not only do they consume fewer raw materials and weigh a lot less, they are also extremely rigid and offer greater dimensional stability. In addition, no sink marks occur as a result of material build-up, and the end product has a smooth, high-quality surface structure. CEO Klaus Engel is clearly impressed with the benefits of GIM: “For us, GIM is often the method of choice, especially with high-gloss surfaces.”

Engel was keen, however, to further increase the quality and productivity of its process flow. And so the company teamed up with gas expert Linde and its technology partner Maximator, specialist in high-pressure equipment, to explore the possibility of improving the efficiency of GIM with nitrogen (N_2). Working in close collaboration with Engel and Maximator, Linde enhanced the basic process with an innovative, additional inner cooling step, enabling more efficient, controlled flushing of N_2 through the cavity. This was combined with a supplementary inerting step to increase efficiency even further. Engel production manager Günter Magnus worked closely with Linde to align these process innovations with concrete operating requirements at Engel. He is highly satisfied with the outcome of the complementary inner cooling and inerting steps: “This solution is ideally suited to minimising the contamination caused by oxygen, particularly in the gas injectors.”

Reduced cycle time: The production time of refrigerator handles decreased by 36%

Users of GIM technology based on N_2 usually have to accept long cycle times since N_2 does not contribute to the cooling process due to its low density and specific thermal capacity, with the result that the moulded part is cooled almost only from the outside. Water injection moulding, which has been in use for some years already, has become established only in certain niche segments, even though it offers shorter cycle times. This is because it is more complex and unpredictable, and the required hardware is considerably more expensive. A major disadvantage in practice is the inevitability of water leaks, resulting in production stoppages, higher reject rates and – in extreme cases – tool damage.

How carbon dioxide improves cooling

Despite the valuable process enhancements achieved through inner cooling and inerting, Engel – like all automotive suppliers – nonetheless faces growing market pressure to constantly increase efficiency and reduce cycle times. Linde and Engel decided to collaboratively explore the possibilities of carbon dioxide (CO_2). This gas is already successfully used for other plastics applications such as spot cooling of injection-moulded parts. At the same process pressure, CO_2 has a significantly higher density than N_2. Put simply, more CO_2 than N_2 molecules will fit into a cavity of identical size. Furthermore, CO_2 has a higher specific thermal capacity. And last but not least, the refrigeration effect of expanding CO_2 contributes to cooling. In other words, the plastics component cools significantly faster.

Unlike N_2 – which is injected in gaseous form – CO_2 is injected in liquid form into the melt. The CO_2 becomes supercritical in the gas channel as it draws heat from the component wall, thereby heating itself. A high filling and holding pressure – ideally over 150 bar – is critical here to maintain a density higher than that offered by N_2. The higher gas consumption naturally resulting from the increase in pressure is more than compensated for by the advantages of this method.

The use of CO_2 requires slight modifications to the pressure boosting, pressure control and injector equipment. In order to explore and demonstrate the actual potential of CO_2 in GIM applications, Linde and Maximator developed a pilot system. Engel used this system to carry out extensive practical trials on a refrigerator handle under real conditions. A direct comparison between CO_2 and N_2 revealed the same high quality levels with an approximately 36% reduction in cycle times.

CO_2 is also in use in other plastic applications, such as for the targeted cooling of portions of an injection mould. Gas detectors are required to ensure that CO_2 rates do not exceed a certain threshold. For Klaus Engel, it's a simple cost/benefit analysis: "If the increase in efficiency due to shorter cycle times exceeds the additional costs, we have cost optimisation – it's a simple mathematical equation." Marc Kohler, Sales Director at Engel, adds: "With this new technology, the Sales department has an additional tool in its sales kit. Our customers are in general very interested in the advantages offered by carbon dioxide in GIM and how we can pass those benefits on to them."

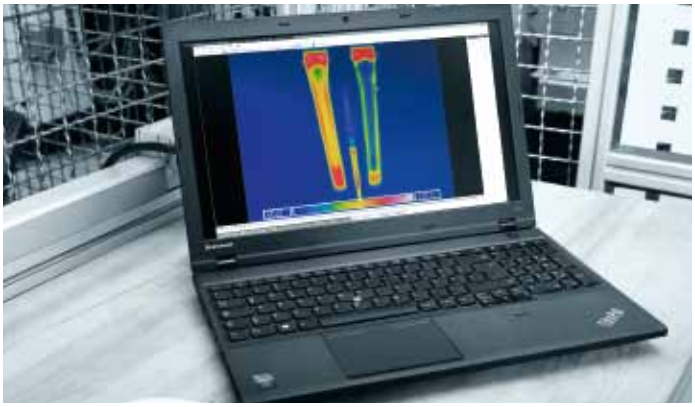
PLASTINUM® GIM C is the outcome of ongoing joint development work between Linde and Maximator

Step-by-step migration

The PLASTINUM® GIM C solution is the result of ongoing joint development work between Linde and Maximator in the field of CO_2. A specially developed CO_2 compressor control module offers an easy entry point for users such as Engel, who are gradually converting to the patent-pending CO_2 technology. This module allows operators to initially supply CO_2 from cylinder bundles before switching to a tank at a later date. In addition, the system features CO_2-specific injectors. Existing GIM machines only require minor modifications to the injectors and no changes to the tool geometry to convert to CO_2.

The process conversion, including trials and optimisation, was completed in a period of only four weeks. Cylinder racks ensure a flexible supply of CO_2.

Engel has been working with the new system since summer 2015, marking its industrial series production premiere. Dietmar Engel reflects positively on the cooperation between Linde and Maximator: "For us it was a stroke of luck that we were able to engage in this kind of basic research together with Linde. This joint development alliance gives us an early-adopter advantage that puts us at least one year ahead of the field."



Direct comparison in practical trials with colour-coded temperature areas: When using carbon dioxide, the part cools down faster (right) than when using nitrogen (left). The trials showed equally high-quality results with a significant reduction in cycle times

Summary: Further applications in planning

Compared with N_2, CO_2 in GIM applications can shorten cycle times significantly. It does, however, require slight modifications to the gas pressure boosting, pressure control and injector equipment. To enable customers to easily implement these changes, Linde and high-pressure equipment specialist Maximator have developed and successfully tested the PLASTINUM® GIM C system. Engel Formenbau und Spritzguss GmbH started using this method in series production in the summer of 2015. Building on Engel's extremely positive experience with this technology, Maximator and Linde are already implementing a successor project with CO_2.

Jointly implementing the new technology (from left to right): René Himmelstein (Maximator GmbH), Günter Magnus, Klaus Engel and Dietmar Engel (all Engel Formenbau und Spritzguss GmbH) and Andreas Praller (Linde AG)

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Company profile

For many years, Engel Formenbau und Spritzguss GmbH has been developing and manufacturing high-quality injection-moulded parts and assembly groups. Under the guidance of the two executive directors, Klaus and Dietmar Engel, 75 employees are working at the company's location in Sinsheim, Germany. Seven to ten million high-quality injection-moulded parts of different sizes leave the plant every year, to be assembled for instance as handles on refrigerator doors or in luxury cars by well-known brand manufacturers.

The company has grown to become a leading international supplier in the household appliances, automotive, building technology and renewable energy sectors. The portfolio encompasses the entire handling of projects and repeat orders, from part development to injection moulding. Their technical expertise includes the assembly of single components and assembly groups as well as surface finishing by varnishing, foiling and galvanising, etc.

www.engelgmbh.de

The many uses of CO_2

Carbon dioxide (CO_2) is used across a broad spectrum of industrial applications, including in the plastics industry. Like all gases, it must be stored and used safely and correctly – and this calls for specialist knowledge. Linde has developed a package of dedicated product stewardship services, which includes safety training and consulting, to support customers in the safe handling and use of this gas.

Committed to mitigating the effects of climate change, Linde seeks to minimise its carbon footprint by recycling carbon dioxide instead of generating new streams of this gas. Approximately 80% of the carbon dioxide that Linde supplies to its customers comes from chemical processes where the carbon dioxide occurs as a by-product – such as ammonia synthesis or ethylene oxide production. The remaining 20% of the CO_2 delivered by Linde originates from natural sources.

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability.
Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

Discover more at
www.linde-gas.com/plastinum

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