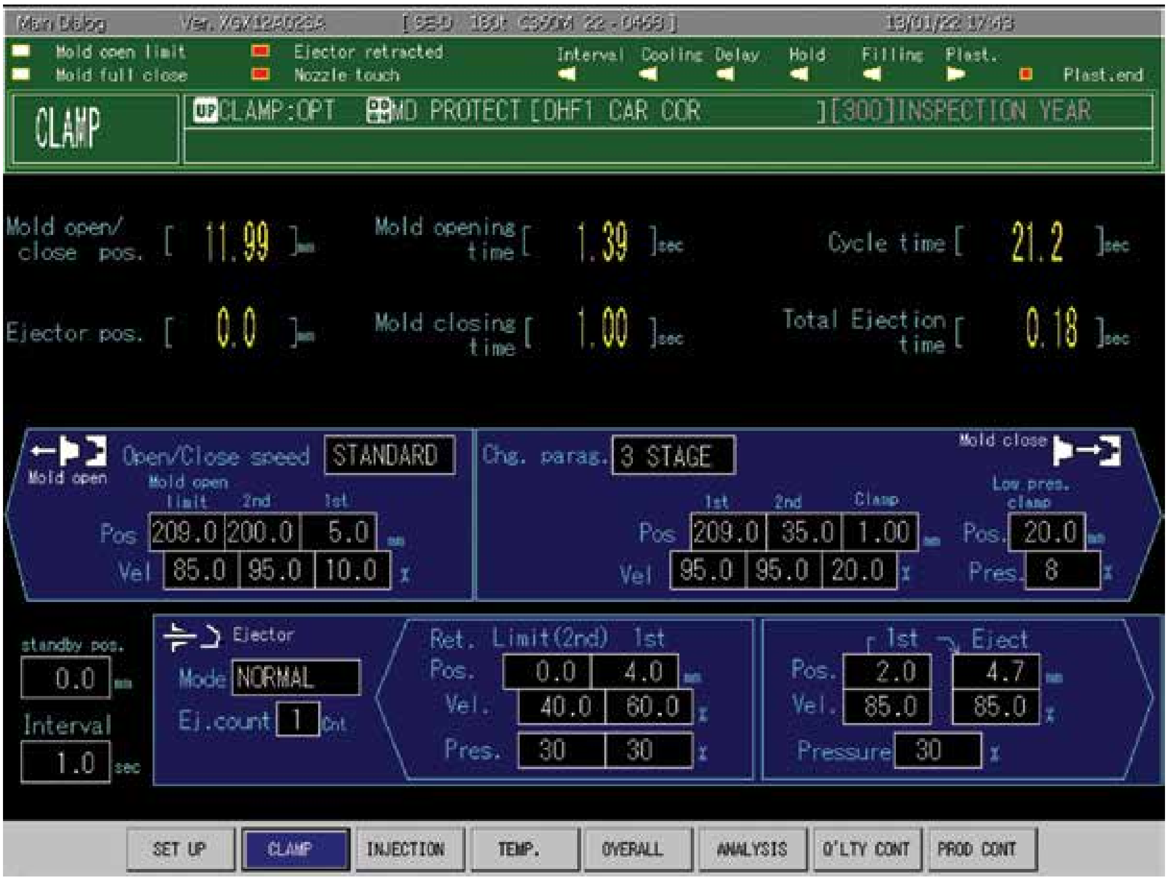


Main image: Your machine control provides the data you need to determine the stability of your process

Take control of process data

In the second part of this discussion of process variables, moulding expert John Goff explains how consequential variables can be used to determine the robustness of the moulding process

The first part of this discussion (published in the previous edition of *Injection World*) looked at the distinction between controllable and consequential process variables. To summarise that discussion, it can be said that controllable variables dictate the base line of component manufacture and productivity, whereas consequential process variables are those upon which the overall stability and robustness of a moulding process is assessed. Examples of controllable and consequential variables were presented and attributed to each of the main six steps of the process cycle in a table (see here).

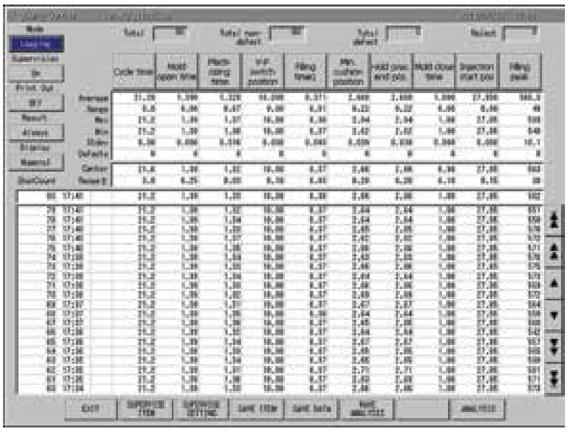
These consequential variables can be easily presented in tabular form from the data collected from each cycle by the computerised control within the injection moulding machine. These values can then be compared against previous cycles, highlighting the deviation (range) between the values as well as the average value for a pre-selected number of consecutive cycles. The control screen images (Main image and Figure 1) present examples of such variables.

By reviewing the amount of variation incurred within the range values, the extent of process consistency can be seen at a glance. Figure 2 shows values displayed on the control screen of the injection moulding machine for a limited number of consecutive cycles. It demonstrates that, in real terms, the time period over which the extent of process variability is viewed can be quite small and in many cases relates to less than one hour.

For this reason, the overall consistency of the moulding process should be viewed over the whole production run or time period. With current injection moulding machines this is rarely a problem but, where

Figure 1 (right): This screen shows the depth of data that can be extracted from modern machine controllers

Figure 2 (right): Machine controls provide cycle-to-cycle variation over short and long periods but many moulders do not use the data effectively



older machines are being used, an alternative solution is to employ a separate central data collection and analysis package. Unfortunately, such tools are not always employed . Over the years, the author has learned that many moulding companies may have the facility on their moulding machines to monitor important process parameters but do not use it.

It is important to appreciate that the values viewed in these machine control screens relate only to the moulding process. Consistency must be extended to the mouldings to ensure correlation of such processing values – particularly its weight, critical dimensions, strength of part or surface finish.

An extremely simple but effective analytical tool to assess the consistency of moulded products was developed 25 years ago by Frank Price, a practical statistician who worked in the injection moulding industry. Price devised a simple spreadsheet which required the recording of either the individual shot weight of each impression or the collective shot weight for 32 consecutive shots. The percentage variation calculated for the 32 shots highlighted the consistency of the process, with a lower percentage indicating a more consistent moulding process. The percentage value was then used to determine whether the resultant mouldings were suitable for measuring.

This approach of weighing the components prior to measurements being taken has been found to be much more cost effective and creates confidence prior to the metrology exercise being carried out with the knowledge that each impression would be consistent with each other. An optimised process is often called "free and easy" and has a variation of 0.4% or less.

The format employed within the spreadsheet in Price's method is to segregate the 32 shots into eight groups of four, upon which the average and range values are determined. Once these values are determined, further calculations in association with statistical principles are undertaken to ascertain the extent of inherent variation present. This value (inclusive of ±3 standard deviations) is then converted into an overall percentage value.

The mathematics incorporated for the 32 shot study is akin to that employed for the traditional 50, 100 and 500 shot assessment. As the predicted variation for the 32 shot study is only minutely different to that determined by the traditional techniques – and is not sufficient for the incorrect conclusion to be made - it is often preferred due to the significant savings in both time and costs it offers.

Many validating bodies now accept as proof of evidence the information obtained from the 32 shot study, in association with the processing data from optimising the injection moulding process by the systematic technique, as demonstrating how the process parameters have been determined and the relevant consistent component quality achieved from these conditions during their manufacture.

At G&A Moulding Technology, it was decided to include the 32 shot study within the company's PRO-OP software program for mould tool proving and validation, as well as for process optimisation purposes, as it provides a direct correlation to the stability of the process and Cp values for the measured components.

The next article in this series will look at the effect of external influences and malfunctions of important ancillary equipment on overall process stability.

About the author:

John Goff is a chartered engineer (CEng), a Fellow of the Institute of Materials, Mining and Metallurgy (FIMMM), and managing director of injection moulding process consultancy and moulding process optimisation software developer G&A Moulding Technology (www.gandamoulding.co.uk). This is the 26th instalment in his Moulding Masterclass series of injection moulding process optimisation articles and is the second part in a discussion on the understanding and effective use of measured process variables. You can read the most recent instalments in this series **here**, **here** and **here**.