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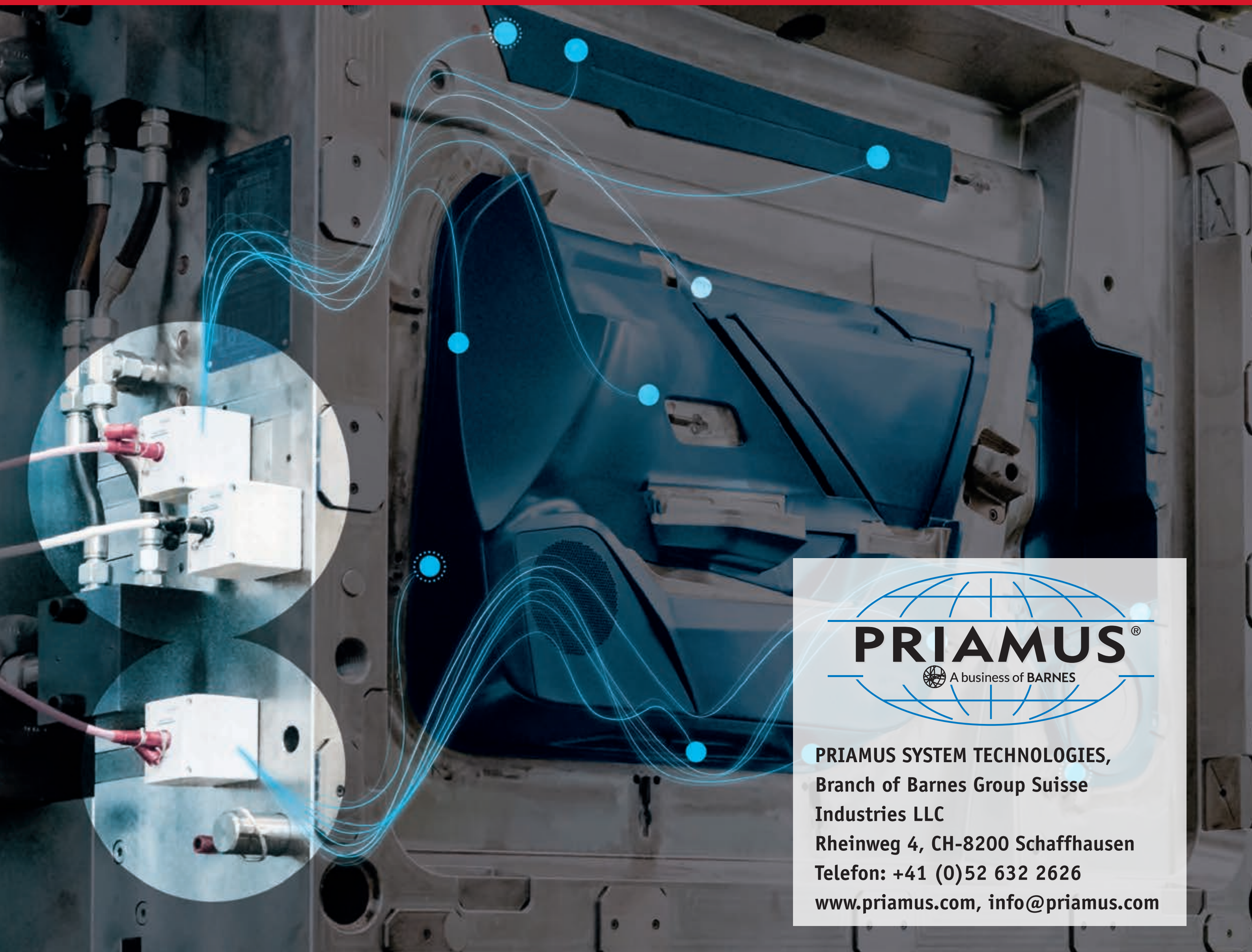
A Family in Sync

Priamus Control Systems Take over Complex Tasks of the Machine Setter



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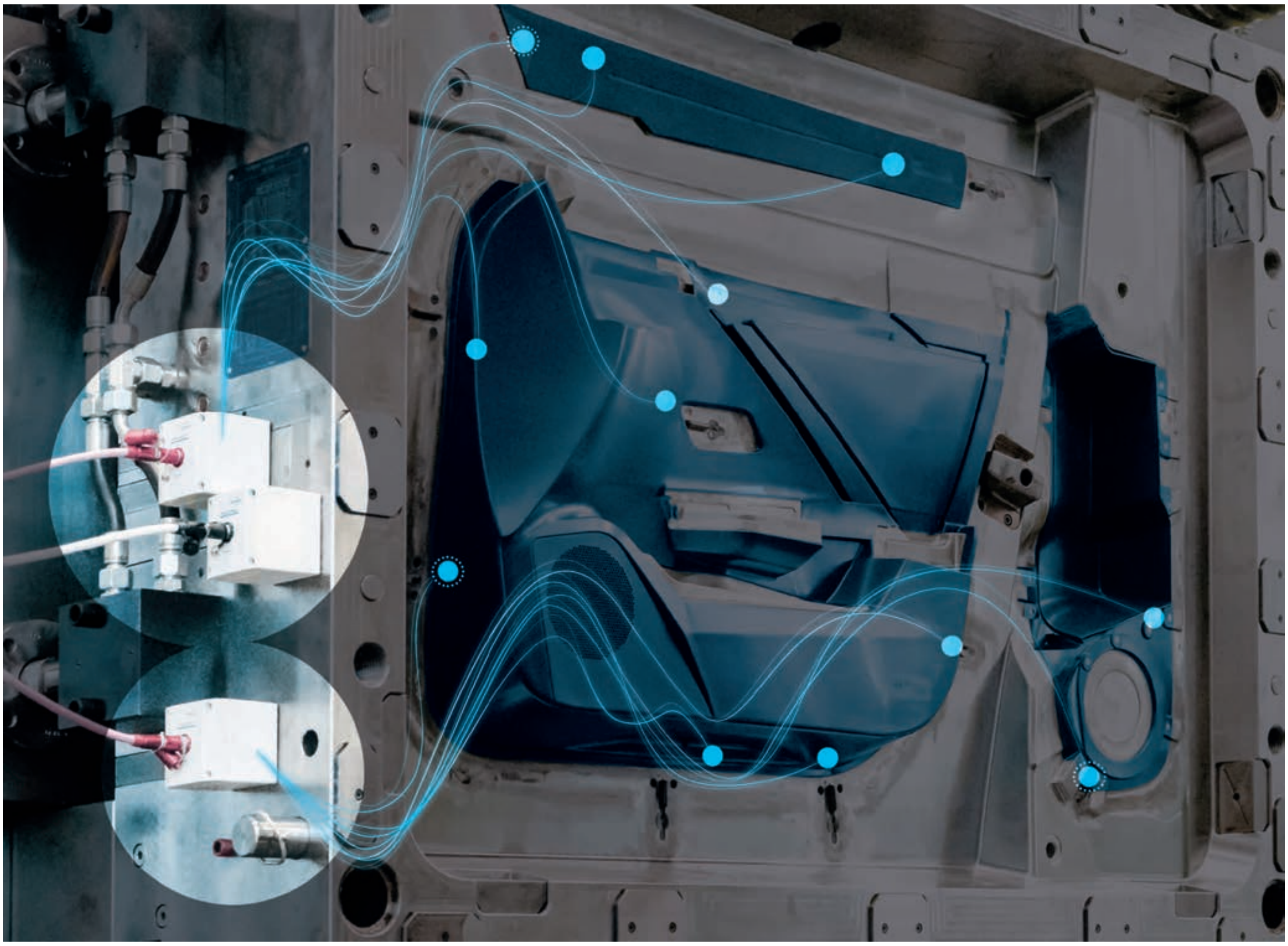
Priamus Control Systems Take over Complex Tasks of the Machine Setter

A Family in Sync

When injection molding specialists talk about balancing, they are referring to the synchronous reaching of the end of the melt flow in the cavities. It would consequently be better to refer to this as “synchronizing.” This synchronization of the end of the melt flow is influenced by several parameters: the molding compound, the injection molding machine, the tool, and the hot runner. With family molds, in particular, with multiple injection points of the parts, synchronizing becomes an even greater challenge. We show an alternative to complex manual cascade settings in a realistic test set-up.



Priamus control technology enables automatic cascade adjustment and simplifies set-up. © Priamus / Barnes Molding Solutions

Setting-up a complex cascade application from scratch is time-consuming and requires a lot of experience. During process development, the setter encounters a conflict between even mold filling (preventing flow marks, flow lines, and air inclusions) and a homogeneous holding pressure effect (preventing local sink marks). At the same time, they must move the unavoidable flow lines into acceptable areas of the part. To achieve the quality of the required part, this conflict is influenced by adapting the cascade switching times of the valve gate nozzle depending on the screw position. These switching times, however, are in turn dependent on the injection speed and the division of the volumetric flow to the respective valve gate nozzles.

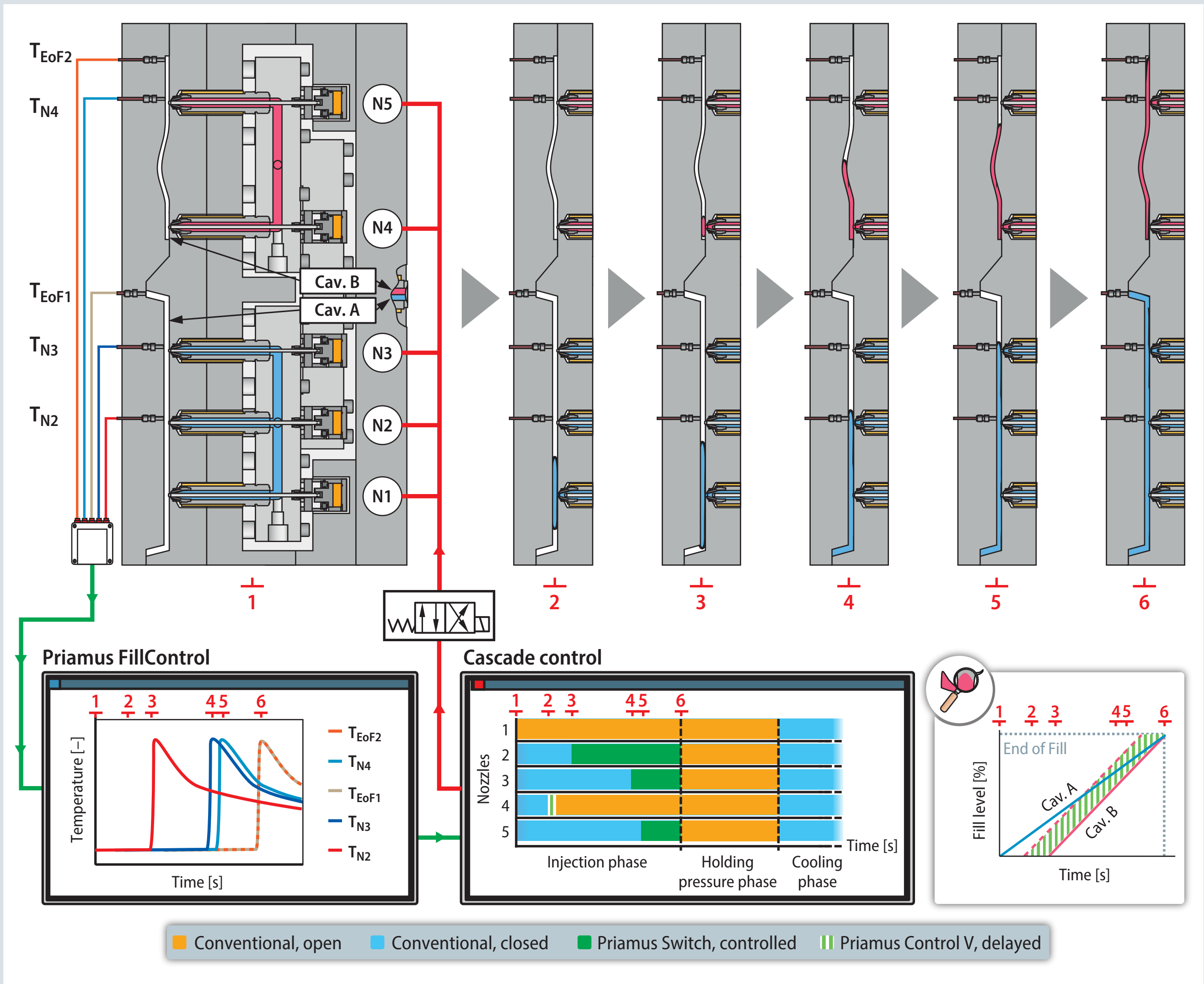


Fig. 1. Automatic cascade control using temperature sensors and Priamus Fillcontrol Switch. The family mold shown here has two different cavities and a total of five valve gate nozzles (N1-N5).The different colors of the compound (blue and red) identify the different molded parts.

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Manual Cascade Settings and Adjustments to Process Interferences

For family molds that produce an assembly – for example, a door trim panel – the cascade settings become even more complex due to the different part properties, especially the part volume and wall thickness. The described division of the volumetric injection flow between the open valve gate nozzles means that a change in the switching time on one part will influence the filling of the other part. In addition to controlling the quality of several parts, the setter is confronted with the challenge of synchronizing the end of the flow path of all parts to avoid overpacking.

The general question for cascade settings always concerns the position of the flow front relative to the gating points. If the position of the flow front can be detected during the injection molding process with a suitable sensor system, an automated cascade setting can be implemented with an appropriate open-loop or even closed-loop control approach. In addition to reducing the great manual effort described above, this also makes it possible to automatically correct fluctuations caused by material batches, the machine, or outside influences.

Automatic Cascade Settings in Real Time

The patented, automated flow front detection by the directly triggered Priamus mold wall temperature sensor makes it possible to know the position of the flow front during the injection process [1]. In combination with the Priamus Fillcontrol Switch, more sensors around the valve gate nozzles can be used to implement an event-based control (**Fig. 1.**). The automatic cascade control function (in the figure below, left) communicates directly with the cascade control (below, center). The filling process starts with nozzle N1. When the flow front reaches temperature sensor T_{N2}, a switching signal is sent to the cascade control. This signal opens nozzle N2, and the filling process continues until temperature sensor T_{N3} is reached. During the holding pressure phase, all valve gate nozzles are open during the entire holding pressure period to achieve a pressure effect across the whole area.

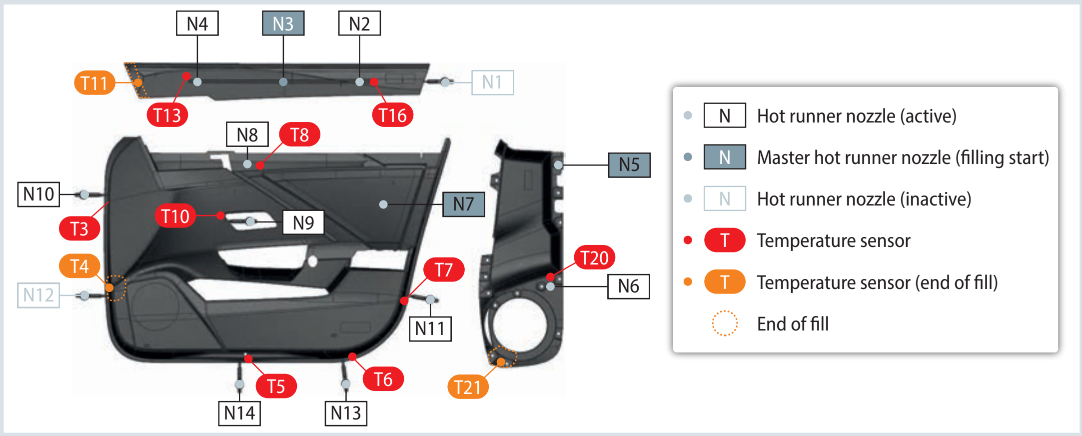

Fig. 2. Nozzle and sensor positions in the test mold. The nine red temperature sensors are used for automatic cascading with Priamus Fillcontrol Switch. The three orange sensors monitor the respective flow path ends.

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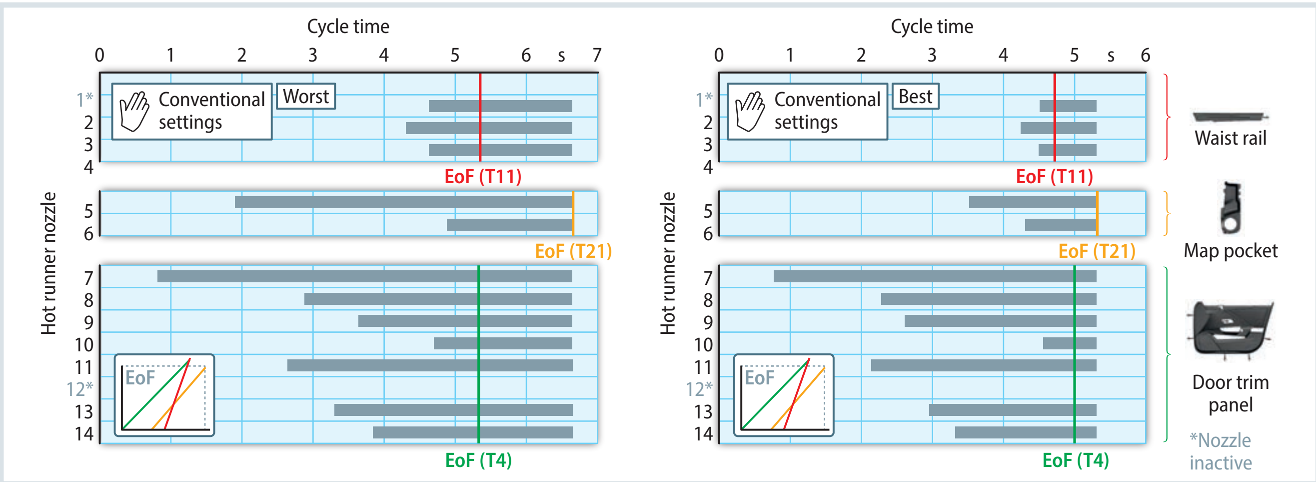

Fig. 3. Diagram of the flow path end for the manual set-up of a cascade in a family mold.
Even after manual optimization by the setter (right), a filling time difference and thus the risk of overfilling two cavities remains.

Source: Barnes Molding Solutions, Simon Wurzbacher; graphic: © Hanser

The temperature sensors are located in the immediate vicinity of the valve gate nozzles (T_{N1}-T_{N4}) and at the respective flow path end (T_{EoF1}, T_{EoF2}). The nozzles with which the filling process starts (N1, N4) do not have to be equipped with sensors, but are controlled conventionally via manually selected switching times in the cascade control system (**Fig. 1,** bottom center, orange). The green switching times are determined by the Priamus software automatically. This function can be used for automatic cascade control with single and multi-cavity molds.

In family molds with different fill volumes, the Priamus Fillcontrol Control V function enables synchronization of the flow path end through a fully automated, controlled delay of the filling start (**Fig. 1**, below, right**,** nozzle 4, green-and-white hatching). The filling processes in the individual cavities influence each other, which is why Priamus Fillcontrol Control V should only be used in combination with Priamus Fillcontrol Switch, as the cascade control automatically takes into account any differences in the flow front position and makes adjustments in real-time.

Test Set-up: Family Mold for a Door Trim Panel

The example assembly "door trim panel" was selected for the tests, with the three individual components arranged in a family mold (**Fig. 2**). The three individual cavities can be filled in different filling scenarios through a total of 14 hot runner valve gate nozzles. The hot runner nozzles are directly connected to the respective cavities and through cold runner sprues. The test was carried out at the Molding Solutions Customer Experience Center of Foboha (Germany) GmbH, Haslach im Kinzigtal. This is where all process solutions from Barnes Molding Solutions can be replicated for research and development tasks, customer trials, and limited production runs [2].

All sensors are linked to the Priamus system, which sends the switching times in the test set-up to an external Gammaflux SVGC (sequential valve gate controller) cascade control. It is also possible to forward the signal outputs to the cascade control integrated into the machine or to directly activate the gate nozzles, depending on the hot runner solution. Exclusive use of the temperature sensor significantly reduces the complexity and cost factor. This approach applies in general and can easily be adapted to similar tools.

Managing Filling Time Differences in Family Molds

Figure 3 illustrates the challenge of manually synchronizing the individual cavities. The diagram shows the switching times of the valve gate nozzles »

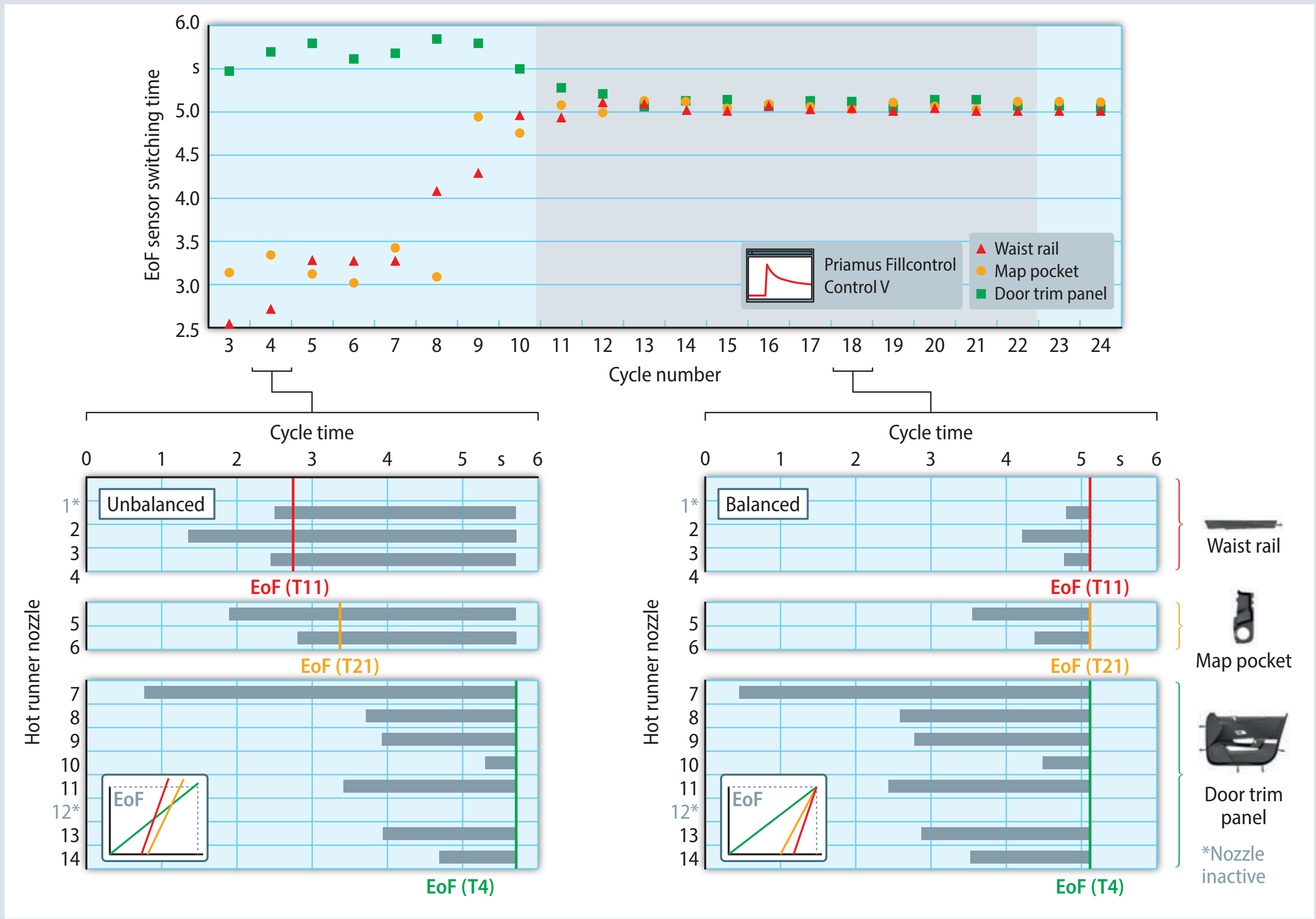

Fig. 4. With Priamus Fillcontrol Control V, the filling time differences of the individual cavities are synchronized further with each cycle. The figure shows the switching times of the temperature sensors at the respective flow path ends of the individual cavities. Source: Barnes Molding Solutions, Simon Wurzbacher; graphic: © Hanse

(gray) and the reaching of the flow front at the end of the flow path ($T4_{EoF}$, $T11_{EoF}$, $T21_{EoF}$) with manual optimization of the cascade settings. The measured values were only recorded, not controlled, with the Priamus system and evaluated only after the set-up. The cascade settings were made based on a visual inspection of the quality characteristics of the individual parts and an initial filling study. However, production tools are not usually equipped with such a large number of sensors.

The left-hand diagram (**Fig. 3**) describes a cycle from the progress of the manual cascade settings, where the time difference between reaching the flow path end of trim panel and that of the map pocket is 1.3 s (worst). The right-hand diagram shows the switching times after extensive manual optimization by the setter, where the time difference is still 0.6 s (best). These cascade switching times theoretically selected by the setter for the production process result in overpacking of the waist rail and door trim panel due to the switching time differences. This can lead to premature wear on mold components and a higher required shot weight.

Controlling the Filling Time Differences – Machine versus Human

Complete synchronization of the flow path ends of all cavities is only possible if the switching times are controlled automatically. First, however, a basic setting is needed where all three parts are filled and ideally can also be removed automatically by the robot. These settings can be based on simulation data or manual set-up/estimation of a cascade sequence to avoid marked overfilling or underfilling of the individual cavities [3]. Then the control via the Priamus system is started. To ensure the fastest possible adjustment, the machine and the part removal process run in automatic mode.

The Priamus Fillcontrol Control V automatically determines the delay of the switching times of the master hot runner nozzles by detecting the flow front at the respective flow path end. This minimizes the time difference between the "fastest" and "slowest" cavity with each shot, which results in the end of all flow paths being reached synchronously (at the same time) (**Fig. 4**.). All other opening times of the valve gate nozzles are automatically adjusted in real-time by the Priamus Fillcontrol Switch on the respective nozzle.

Figure 4 (below, left) shows cycle number 4 as an example, where the filling time difference between the waist rail ("fastest cavity") and the door trim panel ("slowest cavity") alone is 3.1 s. The comparison of the cascade switching times between cycles 4 and 18, on the other hand, shows that the Priamus Fillcontrol Switch also adjusted the switching times of the respective nozzles automatically to react to the change in the injected volumetric flows at the respective point in time.

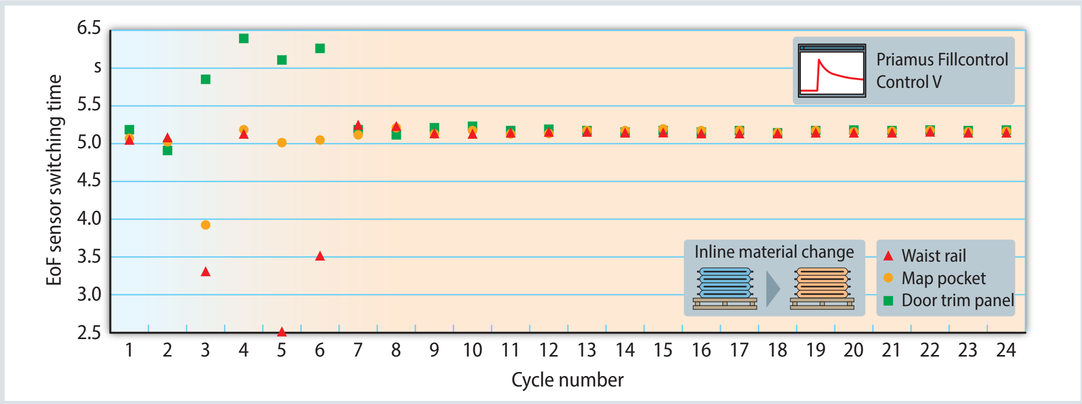

Fig. 5. Automatic compensation of fluctuations in the material properties on the example of the inline change to recompound.
Source: Barnes Molding Solutions, Simon Wurzbacher; graphic: © Hanser

Once balanced, after only twelve cycles and converged with a filling time of 5.1 s, the difference between the filling times is less than 0.1 s (upper graphic) and is adjusted continuously during production. This makes it possible to react to various process fluctuations in real-time to automatically ensure constant parts quality.

Compensating for Batch Fluctuations during an Inline Material Change

With conventional settings for the cascade switching times, fluctuations in the flow properties of the processed plastic compound can sometimes require manual adjustments to the process. In the test described below, an inline material change from "new material" to "recompound" was implemented to simulate a strong batch fluctuation without interrupting the production process. To do this, the material feed was changed during operation to a recompound of the originally used PP material, often used for automotive interiors. There was a clear difference in the representative viscosity between the new material (59 Pa·s) and the recompound (24 Pa·s) as determined with the Priamus Fillcontrol system.

Figure 5 shows the filling time differences for the cycle number after the inline material change. In cycle 1, there is still new material in the plasticizing unit. Afterwards it is mixed with recompound during the following cycles. From cycle 4, the plasticizing unit and the hot runner are filled with recompound, and the flow path ends are synchronized again, adapted to the other material properties. From cycle 5, the continuous intervention of the Priamus Fillcontrol software automatically adapts all opening times of the gate nozzles, resulting in synchronized part filling from cycle 7. The filling time difference is less than 0.1 s – the same as when new material is used. However, the end of the flow path is only reached approx. 0.1 s later.

Conclusion

The presented results proof that, in the complex conflict of the cascade control for family molds, humans miss an opportunity against the machine when it comes to set-up time and process quality. The Priamus control systems can take on time-consuming and complex tasks of the machine setter and simplify the setup process for qualified personnel. In addition to the set-up process, product quality is also ensured during the ongoing process through continuous monitoring and control functions. The combination of the Barnes Molding Solutions products increases the efficiency over the entire product development process and product life cycle. The areas of interface coordination, scrap reduction, start-up characteristics, and quality assurance are particularly important here.

The fully automated control of the cascade switching times can be combined with manually delayed switching times of individual nozzles in the Priamus Fillcontrol Switch software. Future additional examinations will be conducted to show how this function can facilitate management and constant positioning of the flow lines with varying parameters (compound, injection molding machine, mold, and hot runner). ■

Info

Text

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References

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