Troubleshooting blister in forehearths

Through a combination professional training and forehearth optimisation audits, Forehearth Services has helped improve productivity for many of the glass industry's leading container and tableware manufacturers across for continents. However, the company is also regularly called upon to troubleshoot a myriad of forehearth-related operational problems, as John McMinn explains.

The years 2014 and 2015 saw an unprecedented increase in requests for assistance from customers suffering from blister problems. Using techniques developed four forehearth performance audits, Forehearth Services has established an audit routine specifically designed to identify operational and design factors responsible for blister formation.

Blister formation can be complex, may be caused by a variety of factors and can form anywhere in the system. Consequently, an investigation of blister formation necessarily requires a methodical analysis of both the blister itself and the current and historical operational parameters.

A COSTLY PROBLEM

A severe incidence of blister bubble can be an exceptionally costly problem for container manufacturers. Understandably, when a plant experiences a blister problem, the response required is immediate and above all, measured. The author's 40 years in the glass industry has shown that regardless of experience and the claims of some, it is a myth that a visual examination of a container can produce a definitive diagnosis of the cause of the blister and the formation position based on the type of blister, its size, shape or position on the container, regardless of the experience of the viewer. Of course, these can provide clues but a reboil blister in an amber container can be visually identical to a blister caused by metallic contamination. Visual inspection will not differentiate the two bubbles, nor will it identify the source.

Bubble analysis techniques can point to the origins of the blister, based on the chemical composition of the gases within the bubble. Other techniques allow for the pressure within the bubble to be measured, providing clues to the age of the bubble and consequently, the area of the distributor/forehearth in which it was formed. Analysis of solid inclusions within, or in close proximity to the bubble can also aid the forensic determination of the source of the bubble.

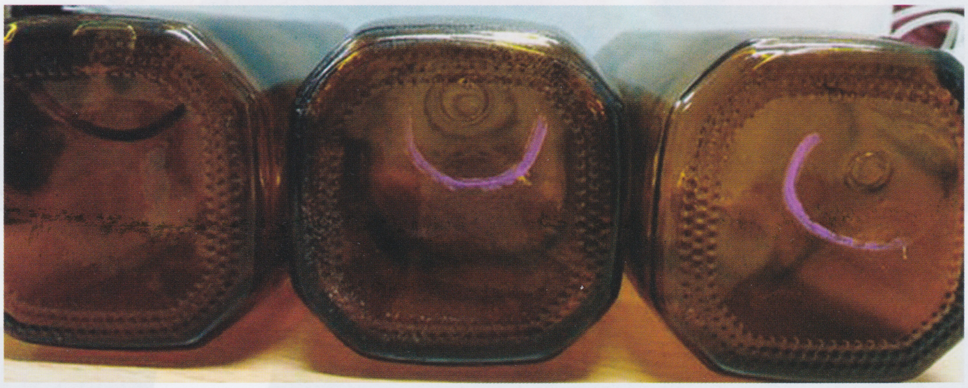
AMBER REBOIL

Arguably the most disruptive and costly blister occurs in amber glasses and is known as amber reboil. This is largely associated with the interaction of two forms of sulphur - SO_4^{2-} and S^{2-} that interact to produce SO_2. Although reboil is generally considered a reheat phenomenon, where the glass is locally reheated within the distributor, forehearth or spout, there are a variety of mechanisms that can lead to the formation of SO_2 containing blister bubbles, including mechanical, chemical and physical reactions.

For a variety of reasons, the distributor/working end is a critical area for reboil blister. The solubility of SO_2 is particularly low between 1200°C and 1400°C, a span that generally encompasses the temperature profiles found in distributors. This, however, is not the only potential source of blister. Many modern distributors are configured with excessively deep glass depths, especially in the central zones.

For coloured glasses such as amber, the radiation characteristics prevent the combustion system from penetrating the lower glass layers. Consequently, the lower glass layers are considerably colder than the top layers. There are many problems associated with this that could easily form the subject of a separate article but in terms of bubble formation, the interface between hot and cold glass streams represents a significant bubble forming potential. During operation, equilibrium is established between the hot and cold glass layers that can be disrupted by changes in distributor operation, resulting in the cold layers being heated. As the cold glass reheats, the solubility of the SO_2 decreases, providing the conditions for blister formation. The same problem can exist where inappropriate distributor base depth transitions allow the formation of stagnant glass areas.

Reboil blister caused by reheating the glass is well known to forehearth operators and the usual strategy is to configure the setpoint profile between the throat and the spout with a decreasing temperature profile. In fact, Forehearth Services audits have proved that adhering to a decreasing setpoint profile does not always provide a guarantee of reheat blister prevention. This is especially so where the differential in setpoint between zones is small. In such cases, it is necessary to calculate the heat input/zone/metre provided by the control outputs that are required to maintain the setpoint profile.



Metallic contamination or reboil?

BLISTER FORMATION

The oxidation of reduced amber glass is often quoted in discussions of blister formation. The mechanisms of SO_2 formation through oxidation are supported by well-known oxidation formulae. As a result, many companies producing amber containers operate the combustion system with a reducing air/gas ratio to avoid oxidising the glass. However, the same forehearths operate with direct cooling, in which rich sources of oxygen, in the form of cooling air, are pumped into the forehearth combustion chamber, without producing blister. Oxygen plus amber glass does not necessarily equate to bubble formation.

Amber glass is essentially a liquid, supersaturated in SO_2. Although not recommended with molten glass, if a finger is dipped into a glass of carbonated drink, bubbles form extensively on the contours of the fingerprints. This formation is due to a mechanism called nucleation and in a forehearth can lead to bubble formation on damaged or rough refractory or on expendable refractory with sharp edges such as stirrers and tubes.

Forehearth Services audits have shown that the spout area provides a surprisingly large potential for both blister and seed bubble. Mechanical movement of the glass within the spout and inappropriate spout combustion are responsible for the majority of blister bubbles in this area, whereas the expendable refractories are largely responsible for the formation of seed, with both bubble types formed by a variety of mechanisms.

Sudden, unexplained bubble formation is often the result of hydrocarbon contamination. The atmosphere around the forehearth is heavily polluted with oil and hydrocarbons from the swabbing process that condense on both the structure of the building and the forehearth superstructure. Forehearth flues and gaps between zone blocks provide access to the glass surface for oil-rich contaminants, especially in the presence of negative forehearth pressure. Metallic contamination, especially ferrous and copper metals, are also a relatively common cause of bubble formation. Unfortunately, as trainees on the Forehearth Services training course are shown, the majority of bubbles produced by oil-based contamination are due to bad practice in terms of prevention, maintenance, poor housekeeping and unsatisfactory handling of expendable refractories and thermocouples during pre-immersion warm-up.

FOREHEARTH EXPERTISE

A comprehensive description of all distributor/forehearth/spout-based bubble formation requires considerably more detail than this article allows. However, a key message is that the source of bubble formation cannot be determined by a quick visual examination, regardless of the experience of the viewer. What is required is a combination of bubble analysis by a suitable testing laboratory and a subsequent forensic examination of the entire system operation by a forehearth expert. ■

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