June 2020, Kottingbrunn/Austria

TECHNICAL ARTICLE

HiQ Flow® - 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. HiQ Flow® 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.

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Introduction

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*. 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.

How does HiQ Flow® 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, an increase in weight must be expected. This weight increase results from the lower compression 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 (see also 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.

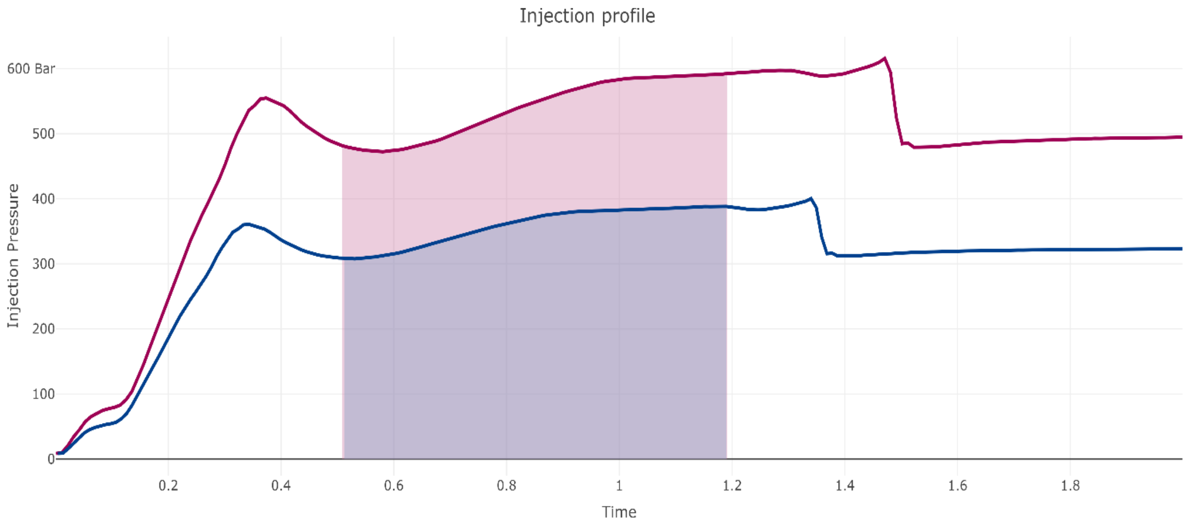

Fig. 1: Injection profile over time for two materials of different viscosities (blue for low and red for high viscosity), with active support from HiQ Flow®. The highlighted area represents the period of time for which the injection work is calculated. HiQ Flow® shifts the changeover point and the holding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

HiQ Flow® visualization

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 HiQ Flow® in the desired mode. The visualization also enables the operator to set the software for situations requiring fine adjustment.

Advantages of using HiQ Flow®

- Achievement of a constant part weight even without cavity pressure sensors
- Prevention of scrap before it is generated
- Less manual readjustment of the production process
- Faster restart after production interruption

HiQ Flow® - a benchmark test

The 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 with a desired weight proportion of 40% fiberglass content. The problem was solved successfully by using HiQ Flow®.

Test method

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 sensor

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. 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 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 dynamic pressure subsides and the pressure of the screw on the cavity becomes steadier.

Pro:

- Better control of the injection process
- More detailed process information about each cavity

Con:

- The high price
- 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.

Fig. 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), 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.

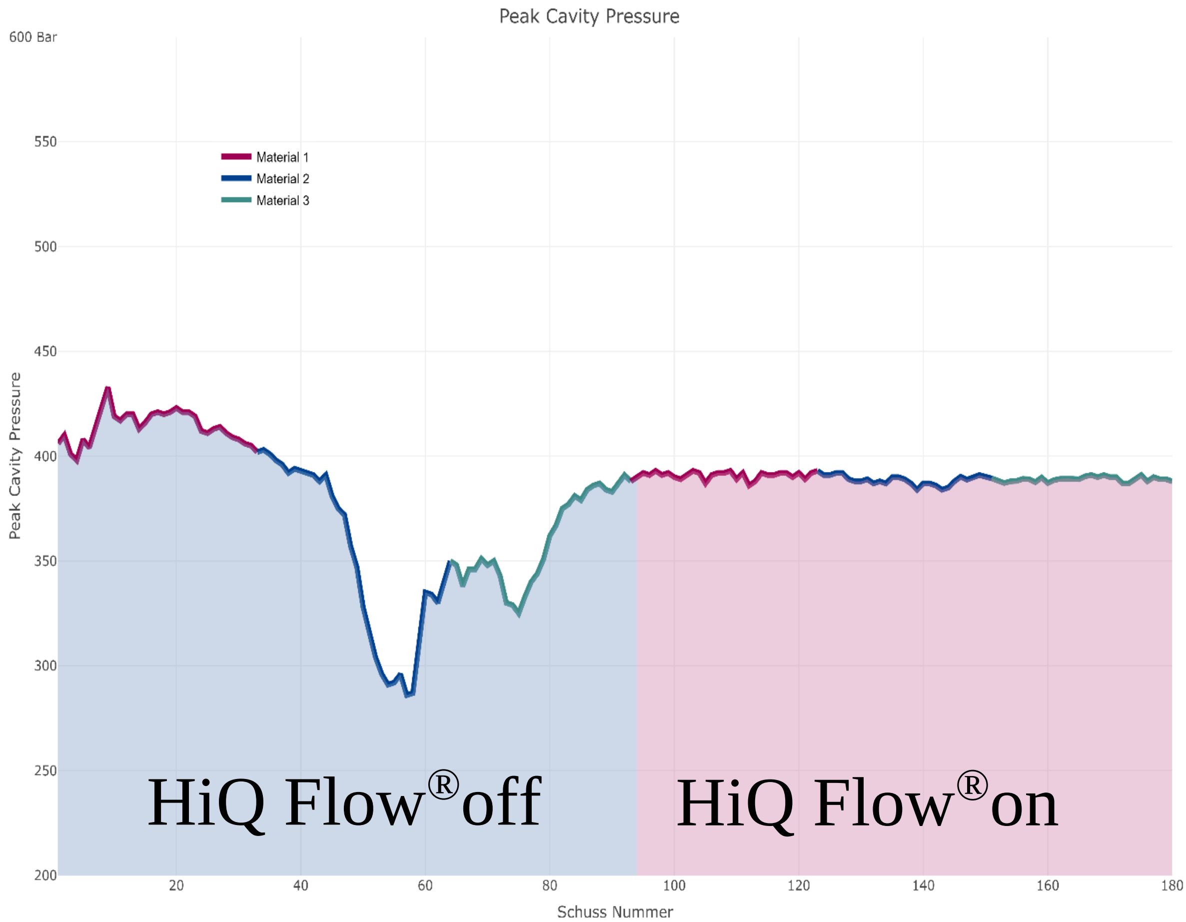

Fig. 2: Peak cavity pressure per shot for three different materials. In the first section, HiQ Flow® is deactivated, in the second section, HiQ Flow® is switched on. This shows that with HiQ Flow® being activated, a stationary cavity pressure and consequently repeatable cavity filling has been achieved.

Fig. 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.

Each material is marked by a different color code. The dots beside the box plot stand for the cavity pressures of the individual injection processes. A total of 6 tests have been carried out, 3 each with HiQ Flow® activated and HiQ Flow® 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.

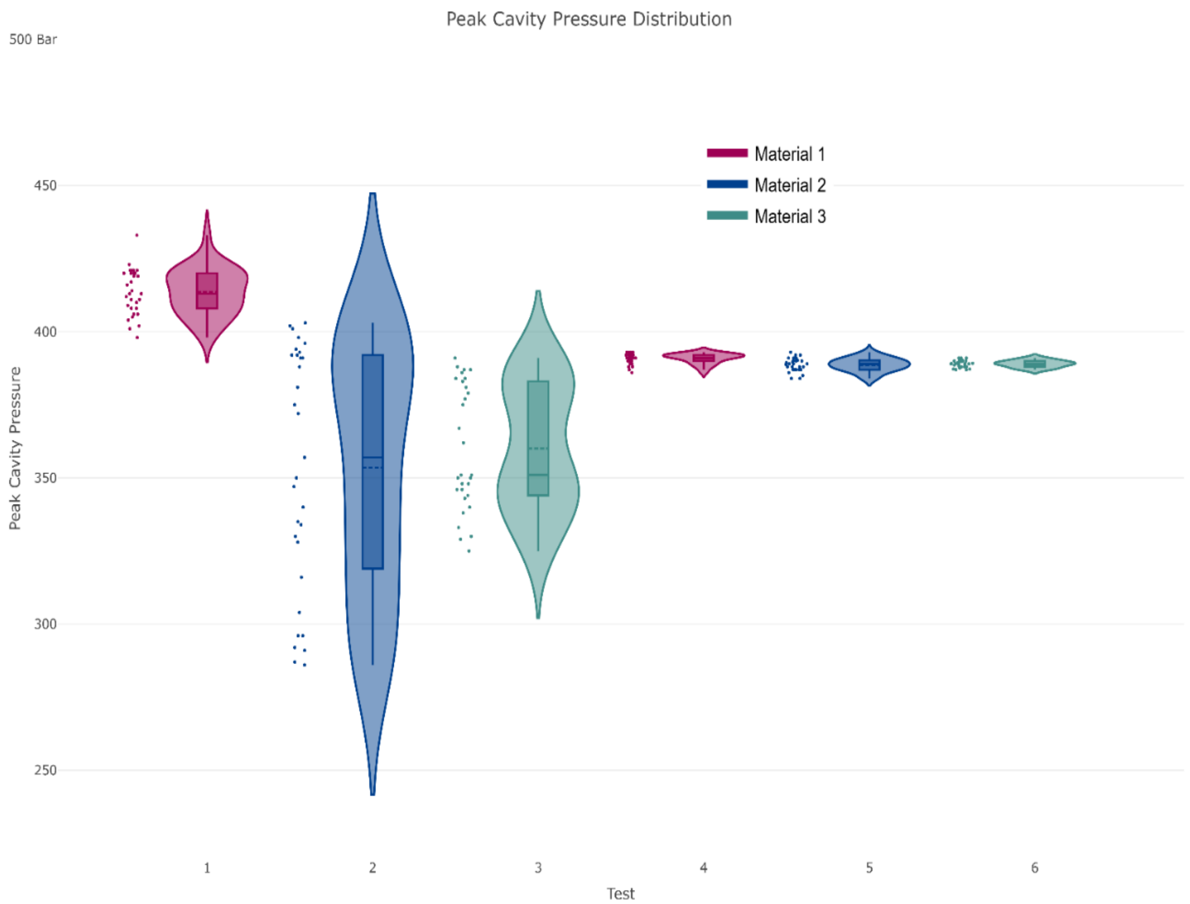

Fig. 3: Combined box plot to compare the peak cavity pressures per material and test series.

Fig. 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%.

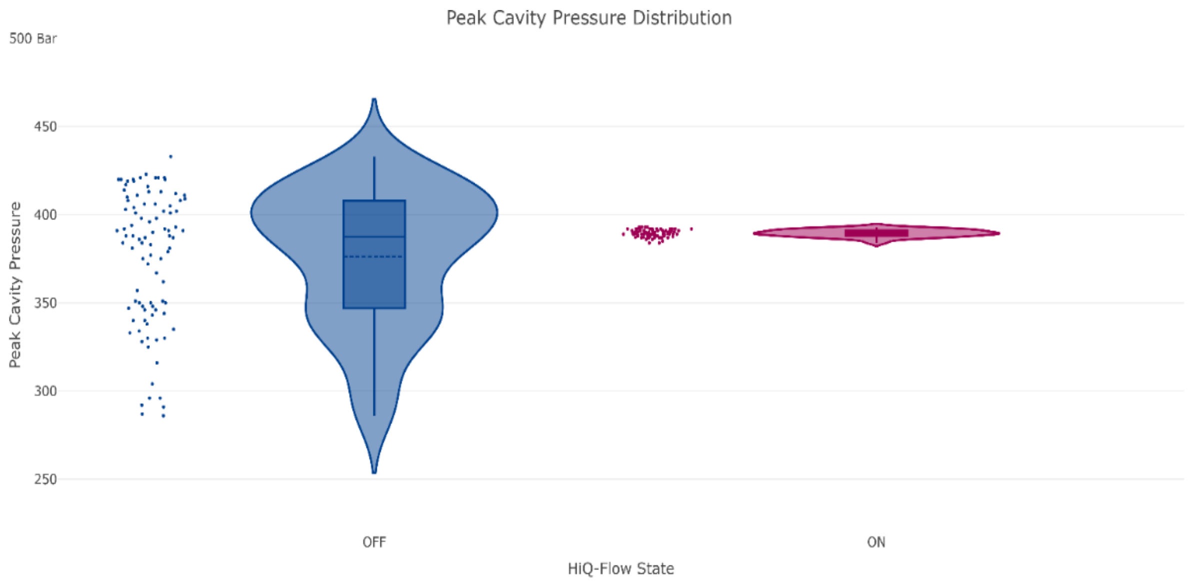

Fig. 4: Combined box plot for comparison of the maximum peak cavity pressures with HiQ Flow® ON/OFF.

Summary

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 HiQ Flow® 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. In this way, HiQ Flow® offers an extremely high return on investment.

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