Hot end forming process control is hot!

Paul Schreuders presents a blueprint for hot end forming process control in the glass container industry. According to the author, it's time to become better organised.

Paul Schreuders

Enormous challenges are faced in the world of glass container production. On the one hand, the industry has to deal with increasing customer quality/cost demands while on the other, production efficiency is low and external pressures regarding environmental issues (carbon emissions) and alternative packaging solutions (PET) are high.

To deal with these challenges, increasing numbers of glass container producers are focusing on hot end forming process control. In general, these companies realise that a stable forming process is a precondition for having predictable output in terms of quality and quantity (less defects, less downtime, less job change time, higher flexibility, higher reproducibility, less swabbing, less weight, higher speed etc). Ultimately, they recognise that a stable forming process is necessary to remain competitive and simply to make a profit.

These companies are certainly correct! Personally and based on where we are today, I believe that a conscious focus on hot end forming process control will bring 20%-25% savings to the industry and to its environment within the next five years. A precondition, however, is to become more organised in terms of hot end forming process control.

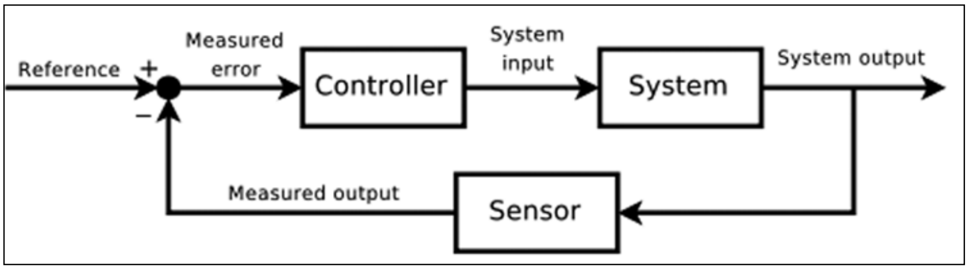


Figure 1: Process control feedback loop.

PROCESS CONTROL

In general, process control follows the logical sequence shown figure 1. Following this logic, it has to be concluded that essential for effective process control is the ability to measure the system output and the ability to control.

In the hot end forming process for glass containers, the system is the IS machine, which consists of many sub processes, for example gob forming, gob loading and container forming. Looking at the IS machine including its sub processes, there are numerous ways to control the sub process and different tools to measure the output of the sub process.

Ways to control sub processes: It might not be fully realised but there are numerous ways to control the output of the IS machine and/or its sub processes. Conversely, looking at an IS machine and/or its sub processes, there are numerous sources of process variation. For example, the following can be mentioned: Machine timing, mould design, cooling condition, job change, mould condition, section performance, ware handling, gob weight, gob loading, glass quality, gob condition, gob temperature, mould material, operator behaviour, not forgetting IS machine construction!

Ways to measure sub processes: Based on what is available from suppliers to the glass container industry, numerous tools can be listed for the measurement of viscosity, gob shape, gob temperature, gob weight, gob accelerator, mould temperature, HPC, PPC, cooling wind control, blow air control etc.

Having so many ways to control and/or so many sources of process variation and having so many ways to measure, questions comes up about effectiveness of control and effectiveness of investments in measurement systems.

Gob shape, for example, can be measured after gob cutting. The measurement system produces nice pictures of the gobs cut, which can be used for the purpose of reproducibility of the cutting process. However, gob shape at the gob cutting position does not explain how the gob looks when it enters the blank mould. And we know that delivery causes many disturbances that will influence this original shape. A positive reason for

INTENSITY CHARTS EXPLAINED

The charts shown in this article are so-called intensity charts. An intensity chart is a standard chart within the XPAR Vision infrared dual camera system. It is based on the thermal analyses of individual bottles. The intensity chart shows the intensity variation of bottles produced per cavity during the most recent hour of production. The intensity variation is shown as a relative value and per single zone of the bottle.

In the example given here, the intensity variation for four specific zones is shown. A sudden decrease or increase of intensity levels per zone is an indication of a sudden process change, eg swabbing, valve issues, loading etc. As such, the intensity chart says everything about the status quo of the forming process.

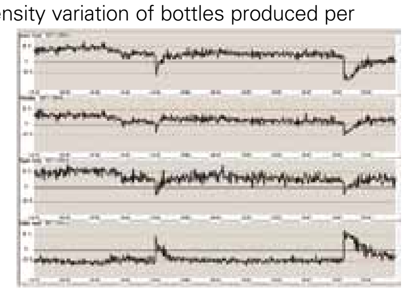


Figure 2: XPAR Vision hot end infrared camera system for inspection and process monitoring and control.

investing in gob shape measurement at this point is that initial variation of gob shape reduces. By how much, however? And what is the effect on the gob when it enters the blank mould? Last but not least, what is the effect on the container produced?

Separately, gob temperature can be measured after gob cutting. The measurement system will finally lead to reducing the initial variation in gob temperature. But how important is this variable in the parison forming process when compared to viscosity, for example? And what is the actual effect of these variables on the glass distribution of containers produced?

A third important consideration involves mould temperatures, which can be measured at the blank side. It should be recognised, however, that the measured blank temperature is a result of contact between glass and blank material and the amount of cooling on the blank. So what is the real value of mould temperature measurement when contact between glass and blank material are not taken into account? And will we ever discover the answer without knowing the effect on the glass containers produced?

In summary, it has to be concluded that although considerable attention is placed on hot end forming process control, there is a lot of internal inconsistency about how measurement and control are executed and thus, a great deal of ineffective financial expense. Time to become more organised about hot end forming process control!

ORGANISATIONAL BLUEPRINT

Having been active in the field of hot end forming process monitoring for more than 10 years, XPAR Vision has built solid experience in this field. The company is developing a concept for hot end forming process control, consisting of several logical, correlated systems or solutions, including the infrared dual camera system, the infrared gob weight control system, the Gob Assist system (measuring loading at the blank mould), the blank side temperature control system and the central SQL-based information system.

Based on a decade of experience, presented below is a blueprint for effective hot end forming process control.

Step 1 – Measure IS machine output: A logical first step towards a higher level of hot end forming process control is to measure the output. And because the IS machine produces containers, formed containers should be measured. Based on these measurements and of course, customer requirements, it is necessary to determine which process steps influence the process quality most and how the process variables interact with one another.

A good tool for measuring formed containers is an infrared camera system for hot end inspection, process monitoring and quality control. XPAR Vision has supplied these systems for over 10 years, installing more than 300 in about 80 factories. The main advantage of having infrared camera systems at the hot end is that with this technology, heat transfer is determined as it has taken and takes place in the forming of containers (see figure 2). No other technology can do that.

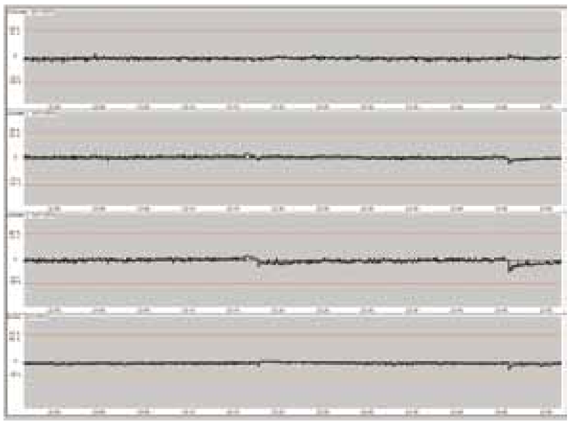
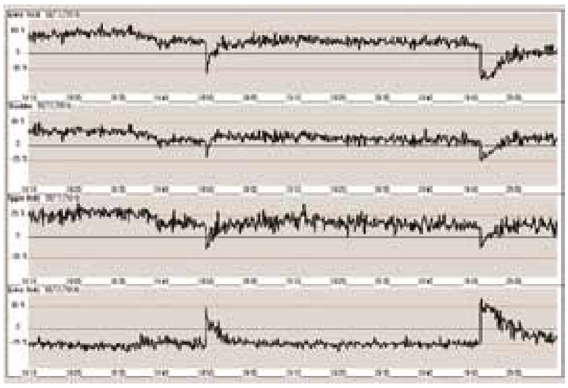


Figure 3: XPAR Vision forming process control charts for a single cavity.
Above: low level of intensity variation = well under control;
below: high level of intensity variation = not properly under control.



With an infrared camera system, it is possible to visualise the behaviour of the forming process in terms of radiation of intensity on cavity level (see figure 3). Through radiation of intensity, we are able to conclude on the status quo of the forming process.

Step 2 – Ensure (negative) operator influence is minimised: Machine operators are heavily involved in the forming process by means of swabbing, changing moulds, weighing bottles, analysing sub process data and taking actions accordingly etc. Inconsistencies in the way different operators perform tasks is a main source of process variation.

Negative operator influences should be reduced by properly implemented standard operating procedures. The monitoring and supervision function of the infrared dual camera system should be used to manage this operator alignment (see figure 4).

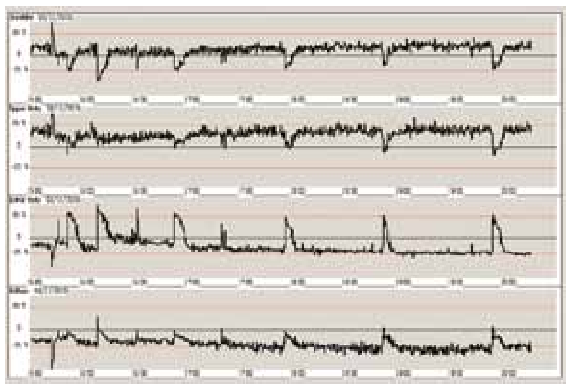


Figure 4: XPAR Vision forming process control charts for a single cavity. The peaks are sudden process changes due to swabbing. It can be concluded clearly that there is no standard operating procedure for swabbing and/or the SOP is not well implemented among different operators.

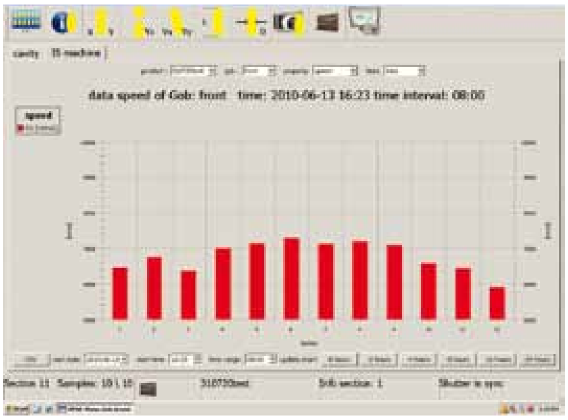


Figure 5: Gob speed differences between sections.

Step 3 – Admit individual section inputs are different: Analysing many different hot end forming processes for years brings XPAR Vision to the conclusion that one of the biggest sources of forming process variation is the IS machine itself. Due to the construction and set up, the input for individual sections is different.

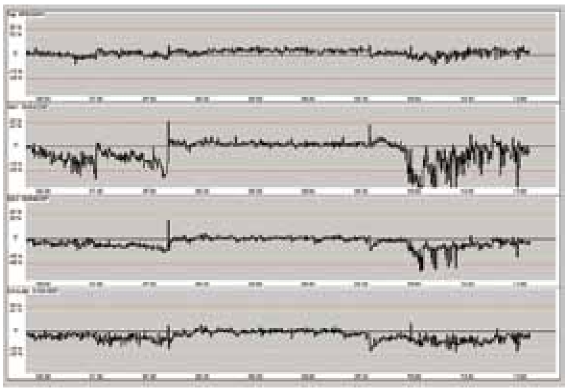


Figure 7: XPAR Vision forming process control charts for a single cavity, clearly showing gob loading getting out of control.

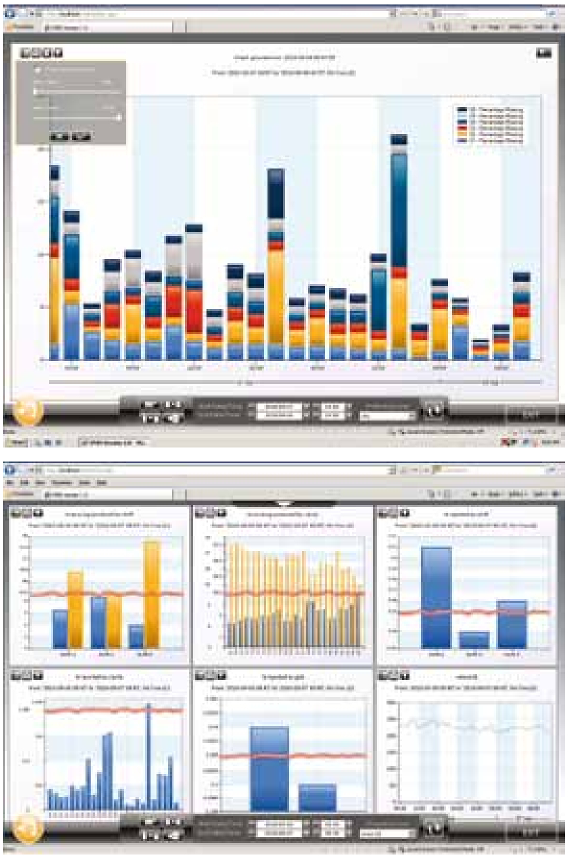


Figure 8: XPAR Vision's XMIS system; shown here are a typical graph and dashboard with hot end process data.

Figure 6: XPAR Vision's Gob Assist, used to measure the gob speed as shown at figure 5.

Figure 5 provides an insight to gob speed differences between sections. It clearly shows a lower speed at the outer sections compared to the inner sections. These differences in speed are the direct result of the IS machine design. If not compensated for, they will lead to differences in quality of output from different sections. The length of gob shows a similar graph.

XPAR Vision's Gob Assist (figure 6) is used to measure the gob speed, as shown at figure 5.

Step 4 - Measure output of the most important independent sub processes and ensure these measurements are consistent internally: The most important independent sub processes are (a) gob forming, (b) gob loading and (c) container forming. Having admitted that the input of each section is different (see Step 3), ensure sections are measured independently. Furthermore, when looking at gob loading, for example, the value of mould temperature measurement is very limited if in the meantime, the gob loading itself is out of control. In other words, temperature measurement only makes sense when gob loading is under control.

Step 5 - Ensure that measurements of sub processes are one-to-one related with the output measurement of the main process: If, for example, gob loading worsens, this can be clearly seen in respective control charts of the infrared dual camera system (see figure 7). The same applies to changes in glass temperature and/or cooling capacity of the moulds.

It should be clear that the infrared dual camera system is acting as a 'gate keeper' for the forming process as a whole. Any change in the process, any source of variation, will be visualised and warned or alarmed for. When a change is that sudden and that bad, there is even the possibility of rejecting the bottles at the hot end. This system of warning, alarming and rejecting in combination with measurement systems of the output of sub processes allows effective diagnosis and actions.

Step 6 - Embed systems in correlation to each other: Most important though is that somehow, the forming sub process control loop is closed. The different control actions and measurements should be brought together in one platform, which allows for making all necessary correlations and analyses. In return, this platform should be used as the main tool for hot end forming process improvement.

XPAR Vision has developed such a tool, called XMIS, an SQL-based information system to which all other (XPAR) systems are connected. XMIS allows all process data and important control actions to be stored on and retrieved from a centralised server (see figure 8).

As such, XMIS enables the user to analyse for critical defects, perform process improvements and benchmark between lines, sections and cavities, for example. It also provides access to historical data, for traceability in case of customer reclamations.

One single and centralised platform is an invaluable step to maximise the understanding of the hot end forming process and to drastically improve both the forming process and product quality. ■

ABOUT THE AUTHOR:
Paul Schreuders is CEO of XPAR Vision

FURTHER INFORMATION:
XPAR Vision BV, Groningen, The Netherlands
tel: +31 50 316 2888
email: contact@xparvision.com
web: www.xparvision.com