



Foaming with CellForm For lightweight and cost-effective parts

Engineering Passion

Krauss Maffei

Facts and figures regarding CellForm technology

Application areas



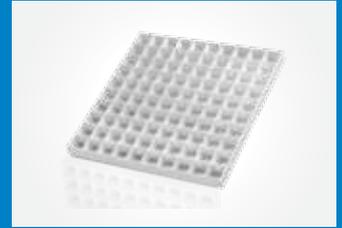
Electricals/electronics



Automotive industry



Electricals/electronics



Infrastructure/construction

Property/process matrix

Properties	Chemical foaming	Physical foaming
Uses	Manufacturing parts, mostly with thick walls, in low to medium production volumes. Used in e.g. toys, non-visible parts for household appliances, the furniture industry or leisure products	Technical parts, even with thin walls, in high production volumes. Used in e.g. parts for the automotive, electronics and electrical engineering industries.
Cell structure	+	++
Used for standard polymers	+	+
Used for technical polymers	0	++
Process window	+	+++
Reproducibility of the process	-	+
Potential reduction in weight	+	++
Dimensional stability	++	+++
Surface quality	-	--
Thin walls (< 4 mm)	+	+++
Residues during foaming process	-	+++
Gas pressure during foaming process	+	++
Reduction in required clamping force	+	+
Investment costs	+++	-
Blowing agent costs	-	+++

- lower performance, 0 average performance, + higher performance

Foaming with CellForm **For lightweight and cost-effective parts**

Foamed plastics possess the perfect combination of a lightweight structure, dimensional stability and functionality, which means they can be used to make automotive and technical parts of outstanding quality. Foamed parts meet the increasingly urgent demand for conserving resources in every respect. Machine concepts from KraussMaffei are able to cover the full range of physical and chemical foaming processes. Our extensive machine portfolio contains the right solution to meet any requirements. KraussMaffei is also the system partner for the MuCell® process invented by Trexel, and is one of the few companies to offer both process and machine engineering from a single source.

Your benefits:

- Complete solutions from a single source
- Processing expertise included
- System partner for MuCell®
- All common physical and chemical foaming processes available
- Extensive product portfolio of electric and hydraulic injection molding machines for CellForm

CellForm technology

Versatile applications

Drinks

Chemically foamed synthetic cork with a cell structure similar to natural cork



Automotive industry

Lightweight and low-warpage foamed car parts for low CO₂ output and easy mounting





Leisure products

Large-format, contoured parts for sun loungers with perfect surfaces and a foamed core



Household goods

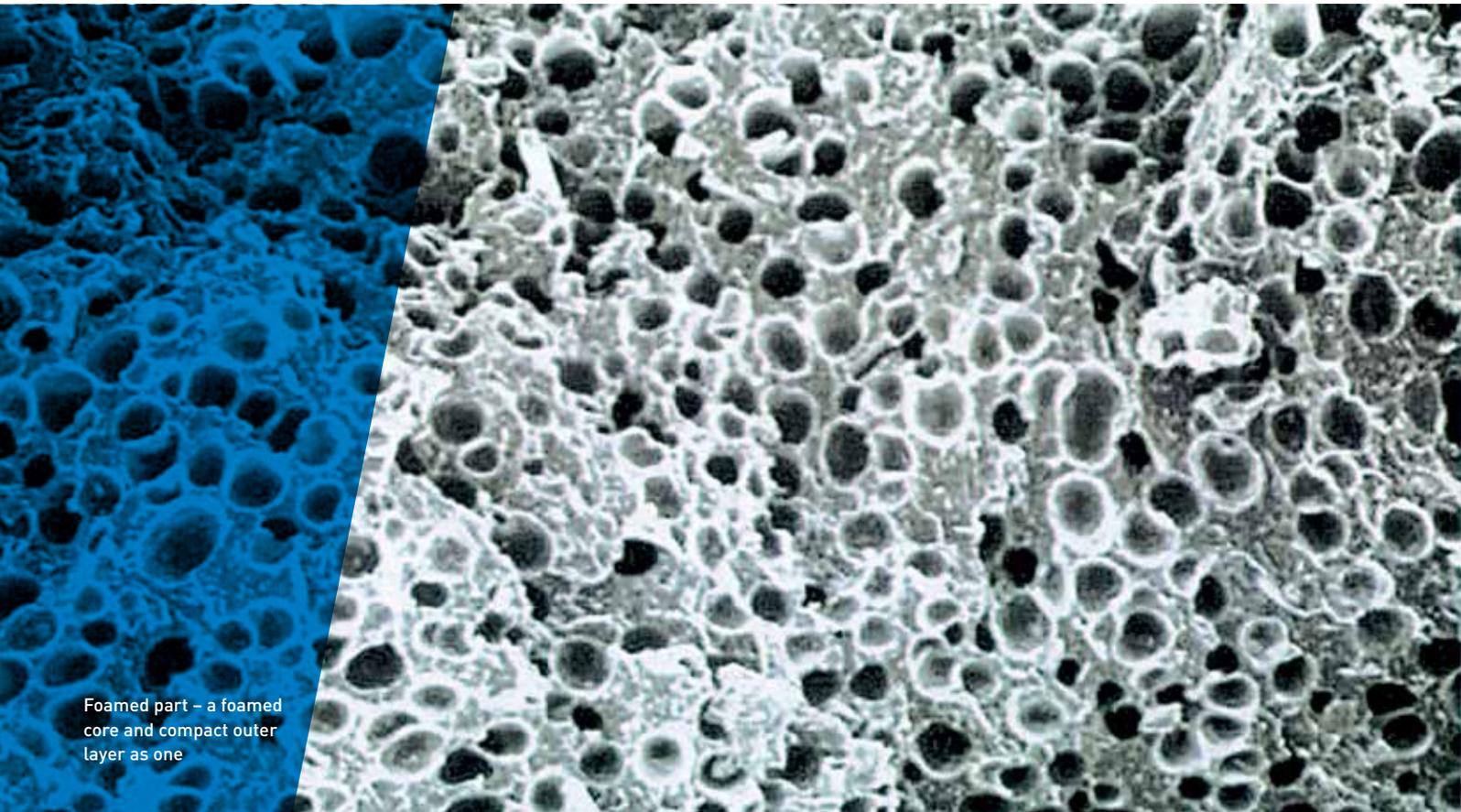
Large-format, contoured housing parts for household appliances made from foamed thermoplastics for soundproofing



Office equipment

Warp-free and dimensionally stable foamed holders for ink cartridges

CellForm reduces part weight and increases efficiency For cost-effective production



Foamed part – a foamed core and compact outer layer as one

In the foaming and CellForm processes, the granulated or gaseous blowing agent is fed into the raw material or melt in order to lower the density of the polymer. Essentially, there are two different types of foaming process: Chemical and physical foaming.

In the chemical foaming process, a granulated blowing agent is mixed into the polymer, a chemical reaction ensues and foaming occurs. In the physical foaming process, by contrast, a gas is added directly to the polymer melt. Physical foaming is probably better known as the MuCell® process, which is patented by Trexel. Both variants allow the density to be lowered and the holding pressure on the polymer to be eliminated. This has numerous advantages:

Faster cycles, lower material consumption and better dimensional stability. CellForm is suitable for making a wide range of parts used in all industries and for nearly all thermoplastic parts. The specific advantages that CellForm confers vary from process to process.

Shorter cycles

The viscosity of foamed materials is very low. This means that injections are generally quicker and temperatures of the melt and the mold are lower. The cooling time is also shorter. Because foaming or gas nucleation occurs inside the mold cavity, holding pressure can be significantly reduced or even eliminated. Faster injections, no holding pressure and shorter cooling times all combine to yield cycle times that are up to 40 percent shorter.

Lower weight and less material consumption

The most obvious advantage of foamed parts is that they consume less material and have minimal weight. The material's lower density translates to savings varying from five to ten percent, without overly affecting its mechanical properties. For parts exposed to less mechanical stress, the weight can even be reduced by over ten percent. If the foaming processes are taken into account when the part is in the design phase, its wall thickness and weight can often be reduced even more. In other words, the design of the part determines its weight.

More dimensionally stable, less warpage

Foaming, which eliminates the need for holding pressure, occurs uniformly throughout the cavity. Sunk spots are therefore reduced to a minimum and the melt solidifies under very little stress. The result is low-stress, warp-free parts with extreme dimensional accuracy – that can be reproduced exactly cycle after cycle.

Lower clamping force

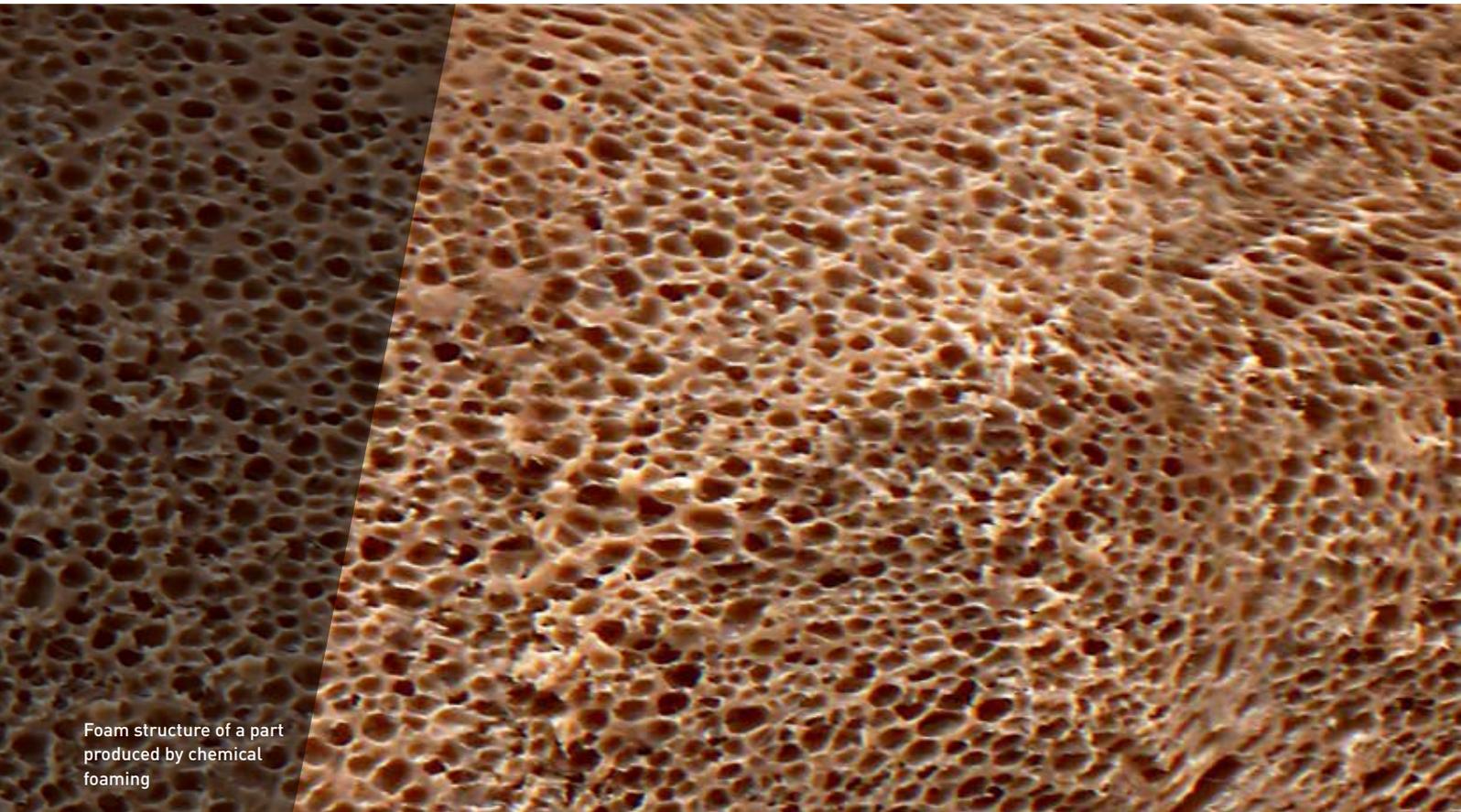
Lower viscosity and no holding pressure means that the cavity pressure for foamed parts does not have to be so high. The clamping force can therefore be reduced by up to 40 percent. This increases flexibility, as the parts can also be produced safely on machines with a lower clamping force.

Your benefits:

- Short cycle times
 - Low part weight and lower material consumption
 - Excellent dimensional stability, low warpage
 - Lower clamping force
-

Chemical foaming

Homogeneous distribution of blowing agents thanks to expertise in screw design



Foam structure of a part produced by chemical foaming

In chemical foaming, a granulated blowing agent is added to the granular molding compounds in the hopper. The blowing agent must therefore be matched to the thermoplastic so that the chemical reaction takes place in a controlled manner.

The heat applied during plasticizing initiates nucleation and leads to the formation of gas bubbles. Foaming takes place in the cavity, where there is room for the mixture of the polymer and blowing agent to expand. There is usually no need for holding pressure after injection, as that pressure is provided by the gas. In chemical foaming, the gas bubbles burst at the surface to produce an open cell structure. Chemical foaming is particularly suited to making parts with walls thicker than 4 mm. The process is also

suited to making parts in low production volumes, as the investment costs of the machines are lower than those required for physical foaming. The blowing agents can be changed to meet specific requirements, for example in order to achieve better surfaces. Thermoplastics with lower processing temperatures, such as polyolefins and polystyrenes, are usually used to do this.

Blowing agent metering

When highly reactive additives – such as chemical blowing agents – are used, they need to be dispersed uniformly throughout the polymer melt. KraussMaffei offers purpose-built HPS-UN screws that distribute the blowing agent extremely evenly, thus ensuring high process reliability and consistent product quality. KraussMaffei supplies HPS-M screws for cost-effective screw changing. These screws also boast excellent mixing performance and, unlike HPS-UN screws, can be used in standard cylinders as well.

Chemical foaming machinery specification

The chemical foaming process requires machinery with certain equipment. Under certain conditions, it is also possible to retrofit existing machines for chemical foaming.

Equipment required

- Pressure accumulator for enhanced injection performance
- HPS-UN or HPS-M screw

"CellForm" equipment package

- Active dynamic pressure control
- Safety modifications
- Reduced nozzle contact force while the mold is moving
- HSVN needle seal nozzle with special monitoring function
- Active dynamic pressure monitoring when safety gate is open



HPS-UN screws with excellent mixing performance are particularly well-suited to chemical foaming

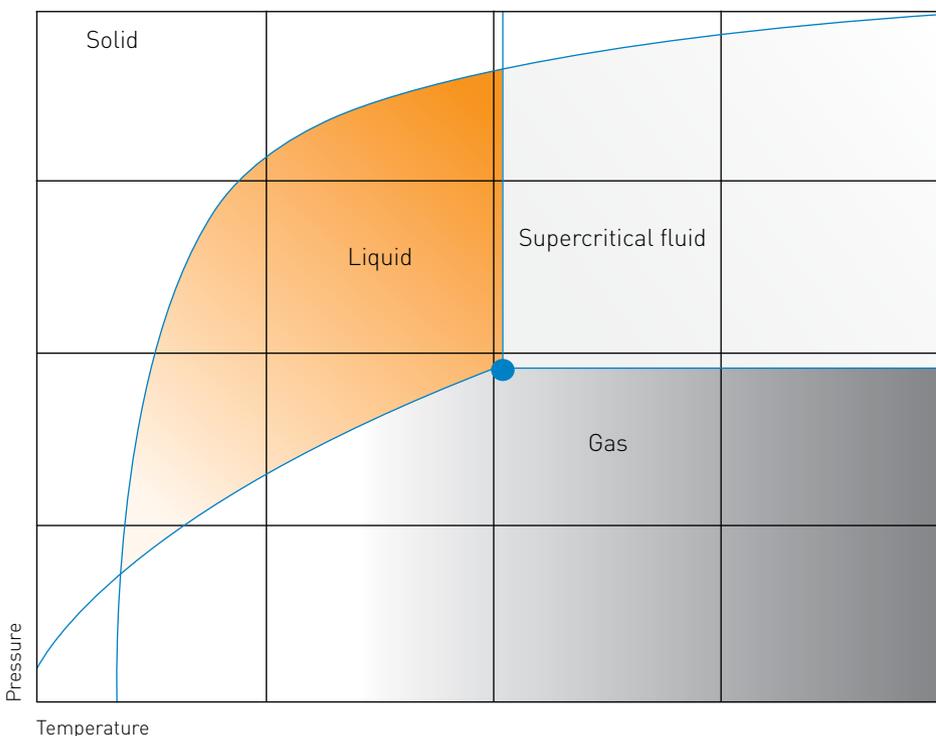
Physical foaming with MuCell® Success comes quicker with a single system partner

The MuCell® process is probably the best-known form of physical foaming. A gaseous blowing agent – N₂ or CO₂ – is injected under high pressure into the already completely melted polymer in the plasticizing unit. The quantity of gas metered in is determined by the type of thermoplastic.

Prior to injection, the gas is a so-called supercritical fluid (SCF), a physical state which means that it has the incompressibility of a liquid and the solubility of a gas. This enables the SCF to dissolve completely in the thermopolymer melt and yield an extremely fine monophasic system with the polymer melt. The combination of active dynamic pressure and MuCell® – also called “MuCell Process Pressure (MPP)” – plays an important role in the process. It is responsible for forming and maintaining the monophasic system and thus ensuring that the gas dissolves in the melt.

All MuCell® machines are fitted with a shut-off valve for this reason. Having been injected rapidly, the low-viscosity mixture experiences a rapid pressure drop inside the mold that generates nucleation seeds. The gas is then released from the melt in a controlled manner and the resulting foaming pressure takes on the role of the holding pressure. The process can be regulated via the pressure and temperature. The MuCell® process is ideal for making parts with wall thicknesses of less than 4 mm.

Phase diagram – typical state changes for a gaseous mix.



Like other gases, nitrogen (N₂) is a supercritical fluid (SCF) under specific pressure and temperature conditions. The SCF dissolves completely in the polymer melt and is released again as a gas inside the mold cavity.

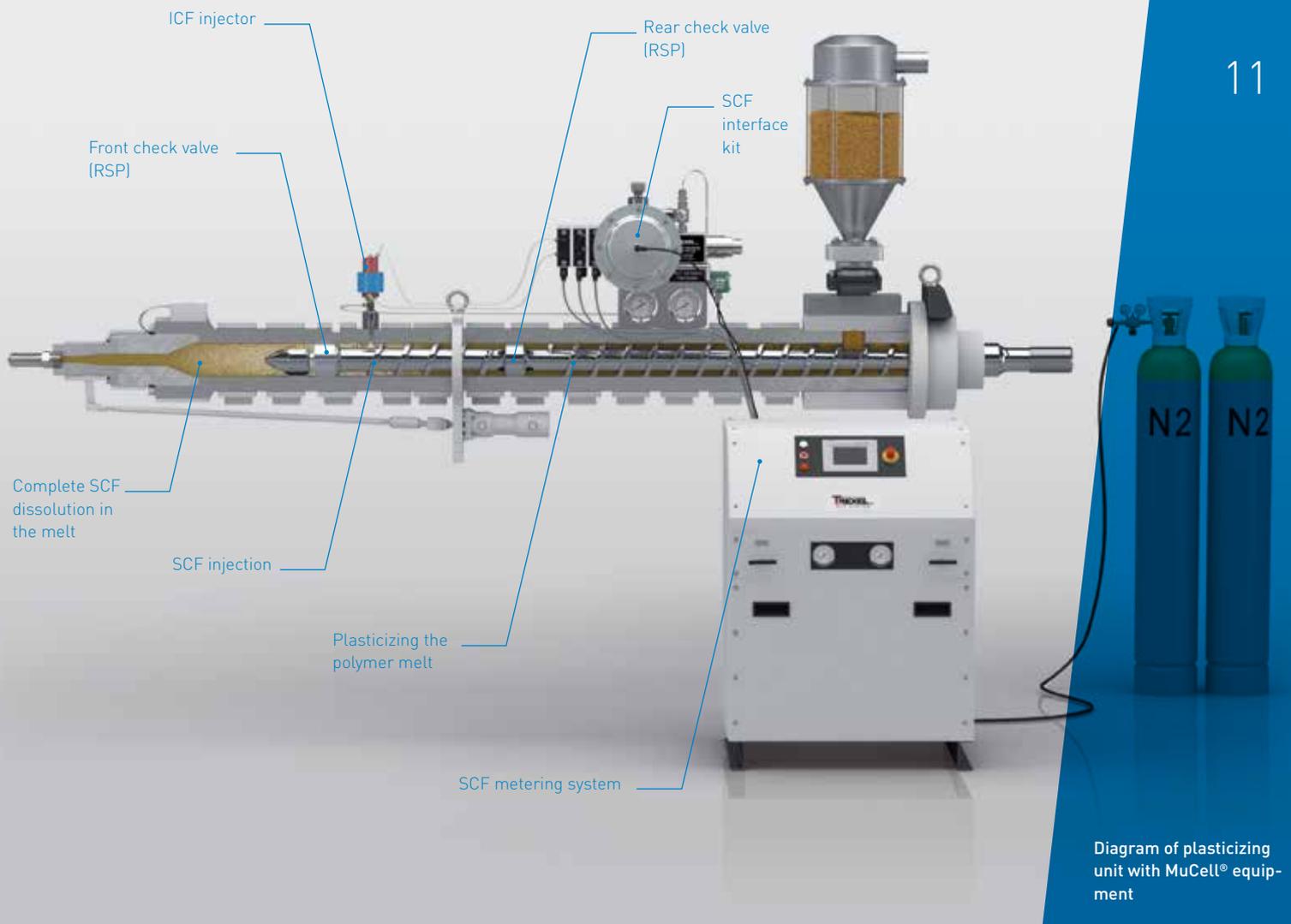


Diagram of plasticizing unit with MuCell® equipment

The main components of a MuCell® machine are shown in the picture. The gas, usually N₂, can be supplied from bottles or a nitrogen installation. The gas is transformed at high pressure into the supercritical fluid state in the SCF metering unit and fed to the interface kit. The interface kit regulates the mass flow required at that moment to the injector. Superfluous gas is returned to the metering unit via the return line. The Trexel self-optimizing control system enables a fully automated process that

generates a constant mass flow, thus ensuring identical gas content from shot to shot. One or two injectors inject the SCF into the melt via the plasticizing cylinder. Injection is triggered by a time- or position-controlled signal. An additional check valve in the middle of the screw prevents unwanted expansion of the gas-melt mixture back towards the feed. Expansion toward the front is prevented by the machine shut-off valve for the same reason. Future machines will be supplied without an interface kit

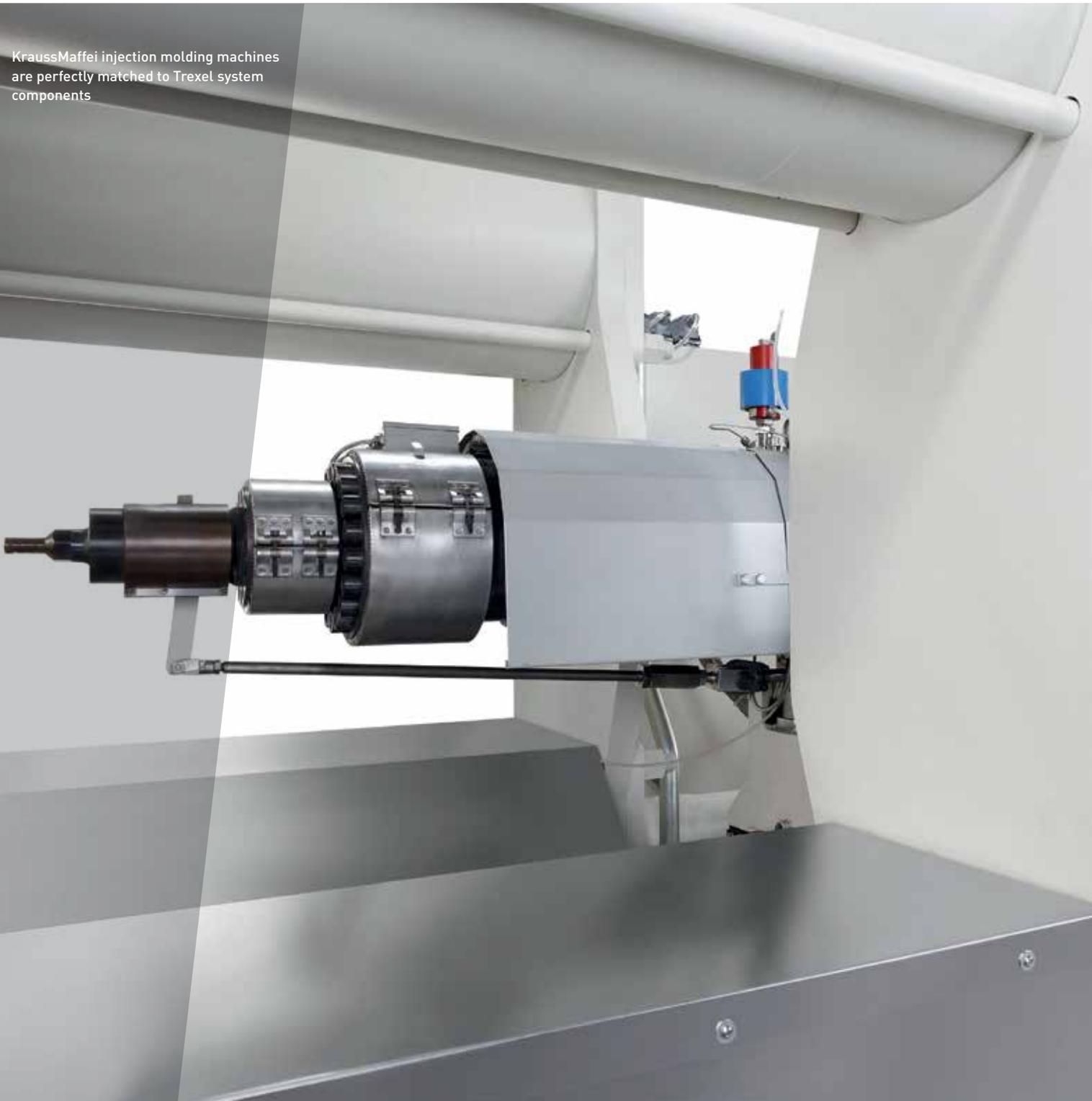
and will be equipped with a small, integrated metering system. The gas quantity will be regulated by the newly developed metering system.

Your benefits:

- Active dynamic pressure control
- Safety modifications
- Reduced nozzle contact force while the mold is moving
- HSVN needle seal nozzle with special monitoring function
- Active dynamic pressure monitoring when safety gate is open
- Interface for MuCell peripherals

Detailed product information Injection molding machine and MuCell® – peripherals in perfect harmony

KraussMaffei injection molding machines
are perfectly matched to Trexel system
components



Everything from a single source

The MuCell® process is licensed by Trexel. KraussMaffei has been successfully using MuCell® technology for many years and is one of Trexel's major clients. The fact that we are the only company in the world authorized to market MuCell® directly further highlights our technological expertise. This means you can order your complete MuCell® system directly from KraussMaffei – without the need for additional agreements with third parties, without teething problems during the course of the project and including all usage rights.

Extremely easy to operate

The MuCell® controller features a special safety gate monitor that allows the dynamic pressure to stay active even when the safety gate is open. The pressure on the gas-laden melt is not reduced. This has the benefit of keeping the start-up phase itself very short and simple. And it extends the uptime of the MuCell® machine while offering a consistently high level of safety for the operator.

Plasticizing unit optimized for MuCell®

MuCell® plasticizing units, like all KraussMaffei plasticizing units, are made in-house to full Trexel specifications. The screws have an L/D ratio of 23 for reliably generating the polymer/SCF monophasic system. They are wear-resistant to ensure the screws have a long service life and guarantee that processes are consistent. The screws themselves feature an intensive plasticizing section and a downstream intensive mixing zone. In the cylinder, the plasticizing zone is installed, followed by the gas injector (up to two may be installed), which is connected to the SCF metering unit. A second check valve prevents the gas from expanding prematurely in the cylinder back towards the feed opening.

Locking system for controlled conditions

For cold-runner molds, the injection units of the injection molding machines are equipped with needle seal nozzles. The nozzles are extended to ensure perfect mating and will reliably prevent unwanted expansion into the cold runner. Alternatively, where molds have needle seal nozzles, a pivot pin needle valve can be provided on the machine side.

Total control thanks to full integration in the MC6 control system

All the functions of the Trexel controller are fully integrated into the KraussMaffei MC6 machine control system. All values, such as throughput rate, injector opening time, pressures, etc. are grouped together on MuCell® screens. The most important process parameters can be monitored via tolerance bands. This allows centralized adjustment and monitoring of the entire injection molding process and adds an additional level of process reliability thanks to full integration.



All process parameters can be set centrally from the MC6 control system using the special MuCell® controller

Optional MuCell® package – retrofittable in stages

Any new or existing machine can be prepared or retrofitted for use with MuCell® with very little effort.

Equipment required:

- Pressure accumulator for enhanced injection performance
- Active dynamic pressure control system, including proportional valve control
- Reduced nozzle contact force
- Nozzle closure actuation while the mold is moving

Preparations for CellForm and MuCell®:

- Interface for MuCell® peripherals
- Safety modifications
- HSVN needle seal nozzle with additional monitoring
- Active dynamic pressure control when safety gate is open

MuCell® retrofit package:

- MuCell® plasticizing unit
- MuCell® software package

MuCell® peripherals:

- MuCell® gas metering unit (SCF system)
- MuCell® interface kit (pressure control module, injector, supply lines)
- All usage rights included

Your benefits:

- Complete solutions from a single source
 - No interface problems
 - All usage rights included
 - Plasticizing unit optimized for MuCell®
 - Complete integration in MC6 control system
-

Further information which might also interest you



Are you looking for detailed information about the right injection molding machine and automated solution for your application?

KraussMaffei boasts an extensive range of injection molding machines. Find out about our hydraulic CX, GX and MX Series or our fully electric AX and EX Series. We can offer you the right robot for every production task. You can also choose special tool clamping systems or other accessories for your injection molding machines.



We have also compiled extensive information for you on the subject of service.

With our servicing and maintenance services you can increase the flexibility of your injection molding machines to meet ever-changing process requirements and enhance their performance in the long term. We are happy to provide you with detailed information on this.

Ask us for information about the following, for example:

- Infrastructure for cost-effective production – linear robots in the LRX/LRX-S Series
- Flexible tools for productive automation – industrial robots in the IR Series
- Our service expertise is the key to your production efficiency – Service & Solutions

You can find our brochures and flyers on other topics online at: www.kraussmaffei.com. On request, we would also be happy to send you information and technical data about our products free of charge.

KraussMaffei

A strong brand in a unique global group

Cross-technology system and process solutions

Whether in Injection Molding, Reaction Process Machinery or Automation – the KraussMaffei brand stands for pioneering and cross-technology system and process solutions in plastics processing worldwide. For decades, our expertise, innovative ability and passionate commitment to plastics engineering have been your competitive edge. As a cross-industry system provider, we offer you modular and standardized systems as well as solutions customized to your needs.

There for you around the world

With our worldwide sales and service network, we offer our international customers an excellent basis for a successful business relationship. Due to the close proximity to our customers, we are able to answer your individual inquiries very quickly. We work out the best possible technical and economical solution for your product and production requirements together with you. Test our machine technology for your applications and let our experts put together an individualized service package for you.

Individualized service

Our employees from customer service, application technology and service help you with your questions and needs on every topic dealing with machines, systems and processes – around the globe, quickly and with a high level of expertise. We have developed an extensive customized service spectrum with our lifecycle design, which accompanies you throughout the entire lifecycle of your machines and systems. Take advantage of the personal interaction and flexibility we offer in our practically oriented seminars. We carry out customer-specific trainings either at your location or at our sales and service locations.

KraussMaffei Group

Comprehensive expertise

Unique selling proposition Technology³

The KraussMaffei Group is the only provider in the world to possess the essential machine technologies for plastics and rubber processing with its KraussMaffei, KraussMaffei Berstorff and Netstal brands: Injection Molding Machinery, Automation, Reaction Process Machinery and Extrusion Technology.

The group is represented internationally with more than 30 subsidiaries and over ten production plants as well as about 570 commercial and service partners. This is what makes us your highly skilled and integrated partner. Use our comprehensive and unique expertise in the industry.

You can find additional information at:
www.kraussmaffeigroup.com

You can find additional information about KraussMaffei at: www.kraussmaffeicom



The KraussMaffei Group has a global presence. Countries with subsidiaries are marked in dark blue. In the white-colored regions, the Group is represented by over 570 sales and service partners.

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For lightweight and cost-effective parts

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