No More Weight Problems

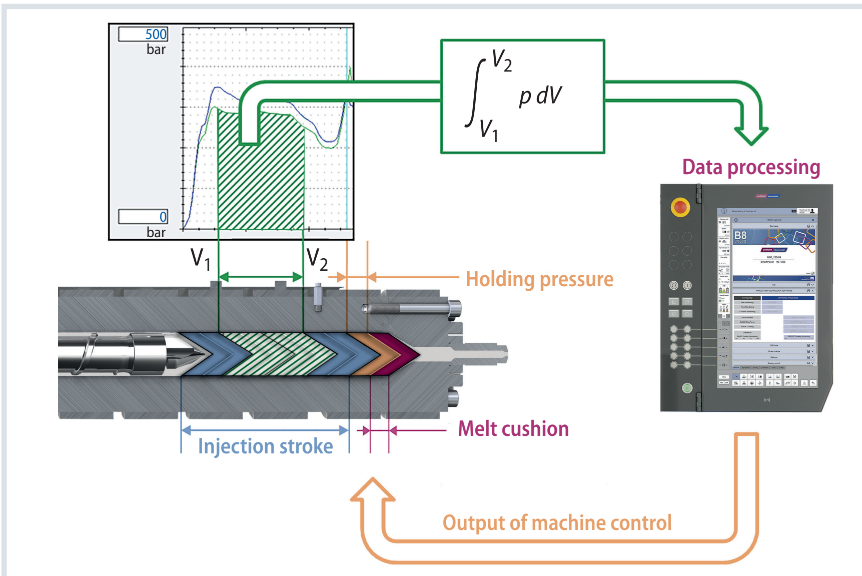
Dynamic Adjustment of Switchover Pressure and Holding Pressure to Achieve a Constant Part Weight

HiQ Flow is Wittmann Battenfeld's answer to the challenge of fluctuating shot weights in injection-molded parts. The assistant system modifies the process parameters in the course of the same shot to counteract viscosity fluctuations caused by batch fluctuations in the material or by the use of regrind.

The viscosity of a plastic melt has a significant effect on the part quality of an injection-molded component. Viscosity fluctuations caused, for example, by different batches of material or the use of regrind may lead to effects such as weight fluctuations or in more drastic cases even to incomplete cavity filling.

In times of 6σ and at the expense of optimized production processes, such fluctuations are not acceptable, so it is necessary to intervene as early as possible using the most verifiable and reproducible methods available. One option is to check the values measured by the injection molding machine in order to detect possible viscosity fluctuations and where necessary already counteract their effect automatically in the course of processing.

This is precisely the approach followed by the process technology developed by Wittmann Battenfeld GmbH, Kottingbrunn, Austria. The software "HiQ Flow" takes care of monitoring, recording and controlling viscosity deviations during the injection and holding pressure sequence in order to achieve a consistently high parts quality regardless of the material's viscosity.



The HiQ Flow software corrects viscosity deviations during the injection and holding pressure phases within the same shot, based on the measurement values taken from the injection molding machine Source: Wittmann Battenfeld; graphic: © Hanser

How Does the Assistance System Function?

Low-viscosity materials require less pressure to fill the cavity than melts with a higher viscosity (and vice versa). If the viscosity drops, the changeover point and the holding pressure are not corrected at a decrease in viscosity, an increase in weight must be expected. This weight increase results from the lower compression of the remaining mass in the cylinder up to the changeover point as well as the better pressure conductibility in low-viscosity melt. The pressure conductibility up to the end of the flow path is relevant for the holding pressure phase and the pressure level set for it.

With HiQ Flow, any viscosity fluctuations detected during the injection phase are actively corrected within the same shot (**Fig. 1**). For this purpose, the integral of the injection work is calculated for a predefined segment of the injection curve. The injection work is the result of multiplying the injection pressure with the cylinder surface and the travel of the injection plunger (the stroke). On the basis of a reference shot, both the changeover point and the holding pressure level are corrected to fit the injection work of the current shot.

HiQ Flow has been developed with the aim of providing maximum possible user-friendliness. The reference values of the injection work are retrieved by a single click on a button. For experienced operators, there is also the option of entering the reference value for the injection work manually. All the operator needs to do subsequently is to activate the system in the desired mode. The visualization also enables the operator to set the software for situations requiring fine adjustment.

Benchmark Test with Automotive Components

There are several advantages for the user when using HiQ Flow. The system

- ensures a constant part weight, even without cavity pressure sensors
- prevents scrap before it is generated;
- requires little, if any, manual readjustment of the production process; »

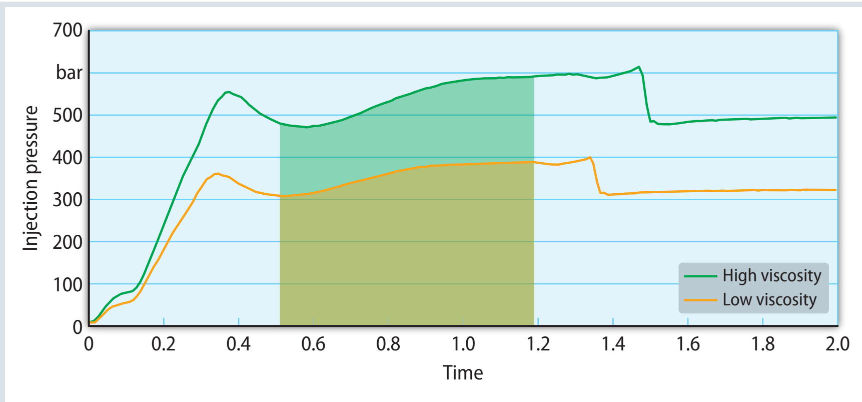


Fig. 1. Injection profile over time for two materials of different viscosities (blue for low and red for high viscosity), with active support from HiQ Flow. The highlighted area represents the period of time for which the injection work is calculated. HiQ Flow shifts the changeover point and the holding pressure level within the same shot on the basis of reference values

Source: Wittmann Battenfeld; graphic: © Hanser

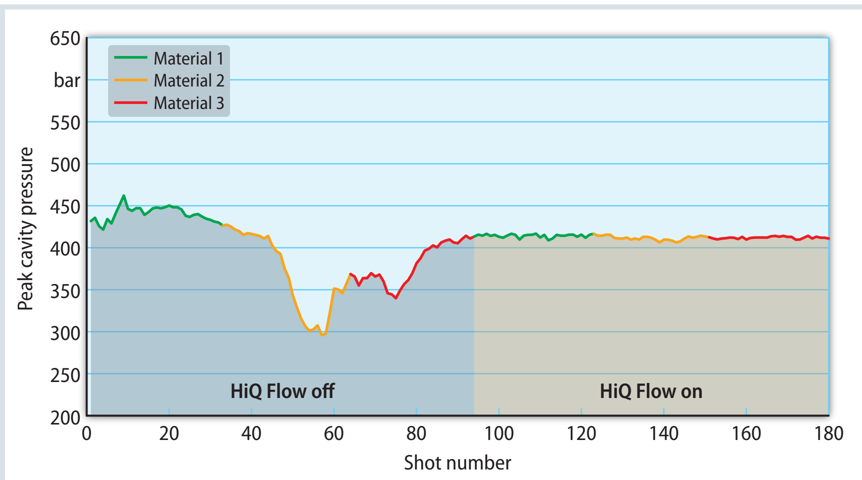


Fig. 2. Peak cavity pressure per shot for three different materials. In the first section, HiQ Flow is deactivated, in the second section, it is switched on. This shows that with HiQ Flow being activated, a stationary cavity pressure and consequently repeatable cavity filling has been achieved

Source: Wittmann Battenfeld; graphic: © Hanser

- faster restarts after production interruption.

The benchmark test was carried out on safety-relevant parts for an application from the automotive industry. The partner company had substantial viscosity fluctuations due to deviations in fiberglass content from one batch to the next. The basic material was a polyamide (PA) with a desired weight proportion of 40 % fiberglass content. The problem was solved successfully by using the assistant system.

Three different batches of the same material were tested. These were designated as material 1, 2 and 3 in the description of the results. 500 g of each batch were weighed out and filled into the hopper as soon as the previous batch had been emptied into the feed opening of the barrel. The material change was registered as soon as the new batch reached the hopper outlet. The same material changes were subsequently repeated with HiQ Flow switched on.

Cavity Pressure as a Decisive Reference Value for Quality

In this application, the weight could not be used as a reference value for quality assessment. This is due to the fact that the varying fiberglass content not only leads to fluctuations in the material viscosity but also varies its density. The focus was on the dimensional deviations of the moldings. It was known from preliminary tests that an exact reproduction of the cavity pressure leads to high dimensional stability. Therefore the part weight is not only determined by the filling level of the mold, but by the material density in each case as well. Consequently, the part weight is not directly related to the correct dimensions of the part. This is why the peak cavity pressure was taken as the relevant reference value for quality assessment.

A cavity pressure sensor is a pressure transducer installed in the mold, which is able to measure the melt pressure inside a certain cavity. The peak value of the cavity pressure is directly related to the part filling level, and this in turn to the final dimensions of the molded part.

During filling, the material is pressed into the cavity through small orifices in the nozzle and in the mold. These geometric obstacles cause a certain amount of pressure loss in the plastic melt. The maintenance of a constant cavity pressure inside the cavities between the individual injection shots ensures that the melt has the same injection profile in each case.

Deviations in material viscosity have a significant effect on the final cavity pressure. Viscosity fluctuations invariably occur whenever a filler material such as fiberglass in fluctuating quantities or recycled regrind is used. A batch change in the same material may also lead to viscosity fluctuations. The peak cavity pressure is normally reached during the holding pressure phase of the filling, when the complete filling is finished and the pressure of the screw on the cavity becomes steadier.

While the better control of the injection process and the fact that detailed process information about the respective cavity is available – this means that it is the best to use of cavity pressure sensors, the advantages are offset by the costs – a sensor is needed for every individual cavity. It must be noted that a cavity pressure sensor delivers accurate data only as long as the plastic surrounding it remains liquid. Correct placement of the sensors is a decisive factor, since the complex flow paths of the melt inside the cavity must be taken into account. Optimum positioning is not always possible, because the appropriate installation space must be available.

A Question of Distribution

Figure 2 shows the results of the test run. The peak cavity pressure over the number of shots is depicted. Without adjustment of the changeover point (HiQ Flow off),

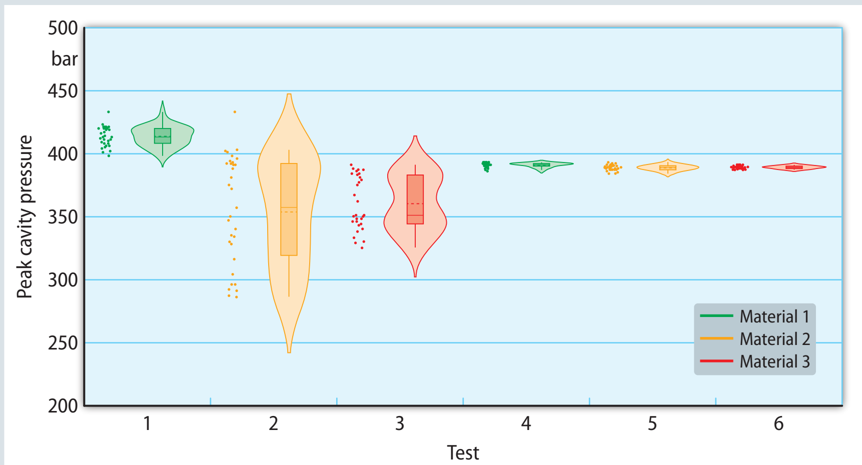


Fig. 3. Combined box plot to compare the peak cavity pressures per material and test series Source: Wittmann Battenfeld; graphic: © Hanser

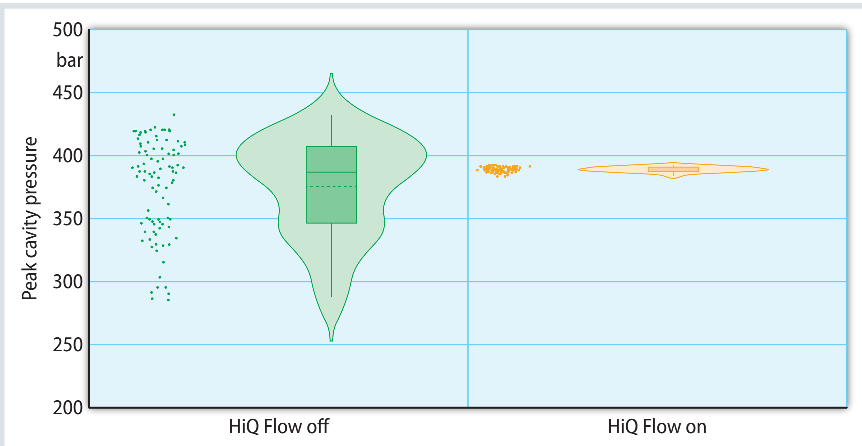


Fig. 4. Combined box plot for comparison of the maximum peak cavity pressures with deactivated and activated HiQ Flow Source: Wittmann Battenfeld; graphic: © Hanser

materials 1 and 3 show similar pressure levels, which means similar proportions of fiberglass content. Material 2 shows lower pressure levels. The process was not stable. With material 2, less plastic melt reaches the cavity than with materials 1 or 3. Only when HiQ Flow is activated, a constant cavity pressure is reached with all three materials. **Figure 3** shows a combined box plot, in which the probability distribution of the individual values is also estimated. In a simplified form it can be said that the steeper the peak or peaks of the distribution, the more measuring points are located in the corresponding area. The dots beside the box plot stand for the cavity pressures of the individual injection processes. Each material is marked by a different color code. A total of six tests have been carried out, three each with HiQ Flow activated and deactivated.

From test 4 onwards, HiQ Flow is activated, and the distribution of the values is drastically reduced. The data reveal that prior to switching on HiQ Flow, the cavity pressure values were distributed across a relatively wide range. Moreover, the individual readings were distributed relatively extensively across the entire distribution range, which means that every additional injection process has a high probability of landing just anywhere within the entire range. But as soon as HiQ Flow is activated, not only the distribution range is diminished, but the injection processes within that range are more strongly concentrated close to the mean value as well. So the value for the next injection process will also be more likely to lie close to the mean value rather than in the marginal areas of the distribution range (compare test 3 and test 6).

Figure 4 summarizes the results and depicts the test serie 1, 2 and 3 grouped into the "Off" section, whereas the remaining tests (4, 5 and 6) were combined under "On". This demonstrates on a practical example the ability of HiQ Flow to keep the part quality constant throughout changing viscosity levels. With the activation of HiQ Flow, the standard deviation of the peak cavity pressure was reduced by more than 85 %, the distribution range of the values by almost 75 %.

Conclusion

HiQ Flow keeps the part quality within tolerance even with a material change. It calculates the switchover and holding pressure levels of the current injection process. As a result, the efficiency of the production cell is increased by reducing the required working hours as well as the scrap rate. This may in turn boost the cost-efficiency of the production.

In the benchmark test, the parts produced under normal processing conditions were outside the tolerance band; by using HiQ Flow, the process was stabilized and the scrap rate reduced to zero. The ability of the assistant system to generate a reproducible peak cavity pressure makes this system a possible alternative to expensive cavity pressure sensors. In contrast to a cavity pressure sensor, which must be installed in each individual mold, HiQ Flow is available to every mold once it has been installed and activated in a Wittmann Battenfeld injection molding production cell. The software increases productivity and offers an extremely high return on investment. ■

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