What use is a forehearth audit?

John McMinn argues that regular audits of forehearth maintenance and operation can increase forehearth life and reduce costs

At the beginning of 2000 the ISO estimated that the annual global production of glass containers was approximately 60 million tonnes. In the late 1990s a survey of UK container manufacturers reported that the production pack rate varied from 68% to 91% with an average of 81%.

The Emhart Glass guide 'Glass Container Defects – Causes and remedies' identifies 66 recognised bottle faults. It is difficult to be exact when attributing the origins of a defect – many are caused by different stages in the forming process. Thin shoulders, for example, can be due to poor thermal profile in the forehearth, but also may be due to machine operation where the blank mould is too hot, or may be because of the feeder mechanism set-up where the gob length is too long.

However the defect guide attributes the forehearth as a potential source of 53 faults (80% of the total). This is not to imply that 80% of the ware is rejected due to forehearth-related faults, but to reflect the importance of the forehearth in the manufacturing process. Absolute figures for forehearth-related ware rejection are difficult to obtain, but around 3% of production is lost due to temperature or conditioning problems within the forehearth.

If applied to the ISO estimate of global glass container production, the amount of containers lost as a direct result of forehearth-related problems is a staggering 1.8 million tonnes of glass per year – the equivalent of the total annual output of 16 x 300 tpd furnaces. At plant level this is the equivalent of a 300 tpd furnace rejecting almost 4000 tonnes of glass per year due entirely to a mismanaged or poorly maintained forehearth.

The opportunity for money saving and increased productivity is obvious but there are other potential savings. For example, the containers may be rejected due to glass distribution which has been linked to a cold glass stream in the forehearth. The cold stream could be caused by the inability of the forehearth to rectify the thermal gradient due to an incorrectly set combustion system. In this case the plant owner pays three times: once to melt the container, once to re-melt the rejected container and once to pay for the wasted gas that may have caused the problem in the first instance.

FOREHEARTH-RELATED WARE REJECTION

Assuming the forehearth and the production requirements are correctly matched and the furnace is functioning correctly, the main reason for forehearth-related ware rejection is incorrect forehearth and / or distributor operation. This in turn is due to incorrect settings / calibration of the forehearth subsystems which, in many cases, can be linked to inadequate or poor standards of forehearth training. Often the only training the operators receive is a quick introduction immediately before or after commissioning.

This degree of training is ineffective and allows poor practice to proliferate; training should be an ongoing procedure designed to provide a fundamental understanding of the processes involved in achieving the desired glass thermal profile. Post-commissioning training is typically restricted to operational basics such as how to increase set-points or install a skimmer block. This does not equip the operator with the knowledge that will enable him or her to understand what is happening when an operational parameter is changed, or predict the outcome and timescale involved in the changes they make. This knowledge is vital as it impacts on the performance of the forehearth, the pack-rate of the production line and the protection of the forehearth and its subsystems.

Another source of wasted money is lack of maintenance and the inability to ensure the forehearth equipment is operating at optimum efficiency. A modern forehearth system is considerably more expensive than a Ferrari; few people would purchase a Ferrari, drive it continuously for 10 years and assume it doesn't need servicing – yet this is how many forehearths are operated in the glass industry today. Unexpected downtime due to forehearth or forehearth subsystem failure is a costly and inconvenient event, yet in many instances it is avoidable. Regular audits of both the forehearth systems and the performance of the forehearth operators provide knowledge of the status of the equipment and how efficiently it is being operated.

WHAT IS A FOREHEARTH AUDIT?

The principal objectives of a forehearth audit are to save money and protect plant equipment and personnel in a hazardous working environment. The audit also determines the maximum achievable efficiency of the forehearth and compares this to how efficient the system is currently operating – the difference between the two equates to money wasted in reduced pack-rates or squandered fuel.

A vital role of the audit is to determine what actions are necessary to ensure the trouble-free operation of the forehearth, and when these actions need to be taken. A forehearth audit provides a detailed account of weakness in the system and its operation. Faults are categorised as red, amber or green depending on the urgency for the replacement or adjustment of the component or subsystem.

The tools used in a forehearth audit are:

- thermal stability analysis
- dynamic response analysis
- combustion efficiency
- cooling efficiency
- combustion linearity
- cooling linearity
- control function verification
- forehearth operation.

Typically a forehearth audit involves over 900 readings and measurements which are analysed to provide an exact verification of the status and performance of the various forehearth components such as combustion and control systems, for example. The audit also maps the interaction of the forehearth subsystems to ensure compatibility of reaction and performance.

In today's economic climate it is understandable that glass plants want or need to extend the working lifetime >

of the forehearth. Unfortunately, forehearth performance deteriorates with age and the chances of a catastrophic, unscheduled shut-down are greatly increased. In cases like these the need for forehearth audits is clear.

OPERATIONAL ASSESSMENT

Most operators use the thermal efficiency value as the basis for the assessment of forehearth performance, however high thermal homogeneity levels do not necessarily translate to good forehearth performance. For example each equalising thermocouple could be at the same temperature but 10 degrees hotter or colder than required for the gob, or the 9 thermocouple points may be reading the same temperature but that temperature is cycling by 10 degrees, causing weight problems.

A typical forehearth audit report is approximately 40 pages in length, so this example is limited to one area: the dynamic response analysis, which is used to identify forehearth operational problems. Figures 1 and 2 show the response of an operating forehearth cooling zone to a 5ºF step increase and decrease in the set point. In the case of a step increase it takes the system 50 minutes to alter the output from the controller from 38% to 47%. During this time the actual temperature increases by 40% (2ºF) of the required temperature change.

Although the PID settings used should be contributing to this slow response, the forehearth audit showed that the low response and temperature increase was in fact due to a wrongly calibrated air / gas ratio. Figure 3 shows the result of the forehearth audit analysis of the O_2 content: the O_2 analysis identified that over this output range the air / gas ratio is significantly off calibration, causing the slow temperature increase. Changes to the PID values would have been of little use, if not actually detrimental to forehearth performance.

The response for the cooling loop should be faster than the heating loop and this was confirmed. Again the PID values being used should provide a slow response and the 5ºF decrease was obtained in 30 minutes with an associated increase in controller output of 17% to 30%. However the forehearth audit discovered that the major contributor to the slow temperature response was due to the settings of the cooling control valve and a lack of control linearity.

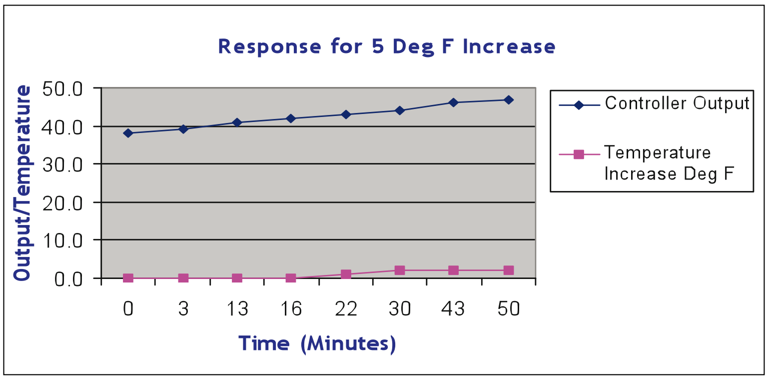

FIGURE 1: STEP INCREASE

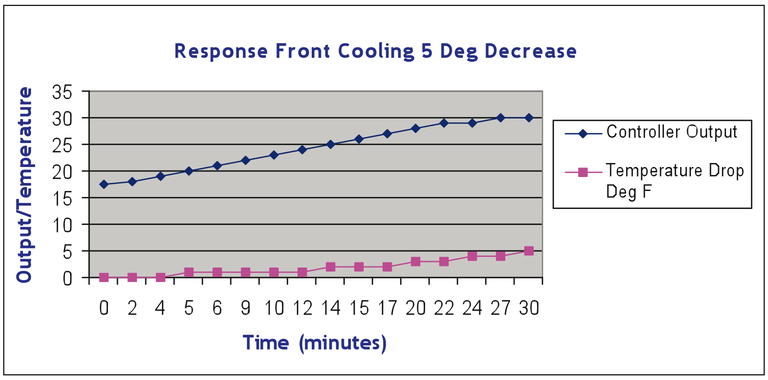

FIGURE 2: STEP DECREASE

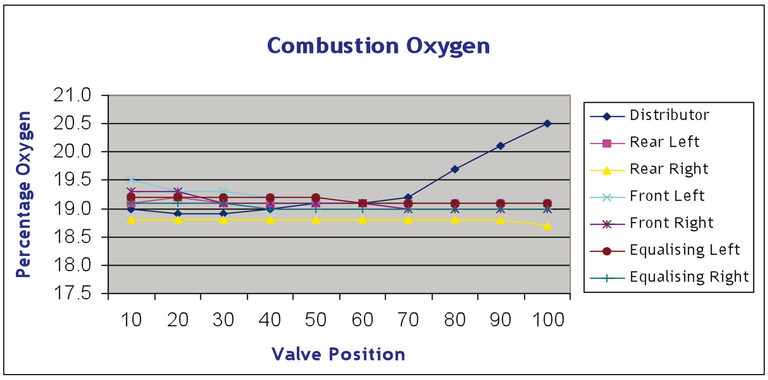

FIGURE 3: AIR / GAS RATIO ANALYSIS

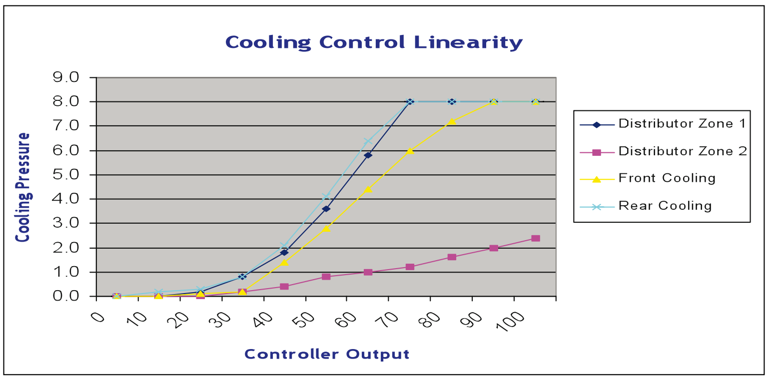

FIGURE 4: COOLING CONTROL ANALYSIS

OVERALL ANALYSIS

The forehearth audit includes an analysis of the cooling system. Part of this analysis is shown in Figure 4 which shows the relationship between cooling pressure and controller output. It can be seen that for the output range 17% to 30%, the cooling pressure is only between 0% and 0.2% of the available pressure range. Consequently the slow response is not due to inaccurate PID settings, which would have been an obvious conclusion, but is due to a badly set up cooling control valve.

This is a small example of how a forehearth audit can correctly and precisely identify the origins of forehearth malfunction. Simply looking at the forehearth subsystems in isolation is not sufficient to appraise the operation of the complete system. Forehearth Services provides independent and impartial engineering services including forehearth audits, forehearth training courses and forehearth consultancy for all forehearth systems, irrespective of design or original supplier. ■

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