Refractory repair strategies for battery life extension

A combination of preventative maintenance and remedial repair strategies, in conjunction with condition monitoring, restores coke oven batteries to proper operational and environmental performance, and leads to life extension.

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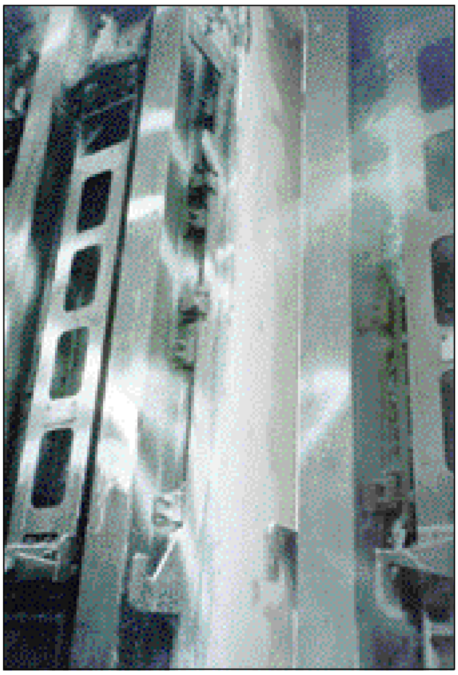
To maximise coke oven battery life and performance, a strategic approach to selecting repair methods is essential. At a number of integrated steel plants the use of teams of experienced operators, refractory engineers and specially trained refractory technicians has identified preventative maintenance (PM) and remedial repair (RR) techniques as two of the core strategies for long battery life. The purpose of such strategies is not simply refractory refurbishment, but to restore the battery to proper operational, thermodynamic and environmental performance.

A PM strategy invokes repairs that eliminate or delay capital expenditure on new batteries or major battery refurbishment, and are carried out with minimal production downtime. A RR strategy involves reconstruction of some or all of the refractory structure, usually requiring capital expenditure and extended downtimes.

The choice of which strategy to use and which repair method is appropriate is fundamental to achieving the goal of long battery life. Additionally, in any battery life extension analysis it is essential to consider every aspect of the working battery, such as operation, heating and bracing in conjunction with refractory strategies. This paper focuses on the refractory repair methods appropriate to PM and RR in battery life extension.

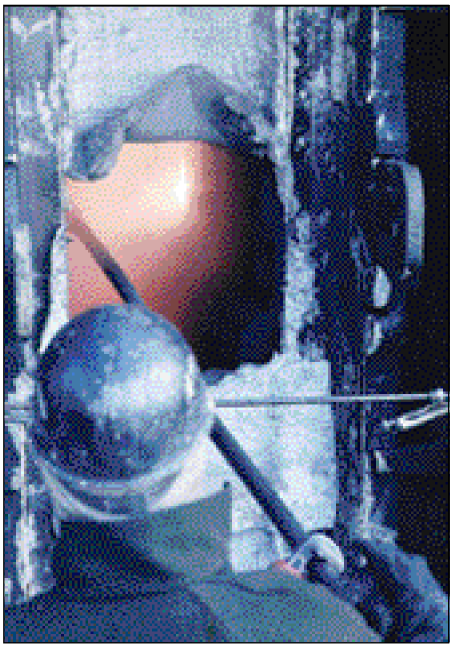
Preventative maintenance
Without a full time PM programme, particularly one that includes condition monitoring as an essential element, battery deterioration will accelerate. Without it, repairs are poorly targeted, dedicated to 'putting out fires', increase the likelihood of extensive remedial repairs, and the goal of battery life extension is ultimately not achieved. PM is the most non-invasive option, yielding a rapid improvement in oven condition, stack and fugitive emissions, structural stability, and assistance in restoring heating control. The significant processes will now be described.



● Figure 1 *Oven gunning*

Gunning Depending on the age and condition of a battery, gunning is an appropriate repair strategy. It provides a more rapid turnaround than refractory welding for sealing oven walls, especially at the jambs (see *Figure 1*), and is particularly necessary when specific attention is required to reduce battery emissions after charging, and to meet environmental requirements quickly. Thereafter, a more concerted welding programme is recommended, targeting the worst condition ovens. Gunning does not restore any structural integrity to the wall or jamb; its prime purpose is to seal the oven.

To effect successful repairs with gunning it is essential that skilled nozzlemen and operators are used to ensure minimal water content, so minimising exposure of the silica wall to thermal shock and spalling. The performance of gunning varies,



● Figure 2 ***Oven welding***

● Figure 3 ***Dusting unit***

depending on battery and operating conditions. For example, repair lives on a Simon Carves No. 3 twin flue battery were optimistically 6–8 months on coke side and 10–12 months on pusher side.

Ceramic welding Weld repairs are considered to be the most effective long-term PM repair to coke oven walls, especially for coke side jambs, deep oven cracks, wall undercuts and roof cracks (see *Figure 2*). The oven is required to be out of service for a longer period of time than gunning, which may not meet the exigencies of production or environment. Because of the high temperature coalescence of the weld material and the silica wall, some structural integrity can be restored to the wall when applied by skilled operators. Panel patch repairs using a fused silica Fosbel zero expansion brick (ZEB) and a weld facing is a quick and effective means of patching holes while bonding the repair back to the existing walls.

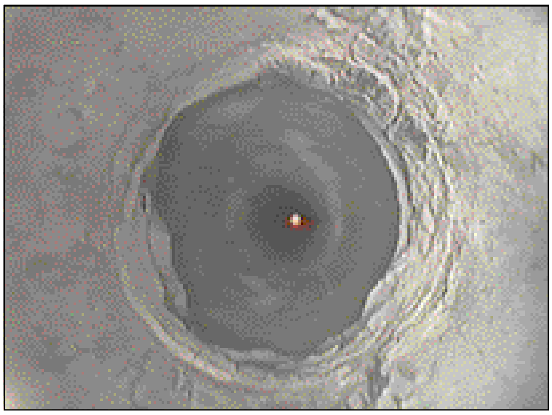
Gunning and ceramic welding are complementary repair methods and should not be considered as alternative strategies, although welding is the more cost-effective and must be a continual process rather than a campaign-based approach.

Dusting of ovens Dusting is a process used to seal small hairline cracks in the brickwork of a coke oven chamber. It provides no long-term life extension benefit in itself, but simply enables ovens that have been out of service and lost their wall carbon to return to service without stack emissions on the first few charges. It is carried out on a regular basis on a number of batteries worldwide and the results in terms of maintaining low stack emissions are very positive, especially after the oven has been out of service for welding or gunning.

Load cells measure the rate of feed flow into the oven to maintain the dust airborne in order to allow increased residence time in the oven (see *Figure 3*). Oven pressure is an indicator of brickwork condition and pressures are recorded both before and after dusting to establish trends in oven wall sealing. Decay in oven pressure over time is also monitored. Good control over the dusting process is essential to ensure that regenerators are not blocked due to leakage of dust through the wall.

Floor flooding Floor flooding is a process used to level oven floors; it is rarely done and only on an as-needed basis. This is usually identified when oven floors develop hollows behind the frame at the sill and when an increase in stickers on that oven may be occurring. Proper floor flooding practice is a time-consuming process to enable sintering to occur. Further development has led to welding floors with successful results. The preferred method of oven floor repair is hot rebricking, and Wilputte batteries are particularly suited to this repair as the oven floor is set between the walls. Successful floor rebricks have been carried out at a number of coke batteries from coke side through to pusher side.

Riser slurrying and sleeving Gas risers are slurried to seal cracks between the regenerators and flue ports using a clay-based refractory with a small amount of fluxing agent. Careful control over the amount of material is necessary to ensure flue ports are not blocked, and inspection of the riser (see



● Figure 4 *Burner riser inspection*

Figure 4) can be carried out using a specially designed high temperature inspection endoscope. Additionally, risers are sleeved with (253MA) stainless tubes to minimise gas leakage to the regenerators and flue ports through cracks in the brickwork. The risers are pre-drilled and sleeved to a height appropriate to battery height.

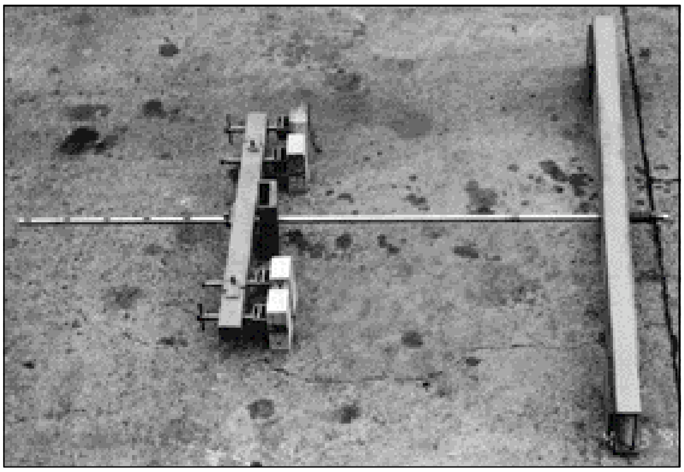
Remedial repairs
These are mostly invasive and have a significant impact on production for those ovens affected. The main processes involved are through-wall repairs, end flue rebuilds, panel patching, regenerator refurbishment and oven top paving. These repairs restore the structural stability of the oven refractory and allow for restoration of proper heating following cleaning and reconstruction of burner and flue ports. The extent of such remedial repairs can be significant, including individual walls, campaign replacement of all walls and pad-up rebuilds. Generally, coke plant management insist that these repairs must maintain the adjacent ovens and silica at or near prescribed temperatures, as the success of any repair is contingent on not damaging adjacent silica through cooling. The difficulty associated with the installation of conventional silica products into hot ovens is thermal shock and the inability to control the rate of heat up for this brick, especially in horizontal flue batteries. As a result, end flue repairs now use MICOWALL a patented end flue design, using fused silica ZEB in conjunction with fewer shapes (see *Figure 5*). This reduces downtime and has been used for over 14 years in panel patch-type applications with very good performance.
MICOWALL (Modular Interlocking Coke Oven WALL) end flues Emphasis is placed on maintaining the heating flues of the adjacent ovens at greater than 1,000°C and the last burning flue of the wall being repaired at greater than 750°C. This is achieved by:

● Figure 5 ***MICOWALL brickwork***

- Supplementary heating (LPG) to maintain silica in the sole and regenerator corbels at temperature through burner tubes placed in the regenerators (see *Figure 6*)
- Heavily insulating the walls with ceramic fibre
- Monitoring closely and responding immediately to the temperature trends in the repair area and use of hot video inspection of the oven walls, gas risers and flue ports to ensure all blockages are removed and heating can be restored

End walls are built tight into hot expanded ovens with no need for complex expansion calculations. No provision is made for expansion between old and new brickwork as the zero expansion characteristics of the new brick mated with existing hot silica has

● Figure 6 *Supplementary heater*



● Figure 7 *Roof support mechanism*

very little differential movement. All end wall repairs have been successful in both refractory and heating performance, with our first repair over eight years old and still in excellent condition.

The use of zero expansion-type products has enabled rapid turnaround in oven repairs with ovens pushed within 24 hours of brickwork completion. For example, the MICOWALL design reduces the number of shapes on a full Wilputte oven wall from over 180 to just 12. These shapes are easily manageable and safer to install due to their reduced weight compared to conventional silica designs, allowing for rapid installation. The original structural and thermodynamic integrity of the oven wall is also maintained with a special interlocking design, especially needed around the horizontal flue.

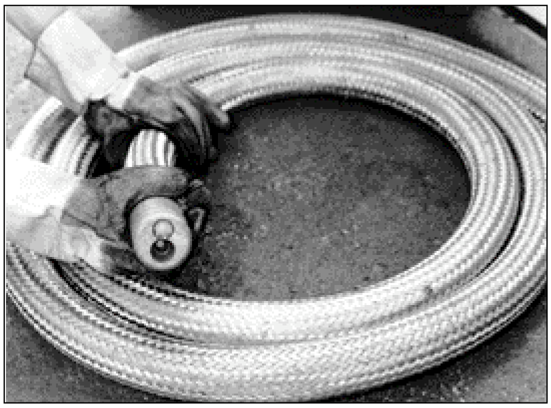
The oven roof is usually left in place with MICOWALL rebuilds although the pinion wall roof and oven top usually require removal due to poor condition. Additional design work for the roof support mechanism is required. The concept developed by Fosbel uses a spring-loaded mechanism to counter vibration from moving machinery while maintaining roof support. Unique outriggers are attached to provide additional support of the oven roof blocks (see *Figure 7*) .

To ensure that the thermodynamics of the oven are restored, the flue ports are inspected with a high temperature video probe (see *Figure 8*). This unit permits visual inspection of otherwise inaccessible flue ports to ensure that no blockages exist. The probe is a flexible water-cooled 'snake' with a stainless steel jacket (see *Figure 9*) and has been used for hot oven repair inspections, riser pipe inspection and flue port inspections in both oven and regenerator areas of the battery.

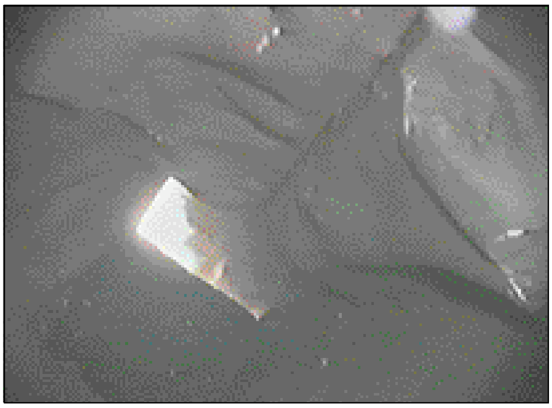
Fosbel are undertaking further research to develop a higher temperature probe for inspection of oven walls through the flue inspection caps.

● Figure 8 *Video inspection unit*

Regenerator repairs Prior to any oven wall repair it is essential to ensure that best heating is available to the repaired wall, and so a programme of regenerator checker refurbishment, flue video inspection (see *Figure 10*) and chamber wall and corbel repair is carried out. This is coupled with stainless steel sleeving to refurbish risers and includes the repacking of coke side and pusher side regenerator chambers in Wilputte batteries and up to four flues on Otto Simon Carves batteries. (Repacking up to 4 flues on Otto batteries provides 90% of the solution to damaged or blocked ports.) The objective is to maintain the regenerator, corbels and oven sole silica brick in a hot condition (>750°C) through insulation (see *Figure 11*) and/or supplementary heating.



● Figure 9 *Inspection probe*



● Figure 10 *Flue port inspection*

Summary

Battery life extension can be achieved through a strategic approach to both preventative maintenance and remedial repairs. A balance must be found between coke production and refractory preservation, while condition monitoring enables targeting of repairs using any available strategy based on merit.

The team-based approach drawing on the skills of a broad group, including contractors, enables the successful implementation of battery life extension strategies. At all times protecting the existing coke battery asset from further deterioration must be a high priority. The strategic approach must include all aspects including operational practices, battery bracing, moving machinery, installation technique, refractory material selection and protecting existing silica during repairs.

The first steps to battery life extension is understanding and adopting preventative maintenance strategies, making budget provision and communicating these goals.

● Figure 11 *Regenerator insulation*

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