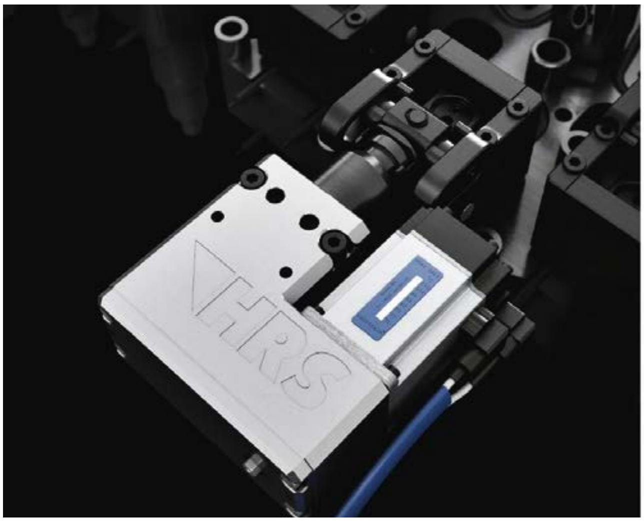
Intelligently Controlled Cascade Injection Molding

The Italian Hot Runner Specialist HRSflow Focuses on the Quality of Large-Format Parts

Flexflow is an innovative, servo-driven, finely adjustable valve gate system for cascade injection molding. Especially with large-format parts as are used in the automotive industry for interior and exterior applications, the technology can be used to attain significant improvements in the surface quality of the part while reducing the required clamping force and even the part weight. It also avoids the dreaded pressure marks on the molding that often occur with the cascade injection molding process.



Flexflow, a servo-driven system for the precise regulation of the valve pin in a hot runner nozzle (left), built into a cascade hot runner mold with individually adjustable five-point gating (right) (© HRSflow)

When carrying out the injection molding of parts with long flow paths in the mold cavity – especially with thin-walled parts – several gating points are essential to completely fill the cavity with melt. If this filling process takes place simultaneously through all the gating points, weld lines in the molding are inevitable. One solution here is to use the so-called cascade injection molding process, in which needle valve nozzles allow the sequentially opening of the valve gates.

This does, however, create other problems. For example, the melt, which is under high pressure, flows almost with high acceleration into the gating area of the mold when the valve pins (normally hydraulically operated) are suddenly opened. This leads to pressure fluctuations in the system, which is one of the typical disadvantages of the cascade injection molding process, resulting in optical defects as a result of pressure marks on the surface of the molded part. Frequently, however, these defects often remain clearly visible in further processing, for example when the parts are surface coated or electroplated. This inevitably leads to costly rejects.

Uniform Melt Flow Results in High-Quality Surfaces

The aim with cascade injection molding should be to obtain, throughout the entire filling process, a melt flow in the mold cavity that is as continuous and homogeneous as possible. The transitions when switching over from one hot runner nozzle to the next must not be too abrupt but fluid, necessitating a coordinated overlap. These were the targets for the Italian hot runner specialist, HRSflow, when it began developing the Flexflow technology – a servo-driven, finely regulated valve gate system for cascade injection molding (**Title figure**).

To demonstrate the results attainable with this system, practical tests were carried out with a mold for a rear spoiler on a present-day series-produced vehicle (**Fig. 1**). The mold was equipped with a five-point hot runner system and additional pressure sensors in the cavity. The spoiler, with a length of 1,260 mm, width of 280 mm and height of 120 mm and a wall thickness of 3 mm, was produced by cascade injection molding from a PP/EPDM compound with 20 % talc.

A simulation was made of the controlled filling of the mold. In the Flexflow hot runner system, it is possible to precisely open and close the individual valve pins step by step and independently of one another (**Fig. 2**). For each opening and closing process, up to eight needle positions can be set with an accuracy of 10 µm. The adjustments are made via a control unit, with which up to 16 hot runner nozzles can be individually controlled. With each valve pin, the stroke, position, speed and acceleration when opening and closing the pin can be pre-set.

Compared with the conventional cascade injection molding process, the sequentially controlled opened hot runner nozzles using Flexflow result in a significantly smoother pressure profile when filling the cavity (**Fig. 3**). The abrupt pressure fluctuations when switching over to the next injection nozzle in the classic cascade injection molding process are balanced out. As a result, the part surface does not have any pressure marks (**Fig. 4**), and high-quality surface finishes are obtained reliably and reproducibly.

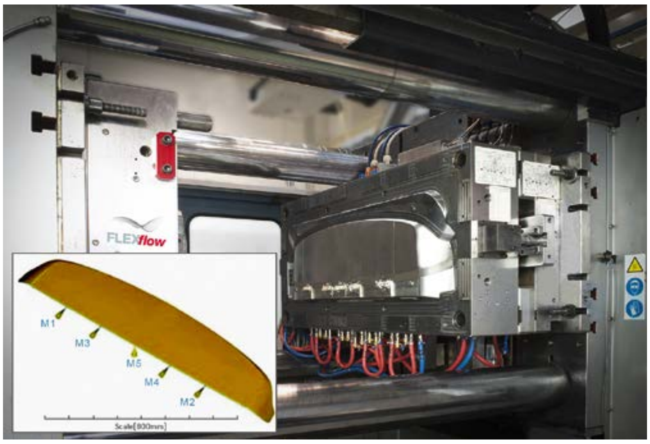


Fig. 1. The test mold for the spoiler was provided with individual five-point gating (M1–M5) and several pressure sensors to record the melt pressure in the cavity (© HRSflow)

Material and Clamping Force Requirements Drop

Flexflow has since also been integrated into the Autodesk Moldflow simulation software. This makes it possible, back at the planning stage, to obtain useful information for the design of plastic parts and injection molds and for the injection molding process as a whole. For example, Moldflow can simulate the stepwise opening and closing of the Flexflow valve gate nozzles, in order, for example, to predict the pressure build-up in the cavity and the necessary mold clamping force.

The pressure profiles in the cavity predicted with Moldflow for the trial mold for the spoiler (**Fig. 5**) were confirmed in the practical trial. This has further product and cost-related consequences. For example, the lower overall pressure level in the cavity attainable with Flexflow results in lower mold bending, and this certainly becomes noticeable in the case of the spoiler with its length of 1.26 m. The original bending (widening at the center of the mold) of 0.10 mm with the traditional cascade drops to only 0.05 mm with the Flexflow control (with the same clamping force of 10,000 kN). As a result, the weight of the part is cut from 975 g to 935 g, a weight saving of around 4 % or 40 g which, in the case of a series-produced part manufactured a million times over, is certainly an economic benefit.

The overall lower pressure level attainable with the controlled valve gate system has a further mechanical effect: The required clamping force for the injection molding machine is lower. Whereas an injection molding machine was needed with a clamping force of 10,000 kN to produce the spoiler, it is now sufficient to have one with only 8,000 kN. This 20 % reduction in the required clamping force also makes itself apparent in the procurement price.

Faster Color Changes

Tests were also carried out with the spoiler mold to see whether and to »

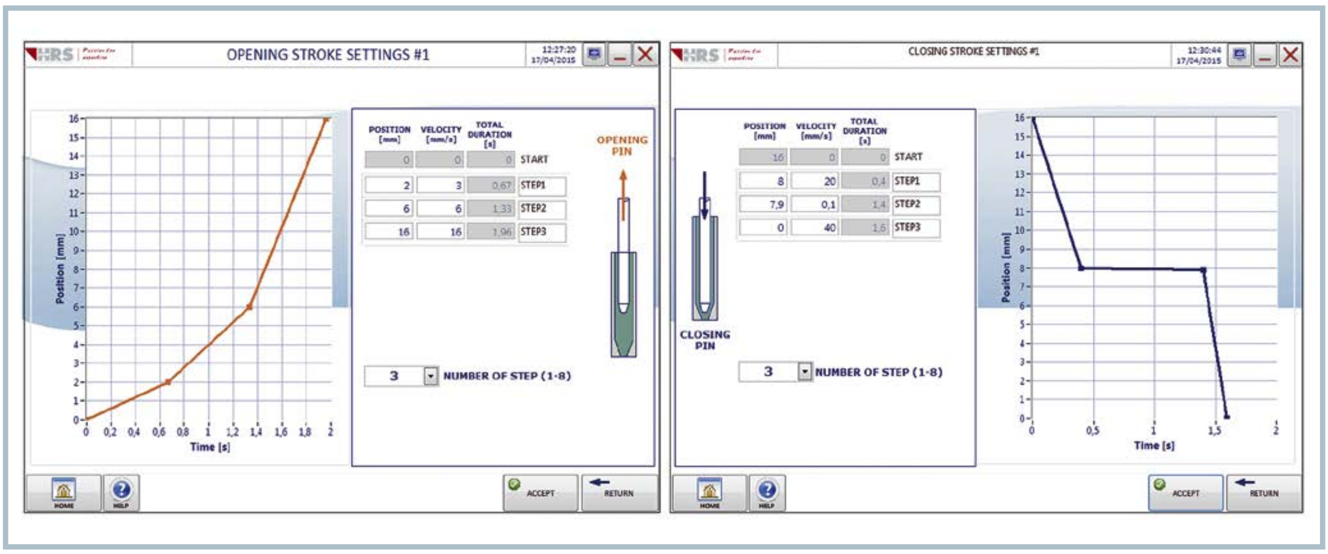


Fig. 2. For each valve pin, Flexflow allows individual opening (left) and closing (right) stroke settings with a total of up to 8 positions in each case (© HRSflow)

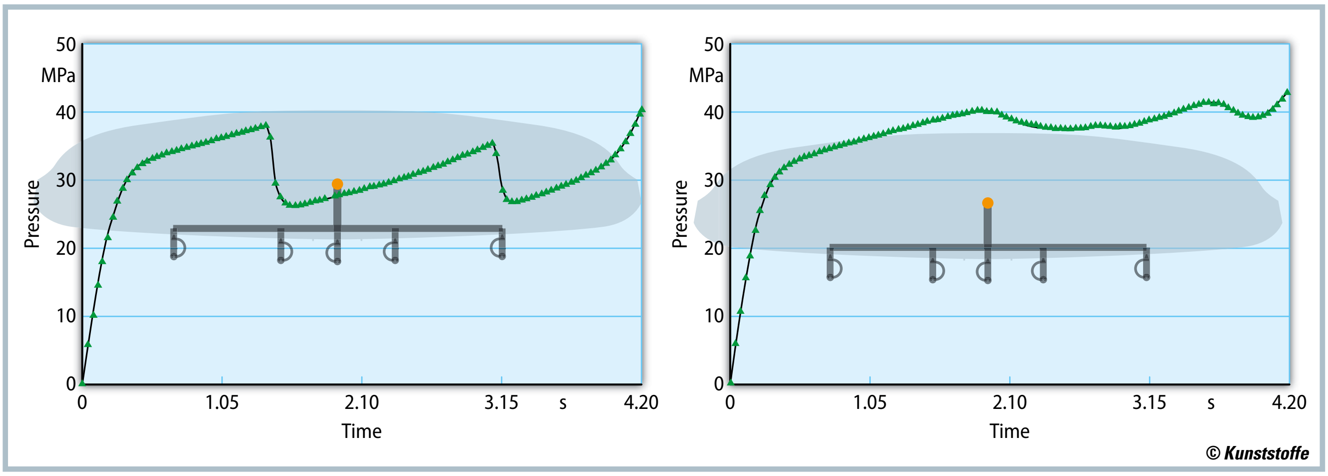


Fig. 3. With conventional cascade injection molding, pressure fluctuations occur when switching over to the next nozzle (left); with Flexflow, a much more even pressure profile is obtained (right) (source: HRSflow)

what extent the servo-driven valve gate system has any impact when changing to a different material or color. The trials carried out in this case involved a color change from black to red. A comparison was made between the standard process (simulated by open hot runner nozzles with a completely withdrawn valve pin) and the Flexflow system with controlled pin positions. Also included in the trials was a comparison between a non-balanced and flow-optimized hot runner (five-point gating). All the machine and process parameters such as melt temperature, filling pressure, holding pressure and cycle time were always identical.

The unbalanced runner in the standard process (all five valve pins completely opened) required 35 cycles before production with the new color complied with the specifications and could be released. With the Flexflow valve gate, the process was shorter:

- four cycles with the pins of all five nozzles in the open position, without sequential cavity filling,
- five cycles with (open) pins withdrawn 3 mm, without sequential cavity filling,
- two cycles in which only the pins of the two outer nozzles left and right were opened by 3 mm and
- five cycles with completely open nozzles, whereby the cavity filling was carried out sequentially.

After these 16 cycles, the color change from black to red was complete and in line with the specifications (**Fig. 6**).

With the flow-optimized hot runner, 20 cycles were needed for the color change using the standard process (all five nozzles open). With the Flexflow valve gate and the following process

- one cycle with open position of the pins of all five nozzles,
- eight cycles each with pins of the five nozzles opened by only 1 mm and
- a final cycle with open pin position of all five hot runner nozzles,

the color change was completed in ten cycles.

With a flow-optimized runner, the amount of work necessary for a color or material change in the standard process

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Fig. 4. Position and typical profile of the pressure marks at the gating points in cascade injection molding (top); in the classic molding process they become clearly visible (bottom left) – with Flexflow, these defects do not occur (bottom right) (© HRSflow)

can be reduced by a good 40 %. With the servo-driven valve gate system of the hot runner nozzles and adapted process control, it is reduced by a further 50 %. Once the best nozzle configuration and sequence have been determined for a particular color change, this dataset can be saved in the Flexflow control, called up if required, and carried out at the press of a button.

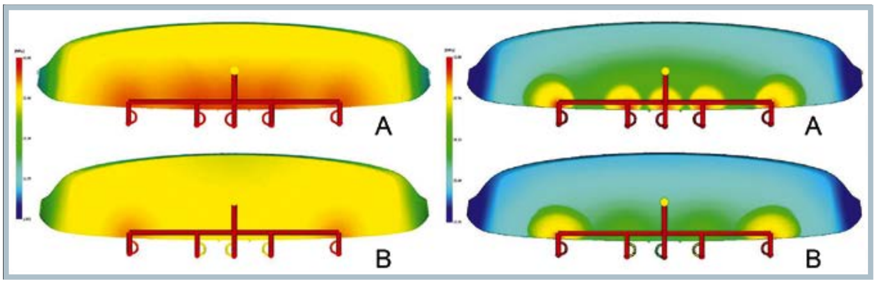


Fig. 5. Moldflow simulation of the filling (pictures on the left) and holding-pressure phase (right) in the test mold for the spoiler with five-point hot runner in the conventional cascade injection molding process (A) and with the Flexflow hot runner system (B): With the servo-driven valve gate system, the pressure profile in the cavity is far more homogeneous and the pressure level as a whole is lower (© HRSflow)

Grand Total = Many Advantages

As the results show, it is possible with the servo-driven valve gate system in cascade injection molding to attain a balanced filling process of the mold cavity. This favors not only the production of high-quality part surfaces and brings significant material savings, it also has advantages for the injection molding system overall. For example, the mold is subjected to less stress during the filling phase, resulting in longer mold service life.

Another advantage is to be found in the system's electrical drive. The risk of leakages (oil or water) as with a conventional, hydraulically operated valve gate does not exist from the very beginning. With its compact construction, the electrical drive can also be built into the mold in a space-saving way and adapted flexibly to the respective part geometry (**Title figure**). Furthermore, the servo motor is very low maintenance, thus improving the general availability of the system (tested up to one million cycles without any maintenance).

Fig. 6. A color change from black to red with a non-flow-optimized hot runner requires 16 cycles with the Flexflow technology (some of which are shown above), but without this support, 35 cycles (© HRSflow)

In automotive construction, the Flexflow technology offers particular advantages in the injection molding of large-area exterior and interior parts such as spoilers, bumpers, front ends, instrument panel supports (IPS) and door panels. Above all, the servo-driven valve gate system offers a wider process window for a stable, robust and reproducible injection molding process. It is, for example, also possible to reduce the present lens thickness of a front headlamp from 3 mm to only 1.8 mm with a five-point Flexflow hot runner, without any flow lines, injection-molded from crystal-clear PC. ■

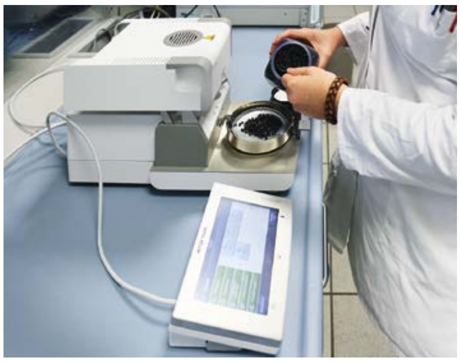
Halogen-Based Drying of Plastics

Residual Moisture Determination for Everyone

Akro-Plastics GmbH, Niederzissen, together with **Mettler-Toledo GmbH**, Giessen, both Germany, performs comparative measurements between Karl Fischer titration (KF method) and the thermogravimetric method to determine the residual moisture with the aid of a halogen-based dryer. The impetus for this comes from the frequently occurring problem that the pellets are overdried prior to processing.

During the production process for plastics and compounds, the moisture content of the pellets is determined in the laboratory by the manufacturer by means of the KF method. While this is very accurate, it is also very involved, expensive and takes a long time. The halogen method is supposedly a simple and easy alternative. Experimental results to date are very promising and the partners are proceeding on the assumption of a good correlation between the two methods.

The distributor ensures that his material reaches the processor in a very dry condition. The compounds are packaged in aluminum-laminated polyethylene (PE) sacks and, according to the company, the material needs to be pre-dried or preheated for only two hours if it is removed directly from the undamaged container.



To date, both companies are very satisfied with the experimental results (© K.D. Feddersen)

This represents an energy and cost savings of up to 75 %.

To the product presentation:
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