Internal wear areas in a furnace

Michael Horsfield identifies and comments on internal wear areas of the furnace refractory structure

For this article the fossil fuel, end-fired regenerative furnace for the production of container glass is selected, although some of the wear areas identified may be common to other types of furnaces. The most common internal wear areas generally known to the furnace designer and glass producer are:

- melting end soldier blocks
- doghouse corners
- throat
- melting end bottom
- regenerator packing
- melting end superstructure
- melting end crown
- burner blocks.

From the results of a furnace refractory structure audit carried out by Dismatec, other wear areas are identified that may cause towards potential problems and additional maintenance during the furnace campaign life. Some generally-known internal wear areas include the following.

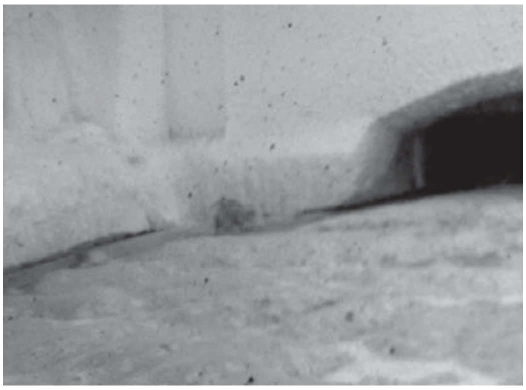

FIGURE 1: THE INTERNAL METAL-LINE (OR FLUX-LINE) WEAR OF THE SOLDIER BLOCKS AT THE PORT WALL AND CORNER POSITIONS

FIGURE 2: THE INTERNAL METAL-LINE (OR FLUX-LINE) WEAR OF THE SOLDIER BLOCKS ADJACENT TO THE DOWN-STREAM DOGHOUSE CORNER

Melting end soldier blocks: The high wear position of the melting end soldier blocks is the metal-line (or flux-line) and immediately below in a tapered profile format towards the mid-height position of the soldier block. This wear is progressive with the rate of wear being affected by external cooling systems and glass production characteristics. As the wear increases a thinner section of the soldier block is created, which in turn creates a significant risk of unpredicted glass leakage. This risk is reduced by the introduction of added refractory at the position, in the form of an over-coat tile and possibly added layers of over-coat together with added cooling systems, either air or water, as the furnace campaign life continues.

Doghouse corners: The doghouse corner blocks progressively wear in a similar way to that of the melting end soldier blocks throughout the furnace campaign life. Depending on the block refractory material, batch charging characteristics, type of charger, batch composition and production requirements the rate of wear can be variable. Generally, the most wear is at the down-stream corner block.

Throat: The throat progressively wears throughout the furnace campaign life in several positions, including the mouth (entry of glass from the melting end), cover blocks and the joints of the cover blocks at the melting end and distributor positions. Cooling systems (air and / or water) are installed at the beginning and on occasion during the furnace campaign life to assist in retarding the internal wear rate and minimising the risk of glass leakage.

Melting end bottom: This progressively wears throughout the furnace campaign life. Most wear will be at an electrode, bubbler or thermocouple position, although a localised wear position could be created due to poor construction techniques or the wrongly selected materials for the bottom refractory matrix.

Regenerator packing: The most noticeable wear here is the top position, as this can be observed through spyholes in the regenerator structure. Other wear areas may be created within the packing at different positions over the total height, which can result in movement or even collapse of the packing. This condition may be caused by the movement of the packing during furnace operation, attack on the refractory material due to internal characteristics, non-standard construction and packing instability. Signs of internal wear within the packing height can be detected by observation of slumping of the top course profile at any position and pieces of refractory material resting in the bottom of the regenerator chamber.

Melting end superstructure: Not generally known as a high internal wear area, local internal wear may, however, cause an external adverse condition as the furnace campaign life continues, including a hot-spot or flame sting-out. This can be observed at an expansion joint seal as the sealing material is progressively eroded on the inside face and / or a refractory joint position where a rat-hole is internally formed.

Melting end crown: Several local areas of internal wear may be experienced due to incorrect operational settings (including high crown temperature and burner angle), incorrect material specification, incorrect materials selection, sub-standard construction creating open joints on the inside face and incorrect expansion control during the pre-heat schedule. Internal wear in the formation of rat-holing at an expansion joint seal, brick joint position or a direct flame location eventually creates an external hot-spot and / or flame sting-out.

Burner blocks: These wear with time and as the internal wear increases, they become thinner and begin to crack in several places. When the cracking condition becomes severe and braking of the burner block begins, burner blocks that are in poor condition should be replaced.

INTERNAL WEAR AREAS

Areas of internal wear identified from the furnace refractory structure audit are:

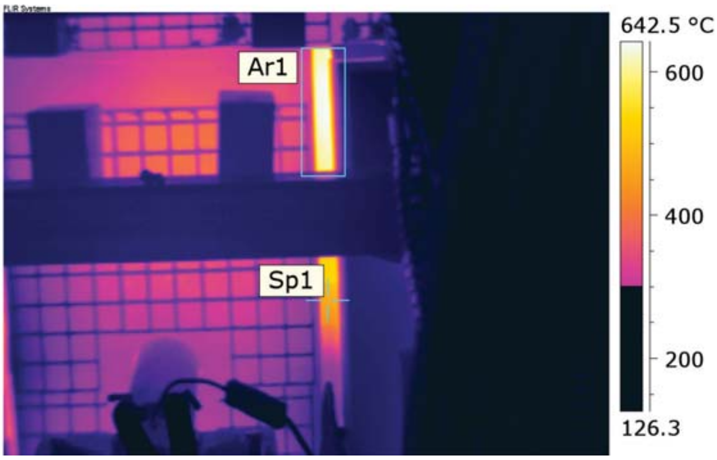

FIGURE 3: THERMOGRAPHY IMAGE SHOWING A TYPICAL TEMPERATURE GRADIENT OF A SOLDIER BLOCK JOINT

- port wall melting end soldier blocks adjacent to the doghouse
- front (throat) wall soldier blocks adjacent to the throat
- soldier blocks adjacent to the doghouse down-stream corner
- soldier block joints
- crack positions of the soldier blocks
- partial over-coat of the soldier blocks
- melting end bottom bubbler blocks
- melting end skewback line.

Port wall melting end soldier blocks: The soldier blocks at the corner of the side wall to port wall, up-stream of the doghouse and beneath the adjacent port become an internal wear area at the metal-line (flux-line) position (see figure 1). This causes an outside face block temperature that is hotter than normally observed at the metal-line (flux-line) to mid-height position of the blocks, with potential for glass seepage in the block joints and an increased risk of severe external adverse conditions as the furnace campaign life increases. The risk of unpredictable severe adverse conditions can be reduced with the introduction of additional over-coat tiles and cooling systems, and correct control of the batch charger to give the correct charging characteristics for the batch into the furnace.

Front wall soldier blocks: Depending on the design of the front (throat) wall soldier blocks and the throat, both vertical and horizontal cracking of the soldier blocks can occur, causing internal wear at a crack position and at the soldier block to throat facer or throat corner block joint. This may lead to opening of a crack, glass seepage into the crack, movement of a block 'piece' or glass leakage at the joint of the soldier block to throat corner block at an unpredicted time.

Soldier blocks: The melting end soldier blocks adjacent to the down-stream doghouse corner (for an estimated length of 1.5-2 metres) experience accelerated internal wear characteristics in comparison to the remaining melting end soldier blocks (see figure 2). As the down-stream doghouse corner refractory block wears internally, the adjacent down-stream melting end soldier blocks wear significantly more than the remaining melting end soldier blocks. The risk of un-predicated glass leakage at the metal-line (or flux-line) can be reduced with the addition of refractory material and cooling systems.

Soldier block joints: Soldier block joints can become very hot on the outside face which may result in glass leakage at the joint and internal wear of the joint (see figure 3). Any internal refractory wear and / or glass leakage at the joint may be retarded by the installation of vertical air cooling to the hot joint position.

Crack positions of the soldier blocks: The melting end soldier blocks are subject to both vertical and horizontal cracking from the top of the block position and below, creating 'piecing' of the soldier block at the area above the backing blocks. Cracking of sidewall electrode blocks is common, with some cracks becoming significantly open at the outside face of the block and glass filling the cracks. Internal wear in the form of upward and / or downward drilling at the crack positions may cause the pieces of block to move outwards or even be lost during the furnace campaign life, leading to potential glass leakage. The risk of un-predicated glass leakage at the metal-line (or flux-line) can be reduced with the addition of refractory material and cooling systems to the outside face of the block.

Partial over-coat of the soldier blocks: The partial over-coating of the melting end soldier blocks can create a weak area at the end position of the length of over-coat tiles and at the bottom joint, which can create a hot-spot and localised internal wear area of the existing soldier block due to the insulating effect of the over-coat tile. This may be enhanced by the varying quality and wear characteristics of the over-coat tiles and the soldier blocks, i.e. chrome content over-coat tile will wear at a lesser rate than a fused cast AZS tile or the primary soldier block manufactured in fused cast AZS material. The potential wear positions may be retarded by the introduction of air cooling.

Melting end bottom bubbler blocks: Depending on the type of bubblers installed, these blocks can become a high internal wear area and potential position for major glass leakage. Internal wear can be accelerated as the bubblers are working, thereby reducing the thickness of the bubbler block significantly at the bubbler and adjacent positions. To retard internal wear, air cooling can be introduced onto the bubbler block together with an over-coat tile at the bubbler location.

Melting end skewback line: The melting end skewback line is a potential area for very hot and localised hot-spot conditions that may cause instability of the crown skewback and flame sting-out. Maintenance may be required during the furnace campaign life to replace any sealing material below the skewback line, or to add air cooling to the skewback itself, to secure the stability of a sealed refractory structure position or retard internal wear.

CONCLUSION

There are a number of internal wear locations of the furnace refractory structure in addition to those commonly known, which all become more pronounced throughout the furnace campaign life. The furnace designer should consider all internal wear areas in detail to provide a furnace design that minimises the risk of refractory structure failure and increased maintenance, and gives a design furnace campaign life to meet the customer's requirements.

The glass producer should be aware of the furnace internal wear areas in order to focus on the areas that have a potential for problems during the furnace campaign period. A realistic schedule for observation, monitoring, recording change and structural maintenance can then be set in place for the campaign life period. The refractory structure audit is a pro-active tool used to identify internal wear areas of the furnace structure and assist both the furnace designer and glass producer in achieving these goals. ■

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