Which is the best forehearth design?

John McMinn considers how any forehearth design, good or bad, is compromised through its subsystems and operation. He concludes that a technically superior and expensive system is no guarantee of forehearth performance.

Having performed performance audits on all major forehearth designs, Forehearth Services is often asked which is the best forehearth design. Some designs are theoretically and potentially superior to others, exhibiting clear advantages in terms of glass conditioning, extended tonnage and gob temperature ranges, job change reaction times and fuel efficiency. Presumably, therefore, the answer to the question should be simple – except that it is not!

Different forehearth suppliers choose different subsystems. The choice is determined by the perceived effectiveness of the system but cost and the need to have differentiation from competitor systems are also important considerations. Consequently, there is a range of cooling, combustion and control technology available.

Forehearth Services forehearth performance audits have repeatedly shown that even the best systems are compromised by two factors – de-calibration of subsystem equipment (cooling, combustion and control systems) and operator skill levels.

Although outside the scope of this article, it is important to understand that the most important element in determining a forehearth's glass conditioning potential is the roof block profile and the control of cooling and combustion gases within the combustion chamber. This presentation concentrates on how any forehearth design, good or bad, is compromised through its subsystems and operation.

SYSTEM CALIBRATION

Calibration and the need for recalibration should be a major factor in choosing a forehearth system. This greatly determines the performance of the forehearth in operation. The important factors to be considered are:

- How long does the system maintain calibration?
- How easy is it to recalibrate the system?
- How long does it take to recalibrate the system?
- What disruption to production is caused by the recalibration process?
- How easily do external factors influence the calibration?

OPERATOR EXPERTISE

The expertise of the operator and maintenance personnel is a vital element in forehearth performance. As systems become more complex, operator understanding of the subsystems becomes more critical. The important factors to be considered are:

- What skill level must the operator possess?
- Does the operator fully understand the operation of the system?
- What additional training does the operator require?
- What routine maintenance is applied?
- How often is the operation of the system checked?
- How to know if the system is underperforming.

COMBUSTION SYSTEM CALIBRATION

It is not possible within the context of this article to concentrate on the many aspects in which forehearth operation is compromised by subsystem de-calibration. Consequently, emphasis here will be placed on the combustion system. In the experience of Forehearth Services, an acceptably calibrated combustion system is rarely encountered. >

Figure 1: The effect of de-calibration on % oxygen stability for what is regarded as a high performance combustion system.

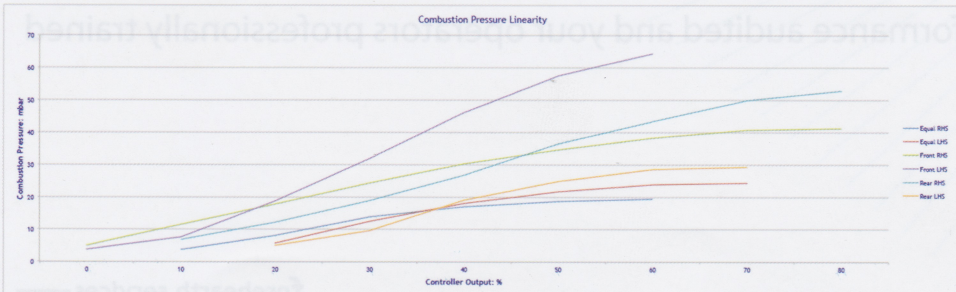

Figure 2: The combustion air control valve is another example of de-calibration.

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Clearly, the combustion system is a vital factor in forehearth operation and glass conditioning. It is also a fact that in terms of the two most critical combustion system requirements - the achievement of correct and stable air gas ratio and combustion valve linearity - some forehearth suppliers offer superior systems. Despite this fact, forehearth audits frequently reveal potentially superior systems operating less effectively than theoretically lesser systems. This is due to the wide variation in the ability of different systems to maintain calibration. It is also due frequently to low operator skill levels, a lack of knowledge of the equipment being used and its calibration requirements.

Performance audits have shown that, correctly calibrated, system A may provide more accurate combustion than system B. However, system B may provide more long-term stable combustion conditions, require less re-calibration, is faster to recalibrate producing less disruption to production and is easier to calibrate, easier for the operator to understand and is less expensive. In this instance, it may be more prudent to chose system B rather than system A. In these terms, recalibration issues can be of more importance than absolute, theoretical combustion accuracy.

Figure 1 shows the effect of de-calibration on % oxygen stability for what could be regarded as a high performance combustion system currently offered by a major forehearth supplier. This is typical of information found during a forehearth performance audit. Clearly the loss of calibration results in poor forehearth performance and low fuel efficiency. This is jointly the result of the tendency of this particular system to de-calibration and the inability of the operator to recognise the signs of loss of calibration due to inadequate training.

Another example of de-calibration is the combustion air control valve. Again, a typical example taken from a forehearth performance audit is presented in figure 2. In fact, the linearity of each combustion loop shown is not untypical. What is problematic for forehearth control and operation, however, is the spread of combustion pressures at the same controller output.

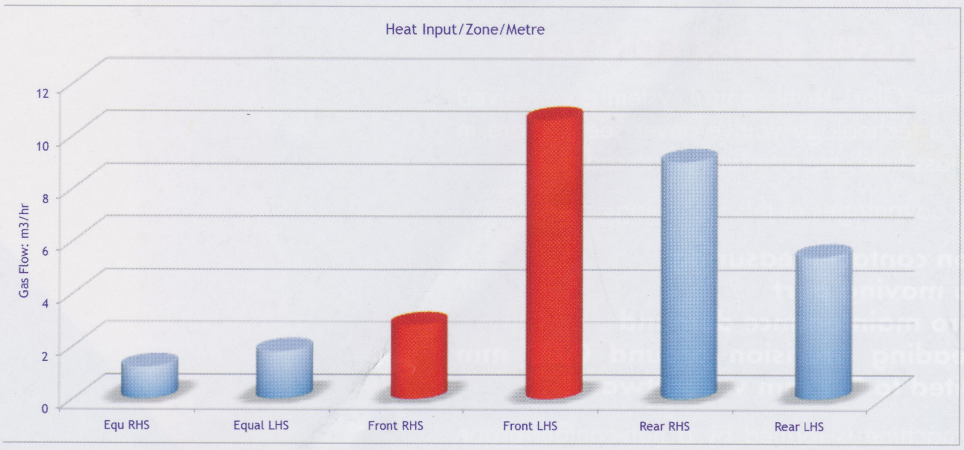

Figure 3: Audit result for a different combustion system and the effect of de-calibration on system performance.

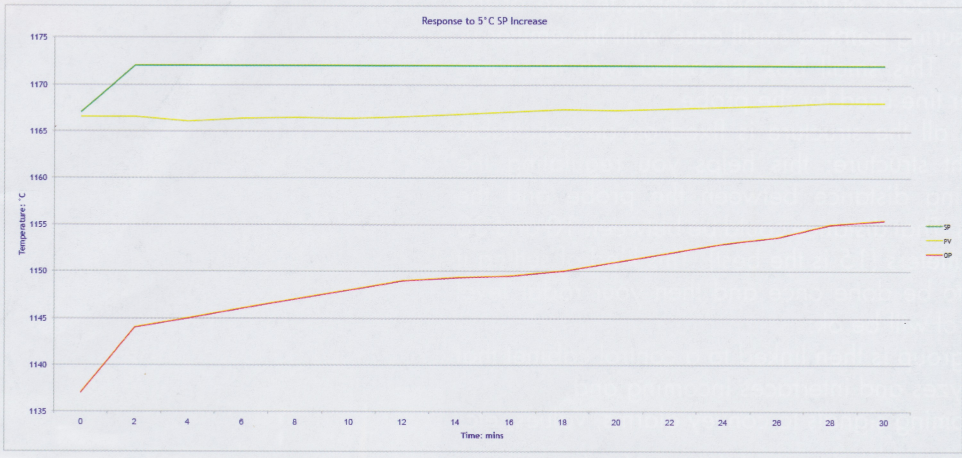

Figure 4: This forehearth is unable to achieve the set point due to de-calibration of the zone mixer air/gas ratio and is also hampered by inappropriate PID values.

Figure 3 shows an audit result for a different combustion system and the effect of de-calibration on system performance. In this case, the forehearth is equipped with independent side-to-side combustion loops to enhance forehearth performance. However, the amount of combustion available to the front zone LHS is three times great than that available to the RHS. Side-to-side combustion is an expensive but potentially beneficial feature offered by most forehearth suppliers. However, in the described case above, the benefits are lost, due again to the de-calibration of the system, poor maintenance and lack of operator awareness, as well as the inability to detect system malfunction.

Finally, another example of de-calibration is shown in figure 4. In fact the problem here is two-fold. The forehearth is unable to achieve the set point due to the de-calibration of the zone mixer air/gas ratio but is also hampered by inappropriate PID values – which is basically also a calibration issue. Interestingly, approximately 85% of all zones audited by Forehearth Services have shown inappropriate PID values.

CONCLUSION

It has been possible to describe only a fraction of the problems caused by de-calibration and inappropriate forehearth operation. While some forehearth systems are inherently superior to others, operation is often undermined by the high maintenance levels needed to maintain the system at optimum performance.

Lack of training and low skill levels of operators often allow de-calibration to persist at the cost of forehearth performance, pack rates and fuel efficiency. A technically superior and expensive system is no guarantee of forehearth performance. ■

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