Poorly performing ancillary items – such as cooling systems – can have a critical influence on process control. Moulding expert **John Goff** explains why

Why cooling really matters

In the March instalment (**http://bit.ly/14ydRlg**) in this Moulding Masterclass series the effect of external influences and malfunctions of important ancillary equipment on overall process stability was highlighted. We will take a closer look at this area of process control in this instalment.

The inclusion of the boundary limits, derived from the process window exercise using the on-line or moulding machine process monitoring facility, allows changes that occur to the process due to external means to be readily detected before a loss of production performance. Such external factors, which can be very difficult to detect in normal working conditions without such monitoring, include:

- A lack of cooling capacity within the moulding operation, leading to ineffective temperature control of the cooling medium (which should be normally be maintained within the range of ± 2°C,and preferably ± 1°C);
- The inability to maintain the set temperatures of the hot runner system through either poor control or ineffective calibration;
- The inability to maintain a constant mould surface temperature due to insufficient pumping pressure, low coolant flow rates and/or ineffective control of the mould temperature controller.

The first of these – ineffective cooling medium control - often becomes apparent when not all of the available injection moulding machines are being utilised, putting less pressure on the existing system and making it more efficient. This leads to statements such as: "We get fewer quality issues with a reduced number of machines working". More importantly, it allows a greater number of components to be produced at or less than the standard costed cycle times, with the overall equipment efficiency increasing due to less frequent interruptions and machine stoppages.

Due to the reduced requirement being placed on the cooling system, increased coolant flow rates often prevail, enabling the heat energy absorbed by the cooling medium to be more effectively removed, thus providing a more consistent and lower base temperature.

Ineffective heat energy removal and variability of the base temperature value are not only reflected in part quality variation but also in moulding machine performance, particularly with hydraulic machines. It is known that the viscosity of the oil passing within and around the moulding machine changes as a consequence of temperature variation, and this ultimately affects the speed of actuation (injection speed), the responsiveness of the control system upon changeover from filling to packing phase, the application of holding pressure, consistency of control of screw back pressure; and variability in injection peak pressure. Any, or all, of these can significantly affect the resulting

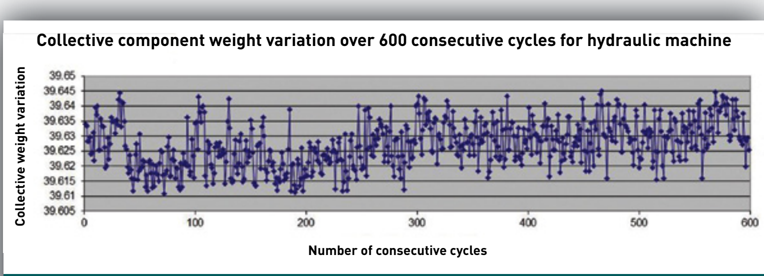

Figure 1: Effect of oil temperature on part weight

moulded components.

It is therefore important that when using hydraulically-actuated moulding machines there is accurate control of oil temperature. Furthermore, different machines necessitate differing oil temperature values of between 40 to 50°, so the manner in which the oil temperature is controlled is dependent upon the base temperature of the coolant and flow rate in and around the oil cooler. Hydraulic machines using servo valve technology require less variation in oil temperature than pump controlled machines for accuracy of performance and maintenance of part quality.

It is often asked: "How would monitoring the moulding process detect such changes in coolant supply and variation in its base temperature?" Some processors correlate changes in product attributes with process condition variation to technically substantiate when variables deviate outside set boundary limits, resulting in non-conformal components.

Figure 1 shows a typical sinusoidal wave characteristic where the temperature of the oil fluctuates due to erratic/poor cooling capacity. More importantly, the time taken for the temperature of the oil to stabilise from production start-up has a significant influence on the dimensional and physical attributes of the resultant components. For this reason, the inclusion of oil pre-warming has become an essential pre-requisite to ensure that oil is up to working temperature before production commences, bearing in mind the oil temperature throughout the machine is often not at the same value so inherent viscosity variation can be present.

Many studies have captured this issue but such variations go unnoticed as so many processes are not monitored. Lack of oil temperature control will cause issues such as:

- Differences in injection velocities;
- Variation in response times from filling to packing phase;
- Differences in part dimensions and/or weight throughout and across production runs.

The emergence of servo-electric moulding machines has overcome some of the problems encountered with the traditional hydraulically-actuated machines.

This discussion will be continued.

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This is the 27th instalment in his Moulding Masterclass series of injection moulding process optimisation articles. You can read the most recent instalments in this series **here**, **here** and **here**.