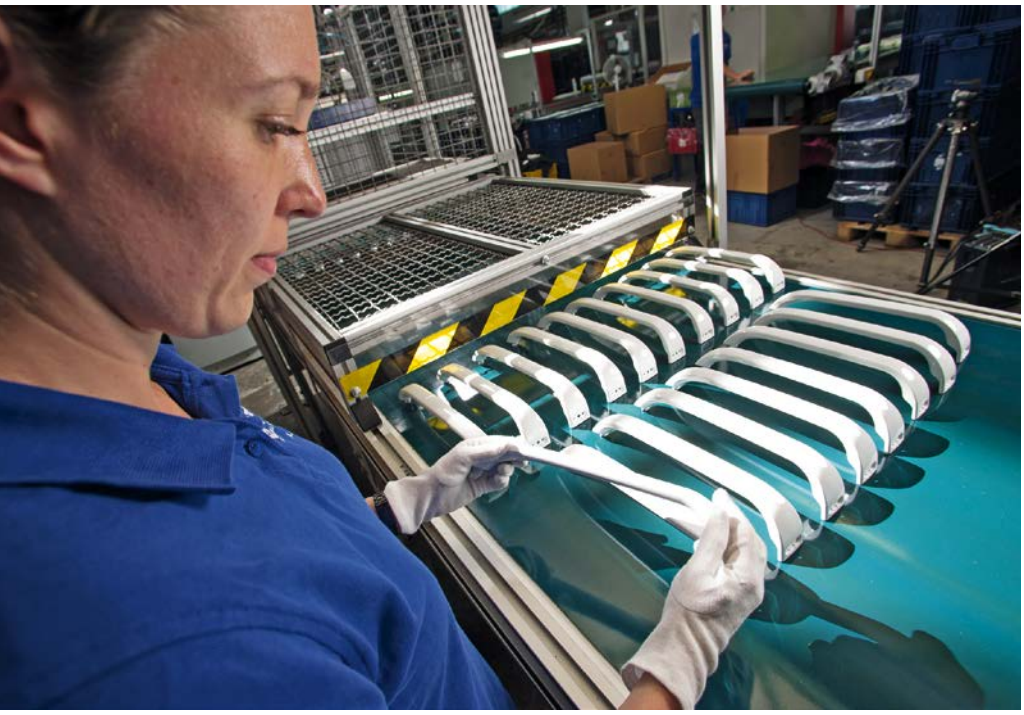
Gas Injection Molding with Carbon Dioxide

Engel Formenbau und Spritzguss GmbH Achieves Leap in Productivity in Series Production

Gas injection molding with nitrogen offers a number of technical benefits over conventional injection molding methods in the manufacture of high-quality molded 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 %.



Reduced cycle time: The production time of refrigerator handles was accelerated by 36 % (© Linde)

Based in Sinsheim, Germany, mid-sized German 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 molding methods, the company also specializes in new and highly efficient production technologies. It has, for example, become a recognized expert in the processing of high-temperature plastics. For over 25 years, the Engel brothers have been focusing on the gas injection molding (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 center of the mold and pressing it outwards to the walls of the mold. 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 Molding

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 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

The Plastinum GIM C system is the outcome of ongoing joint development work between Linde and Maximator (© Linde)

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 minimizing the contamination caused by oxygen, particularly in the gas injectors."

Users of the GIM technology featuring nitrogen usually have to accept long cycle times since nitrogen does not contribute to the cooling due to its low density and specific thermal capacity and the molding is practically cooled only from the outside. Water injection molding, which has been in use for already some years, 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 these valuable process enhancements, 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 CO_2. This gas is already successfully used for other plastics appli- »

GIM process technology with carbon dioxide: Engel Formenbau und Spritzguss GmbH of Sinsheim has been using the technology in series production since summer 2015 (© Linde)

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Company Profile

For many years **Engel Formenbau und Spritzguss GmbH** has been developing and manufacturing high quality injection molded 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 molded 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 molding. Their technical expertise includes the assembly of single components and assembly groups as well as surface finishing via varnishing, foiling and galvanizing etc.

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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) (© Linde)

cations such as spot cooling of injection molded parts. At the same process pressure, CO_2 has a significantly higher density than nitrogen. Put simply, more carbon dioxide than nitrogen 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 nitrogen – which is injected in gaseous form – carbon dioxide 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 nitrogen. 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 carbon dioxide requires slight modifications to the pressure boosting, pressure control and injector equipment. In order to explore and demonstrate the actual potential of carbon dioxide 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 carbon dioxide and nitrogen revealed the same high quality levels with an approximate 36 % reduction in cycle times.

Gas detectors are required to ensure that carbon dioxide rates do not exceed a certain threshold (for detailed information on CO_2 and gas detectors, see **Info box**). 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 optimization – 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."

Basic Development Leading to Complete System

The Plastinum GIM C solution is the result of ongoing joint development work between Linde and Maximator in the field of carbon dioxide. A specially developed

CO_2: Danger under Control

Carbon dioxide (CO_2) is used across a broad spectrum of industrial applications, including the cooling and freezing of foods, as a shielding gas in welding, to neutralize waste water and to clean surfaces in dry ice form. In the plastics industry, the gas is also used, for example, as a foam blowing agent. CO_2 is a component of the air we breathe and is a by-product of numerous processes, including human respiration. It is non-toxic, non-flammable, tasteless, colorless and odorless. Like all gases, however, it must be stored and used safely and correctly – and this calls for specialist knowledge. CO_2 is heavier than air, gathers at ground level, and, in higher concentrations, is damaging to health.

Workplace concentrations must be monitored with appropriate gas detection equipment to ensure they remain below permissible thresholds (0.5 vol-%). Stationary gas detectors continuously monitor the air and automatically trigger audible or visual warning signals when defined threshold values are reached. For the detection of carbon dioxide, the sensors typically sit about 30 cm above the ground. If necessary, a targeted extraction by suction of the gas is required. For this purpose, Linde has developed a package of safety services, which includes education and consulting services.

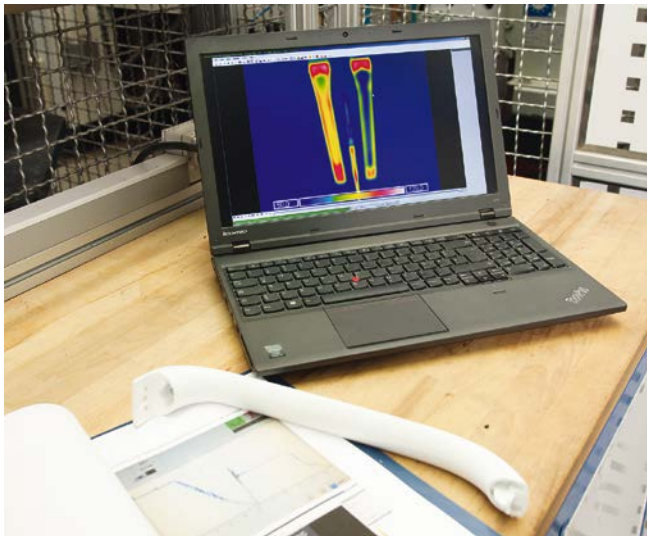
About 80 % of the carbon dioxide that Linde supplies to its customers comes from chemical processes in which carbon dioxide occurs as a by-product – such as ammonia synthesis or ethylene oxide production. Approximately 20 % of the CO_2 delivered by Linde originates from natural sources.

Committed to mitigating the effects of climate change, Linde seeks to minimize its carbon footprint by recycling carbon dioxide instead of generating new streams of this gas.

www.linde.com

carbon dioxide 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 carbon dioxide-specific injectors. Existing GIM machines only require minor modifications to the injectors and no changes to the tool geometry to convert to carbon dioxide. The process conversion, including trials and optimization, was completed in a period of only four weeks. Cylinder racks ensure a flexible supply of carbon dioxide.

For approximately half a year now, Engel has been working with the new system, 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 color-coded temperature areas: When using carbon dioxide the part cools down faster (right) than when using nitrogen (left part). The trials showed equally high quality results with a significant reduction in cycle times (© Linde)

Conclusion: Further Applications in Planning

Compared with nitrogen, carbon dioxide 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 the method in series production in the summer of 2015. Building on Engels's extremely positive experience with this technology, Maximator and Linde are already implementing a successor project with CO_2. ■

Screen Change in Five Minutes

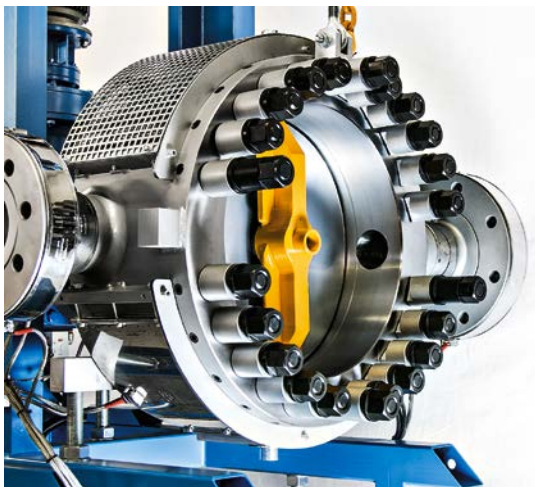
Melt Filter with Automatic Quick-Opening System

According to their manufacturer, the products from **Fimic Srl**, Carmignano di Brenta, Italy, are known for their easy and fast screen change. Until now, customers had to interrupt production for 30 minutes. For users that require frequent screen changes, a new cover reportedly reduces the change time to five minutes. When the screen was used to its maximum capacity, production had to be interrupted for 30 minutes. During this time, the melt filter was opened to change the screen. To remove the bolts and open the filter, pneumatic tools were needed. Through use of a mechanical clamp, the cover can now be opened more easily according to the manufacturer and closed again after a few minutes.

The screen is available as a laser-perforated plate (100–250 µm) or as a stamped perforated plate (300–2,000 µm). Depending on the level of contamination, either can be used for three to seven days. The manufacturer recommends that the screens not be used more than 15 days.

From film extrusion to injection molding – according to the manufacturer, the filters are suitable for a wide range of applications. They can be added to almost every type of extruder and modified to meet customer requirements. The filters are frequently used in recycling and compounding.

To the manufacturer's product presentation:
www.kunststoffe-international.com/1296515



Depending on the degree of contamination, the screens can be used on average for three to seven days (© PromoinVideo)