In search of ultimate shot to shot consistency

John Goff contrasts the use of speed control and pressure control in the latest article in his series on how to achieve optimum injection cycles

Once the correct melt and the ability to deliver the same volume each cycle are achieved, it is important to look at the manner in which the moulding machine delivers the molten material to each impression within a mould tool. The type, make of moulding machine and its mode of control determine the ultimate shot to shot consistency and overall quality of component manufacture. Injection moulded components are not always produced with minimal weight variation being the main objective. Other features such as aesthetics, functionality and the ability to be decorated often take precedence.

A simple philosophy to adhere to is that when a moulding process produces parts that are consistent with each other (whether of good or poor quality) the process is classified as "under control". Naturally, if poor quality parts are produced, steps are taken to overcome this. If the process produces good and poor quality parts in consecutive or respective cycles, then the process is deemed "out of control". Consideration of consistency is vital when selecting the moulding parameters.

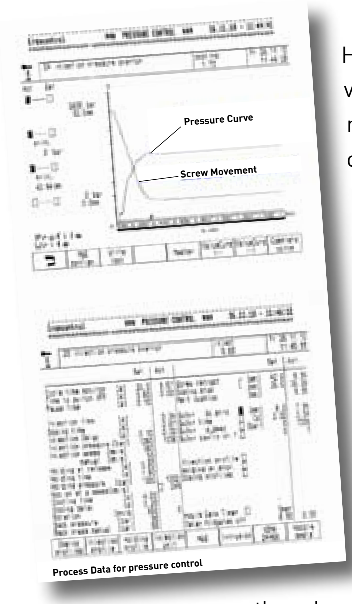
Irrespective of the type and make of injection moulding machine, there are two distinct modes of control used today: speed control and pressure control. The injection moulding process cycle is divided into definitive elements. Each element can be investigated and optimised to achieve the ultimate goal: producing better, consistent mouldings at minimum time cycles.

Conventional injection moulding principles revolve around two phases: filling the mould cavity to a particular fullness each cycle; and once this is achieved, compacting the material within the mould cavity to compensate for the inherent linear and volumetric shrinkage. In this way, a fully compacted component is produced, which upon solidification complies with the required quality standard.

Today's computerised injection moulding machines allow the filling and compaction phases to be distinctly separate and suitably controlled. The major percentage of melt volume required to produce the component is delivered into the mould cavity during the filling stage. Delivery can be achieved by speed or pressure control. The method of control has evolved as a consequence of the technology employed within the moulding machine.

Older, hydraulically actuated machines adopted the principle whereby the injection speed value was set to maximum and the corresponding injection pressure value was selected to throttle the speed of forward movement of the screw. This approach became extremely popular and was regarded as the standard for process setting. It is classified as pressure control.

Nowadays the control technology employed on most machines has vastly improved with regard to the performance of hydraulic components such as valves, pumps and actuators and the speed of communication between the control systems and the receiving component. This technology permits speed control to be used whereby the available injection pressure is often set to maximum initially and the injection speed value set to a value between just above zero and maximum. This speed value is directly related to the thermoplastic material being processed, the mould tool technology employed and the configuration of the component.



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Having the pressure set at a sufficiently high value allows the selected injection speed to be maintained throughout the forward movement of the screw.

Speed control has always been technically proven to be the more consistent technique for product manufacture and quality, which raises the question of why both principles are still used today. By remembering that the value of selected injection pressure has a considerable effect on the forward velocity of the screw, the following two scenarios provide the answer. Click here to download a four-page PDF of supporting graphs and data.

Scenario 1. A component has been produced by speed control. The processing data show the values captured for set injection pressure, actual injection pressure, injection time to fill component, selected injection speed and screw stroke used. The weight of the component is 9.996 g and the materials used are PC/ABS. The pressure–time graph shows the linearity of the line scribed by the forward movement of the screw and indicates that the velocity of the forward screw movement was consistent throughout its travel.

Scenario 2. The same component has been produced by pressure control. The processing data show the values captured for set injection pressure, actual injection pressure, injection time to fill component, selected injection speed and screw stroke used. The weight of the component is 9.994 g and the same grades of PC/ABS is used. Here, the associated pressure–time graph shows the profile of the line scribed for the forward movement of the screw and this can be segregated into two zones:

- linearity of screw movement until the pressure reaches the set pressure value
- after this value, the speed becomes non-linear and its velocity is reduced during the final distance towards the changeover position; this velocity will vary from cycle to cycle and production run to production run, thus inducing variability and changes in quality.

On initial weight comparison, the two mouldings differ by only 0.002 g, which is typical. However, in a prolonged production run that encounters material batch and/or colour changes, the variability experienced using pressure control will be considerably greater (3-4 times) than the variability seen using speed control.

Table I compares the different set and actual injection pressure values. The graph of the screw velocity traces identifies the difference between the control modes. Both techniques can and do produce mouldings in the same cycle time. However, for consistency and repeatability of manufacture, speed control is more consistent and the preferred method.

The question regularly put to me is, "Why would pressure control be used, knowing that inconsistency of component manufacture occurs?" The issues when producing components from high impression mould tools are flashed, over-packed and short components. This is the result if speed control is set incorrectly and inaccurately. Invariably flashed and/or over-packed components are produced when one or more impressions become blocked during a moulding cycle, because the excess volume is forced into the remaining impressions. This can be expensive due to mould damage.

Today's, moulding machine technology is better equipped to deal with these issues. The machine monitors the injection time, distance of screw movement and injection pressure used to fill the cavities, and when correctly set it suitably controls and prevents excess material entering the available cavities. When moulding machines lack this facility, the use of pressure control comes into its own because the moulding process will not allow the injection pressure to be exceeded, thus it prevents the remaining cavities from being over filled.

The main issue with pressure control is that during normal production the presence of shorts and under-packed mouldings will occur when melt viscosity changes are encountered. Flashed components will rarely be produced, therefore certain moulders prefer to adopt this method even though product quality inherently varies.

More information

This is the ninth article in the Moulding Masterclass series. Recent articles can be accessed, here, here and here. John Goff is MD of G&A Moulding Technology.

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Table I: A comparison of set and actual injection pressure values

Type of control	Injection pressure bar		Injection speed mm/s	Holding pressure		Injection time s	Melt cushion mm	Screw stroke mm	Part weight g
	Set	Actual		Set	Actual				
Speed	1800	1570	120	1300	1304	0.34	6.75	35.9	9.996
Pressure	1250	1336	150	1300	1302	0.34	6.95	35.7	9.994
Speed with profile	1800	1395	130/20	1300	1301	0.34	6.81	35.84	9.994