STRATEGIC COKE BATTERY MAINTENANCE PROVIDES BATTERY LIFE EXTENSION[1]

Ernest D. Goffi[2]
Peter D.Kerr[3]
Richard A. Randolph[4]

Abstract
Effective coke battery maintenance requires a balance between coke production and refractory preservation. Fosbel's Complete Battery Maintenance (CBM) offers a strategic approach to coke battery maintenance that optimizes oven availability and extends battery life. This includes comprehensive condition monitoring, as well as a full range of preventative maintenance and remedial repairs. This presentation will focus on two technologies key to the CBM approach: Coke Oven Management Information Technology (COMIT) and Modular Interlocking Coke Oven Wall (MICOWALL). COMIT is a proprietary web-based application that enables comprehensive coke battery condition monitoring. It is based on the philosophy that oven wall condition represents battery refractory damages and operating practices. Therefore, daily condition monitoring is essential to prevent oven failure risks and optimize refractory life. COMIT provides a graphical representation of battery deterioration and improvements, which enables prioritization of battery repairs and ongoing assessment of maintenance programs. MICOWALL is a patented innovative coke oven wall rebuild technology that utilizes significantly fewer shapes to reduce downtime and maintain structural integrity. These shapes are easily manageable and safer due to the reduced weight compared to conventional 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.
Key words: Coke battery maintenance; Battery life extension; Refractory repairs; Preventative maintenance.

---

[1] *Technical Contribution to the 3rd International Meeting on Ironmaking, September 22-26, 2008, Sao Luis City*, Maranhao State, Brazil
[2] *Global Sales Director, Fosbel Inc., Brook Park, Ohio, USA*
[3] *Gerente Geral, Fosbel Ind. e Com. Ltda., Sao Paulo, Brazil*
[4] *COMIT Director, Fosbel Inc., Brook Park, Ohio, USA*

1 INTRODUCTION

Effective coke battery maintenance is required to sustain a balance between coke production and refractory preservation. Ideally, coke production is optimized while refractory damage is minimized. Fosbel's Complete Battery Maintenance (CBM) program provides a strategic approach to coke battery maintenance that not only supports oven availability but can also extend battery life. The CBM program includes comprehensive condition monitoring as well as a full range of preventative maintenance and remedial repairs. The choice of an appropriate strategy and of specific repair methods is fundamental to achieving the goal of extended coke battery life.

The first step necessary in order to achieve battery life extension is the evaluation of the current condition of the coke battery ovens and walls. Secondly, preventative maintenance strategies must be implemented and budget provisions acknowledged. A preventative maintenance strategy invokes repairs that eliminate or delay major battery refurbishment and its coexistent major capital expenditures. Preventative maintenance repairs are also typically carried out with minimal production downtime. Conversely, the remedial repair strategy involves repairs that effectively reconstruct some or all of the refractory structure; these procedures usually require major capital expenditures and extended downtimes. At all times the highest priority is the protection of the existing coke battery refractories from further deterioration. Additionally, any battery life extension analysis must include every aspect of the working battery, such as operating practices, heating, battery bracing, and stack emissions in conjunction with refractory strategies such as installation techniques, refractory material selection, and protecting existing silica during repairs.

This paper will focus on two technologies that are cornerstones of Fosbel's CBM approach and represent components of a strategic coke battery maintenance program: Coke Oven Management Information Technology (COMIT) and Modular Interlocking Coke Oven Wall (MICOWALL).

2 Complete Battery Maintenance

The Complete Battery Maintenance (CBM) program is comprised of many elements and includes a means to rank the condition of coke oven refractories, to identify problem areas, and to repair and extend the life of coke battery refractories through various techniques. The Fosbel Complete Battery Maintenance program is unique in its functional method of collecting and analyzing oven ranking data on a regular basis and in the integration of this data into an overall predictive model and a specific maintenance plan. The basic elements of CBM are COMIT condition monitoring, ceramic welding, MICOWALL oven wall rebuilds or conventional silica wall rebuilds, gunniting, inspection services, and ancillary refractory repair services. Inspection services include heating surveys, visual inspections, lancescope inspections, and expansion surveys.

In CBM terminology, coke oven batteries typically go through three stages of maintenance in a life cycle: (1) condition monitoring, (2) condition monitoring with ongoing preventative maintenance, and (3) condition monitoring with remedial repairs as needed. The first stage begins when a battery is less than 10 to 15 years old and is designated as young. A young battery generally does not require repairs except in unusual circumstances. However, during this stage a reference baseline can be established via regular monitoring of the battery condition. Regular inspections are

recommended to occur in accordance with the COMIT ranking chart and the frequency as established for each ranking. For example, a battery oven wall that is ranked as 0.5, which is a typical ranking for a young battery, would be inspected after 52 weeks. With the utilization of these observations in the COMIT system, over time even relatively small increases in the rate of deterioration can be detected and subsequently addressed.

Generally when a battery is middle aged, 12 to 30 years old, a continual preventative maintenance program is needed. The aim of such a program is to control and slow the rate of refractory deterioration. The condition of the battery is maintained by ceramic welding and other refractory repair techniques. Under ideal conditions the battery will deteriorate slowly and achieve a long life with a minimum of production losses, emissions and major remedial costs. Oven walls in batteries in this stage are usually ranked between 1 and 3 in the COMIT ranking system.

The last stage in the life of a coke battery oven occurs from approximately 15 to 40 years of age. Factors that determine the time frame for this stage include operating and maintenance practices and current refractory condition. Additional factors that impact the rate of aging are the original battery design, battery height, silica density, etc. During this latter stage, remedial repairs usually become necessary in most batteries to maintain the integrity of the structural elements and to support environmentally compliant functioning. It is important to note that during all stages of battery life, ongoing conditioning monitoring and ranking are essential.

2.1 COMIT Condition Monitoring System

Simply stated, Coke Oven Management Information Technology (COMIT) is a comprehensive system that monitors the condition of coke oven batteries of any design. COMIT is based on the philosophy that the present condition of any oven wall is a culmination of operating practices and battery refractory damages. As a proprietary web-based application, COMIT supports daily condition monitoring which is essential in order to prevent oven failure risks and to optimize refractory life. Additionally, COMIT provides a graphic representation of battery improvements and deterioration which enables the prioritization of battery repairs and the assessment of maintenance programs.

COMIT includes operational data collection and reporting, battery analysis and reporting, and wall analysis and prioritization that is presented in a modular format and is available in weekly reports. Although the main focus is on refractory condition, the system also includes modules for monitoring coke battery operational data such as flue temperatures, pushing forces, stack emissions, and include oven rankings, overdue inspections, and refractory repair life. The system can be adapted for any coke battery design and operating conditions. The inherent flexibility of the COMIT system allows varied production goals and needs to be incorporated. The system provides either a standard or customized graphic representation of battery deterioration or improvement trend lines. The success of refractory maintenance programs are also visually presented and easily noted.

Rankings form the basis of condition monitoring and reporting in COMIT. The condition of any part of the battery is assigned a numerical rank from 0 to 5 (Table 1) . Numerical rankings that are based on specific criteria provide a consistent reference that enables comparison and prioritization. Refractory rankings are assigned by visually inspecting the refractory condition of individual oven walls. Each side, coke side and pusher side, of each end of an oven's walls is inspected and ranked

separately. A ranking number is allocated based on prior ranking and the frequency established in the assessment criteria.
In order to designate clearly which oven wall is being inspected or repaired, the COMIT system employs the terminology HIGH or LOW to designate which of the four aspects of an oven is being inspected or repaired. This system for the labeling terminology was devised based on the following points:

(1) Compass point bearings are difficult to ascertain.
(2) Left and right wall designations can differ depending on whether the walls are viewed from coke side or pusher side.
(3) The COMIT terminology holds true for right to left numbering batteries as well as for left to right numbering batteries.
(4) The COMIT terminology is applicable to both coke side and pusher side ovens irrespective of numbering direction.

These designations allow the manipulation of data without confusion for any coke plant throughout the world. Users of the system are then able to make comparisons between plants wherever the plants are located.

Table 1: COMIT Assessment Criteria

Rating	Description		Life	Jamb	Wall	Freq
Unit			(months)	Good / Fair / Poor / Sever		Weeks
0.0	Condition Monitoring	New undamaged wall	+120	As new	As new	104
0.5		Recent Flue Rebuild	48 - 120	excellent	excellent	52
1	Preventative Maintenance	Future CBM Repairs Expected	24 - 48	good	excellent	26
1.5		Imminent CBM repairs forecast	18 - 24	fair	good	20
2		Minor damage - regular CBM	12 - 18	fair	fair	10
2.5		Medium damage - frequent CBM	6 - 12	poor	fair	6
3		High damage - intense CBM	3 - 6	poor	poor	4
3.5	Remedial Maintenance	Major damage - brick patch	2 - 3	severe	poor	2
4		Extensive damage - end flue f/c	1 - 2	severe	severe	1
4.5		Extensive damage - end flue planned	0 - 1	fail	severe	push
5		Wall failure - OOS	0	fail	fail	-

Note: For any damage requiring repair deeper than 4 flues beyond ranking limits add 0.25

Two basic types of activities that supply data for COMIT are repairs and inspections. Repairs can be preventative or remedial. Welding, gunniting and cleaning constitute preventative maintenance. Endflue and thru wall rebuilds are remedial repairs. Every repair includes an inspection immediately after its completion. Inspection comments may also be recorded to give details of specific defects, unusual battery operation practices, or other information which may be useful in battery forensic analysis.
The actual visual ranking is used in the prioritization of oven repairs and feeds directly into the COMIT life chart. This ranking system differs from previous systems in that other systems rank only ovens and provide no indication of where a potential failure could occur on a specific wall. The COMIT system however, provides rankings for each of the four wall surfaces of a coke oven; coke side low wall, coke side high wall, pusher side low wall and pusher side high wall.
COMIT also incorporates material rankings to provide a second measure of wall condition. The material ranking is used to calculate a ratio of the amount of repair material installed to the original material in that area. The theory is that when the amount of repair material installed in a section of the wall equals the amount of

original material in the same section then the possibility of a major brickwork rebuild is extremely high. The assumption is that the first 4 flues give 90% of wall problems and that failure here is the most likely due to operating wear and tear and thermal stresses. Using the visual and material ranking COMIT can prioritize ovens for repair before they fail and also prioritize inspection frequency to maintain operational security.

One of the unique benefits of the COMIT system is its battery life prediction model. A clear trend can be plotted that shows battery deterioration or improvement and is available on a continuous basis (Figure 1). An optimal repair schedule can then be developed to reduce oven downtime. The strategy of targeting repairs through Condition Monitoring ensures that the worst condition oven is prioritized and the scope of work optimizes refractory life. Furthermore, a benchmark can be established so that repair success can be determined.

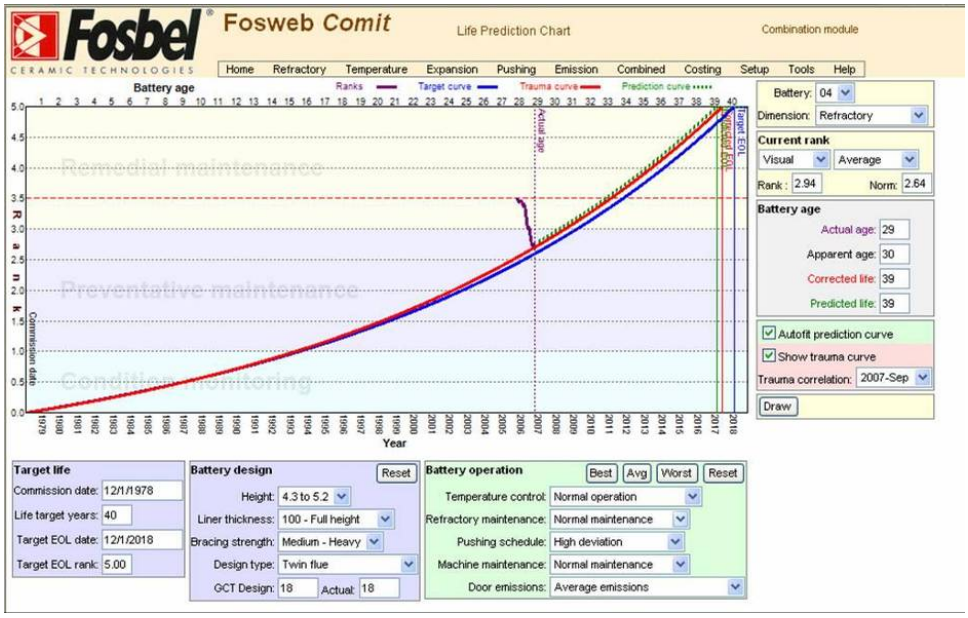

Figure 1: COMIT Life Prediction Model

Additionally the COMIT system allows more accurate prediction over traditional subjective condition analysis of battery life and maintenance requirements. This prediction of life directly relates to effort required to maintain the battery and hence assists in quantifying increases or decreases in budget expenditure to meet life goals of both a capital and maintenance requirement.

COMIT can be useful for annual diagnostics with specific measured outputs or for ongoing oven repair prioritization with direct vertical integration into battery life prediction. It is one system that solves all needs and is unsurpassed in its ability to deliver to the coke producer all of the diagnostic needs and life prediction for optimal coke battery refractory maintenance.

2.2 Micowall

MICOWALL is an acronym for Modular Interlocking Coke Oven Wall, Fosbel's patented innovative coke oven wall rebuild technology. The key requirement of MICOWALL is to initiate repairs that ensure long life, meet environmental requirements, and maintain the stability of the battery heating to ensure coke quality and protect the existing silica by maintaining repair ovens at temperature throughout

the repair. Remedial repairs are typically invasive with significant impact on production for those ovens affected. The main processes in the remedial repair strategy are thruwall repairs and endflue rebuilds. These repairs restore the structural stability of the oven refractory and allow for restoration of proper heating by enabling cleaning and reconstruction of burner and flue ports. The extent of such remedial repairs can be significant, from one wall to a campaign replacement of all walls to pad up rebuilds.

A MICOWALL endflue or thruwall repair utilizes significantly fewer of the original design shapes to reduce push to charge downtime without compromise to coke battery wall quality and structural integrity. For example, the patented MICOWALL design reduces the number of shapes on a Wilputte endflue repair from over 180 to just 12. The MICOWALL design consists of predominantly three shapes; two hammerheads and a binder. Engineering costs are minimized by the generic design and to optimize on cost and consistency of product a pressed MICOWALL shape is used with the exception of the roof where some additional shapes are required. These shapes are easily manageable and allow for more rapid installation due to the reduced weight as compared to conventional silica designs. No mechanical lifting devices are required to handle the shapes from the work platform. The original structural and thermodynamic integrity of the oven wall is also maintained with a special interlocking design, especially needed around the horizontal flue, and tongue and groove bonding is maintained throughout the wall. The MICOWALL design principles are reproducible for both twin flue and horizontal flue batteries, existing air and gas port openings and flue dimensions. Essential to reduce wall movement is a tongue and groove socket interlock across the walls between the ovens. This interlock eliminates the risk of leakage between heating flues.

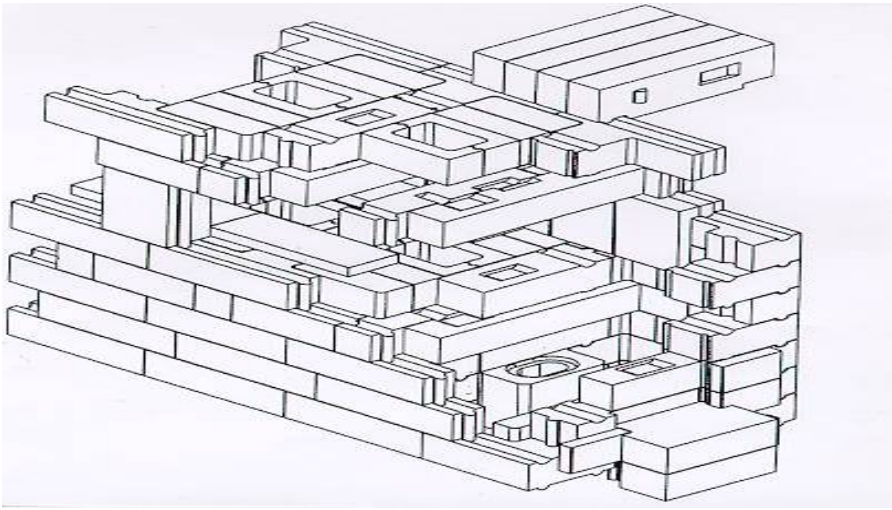

Figure 2: Example of MICOWALL Modular Wall Design

The success of any repair is contingent upon preventing thermal damage to adjacent silica. All refractory repairs must maintain the adjacent ovens and silica at or near prescribed temperatures. Emphasis is placed on maintaining the adjacent ovens' heating flues at greater than 1000°C and the last burning flue of the wall being repaired at greater than 750°C. This is achieved by heavily insulating the non-repair walls with ceramic fiber, providing supplementary heating to the sole and regenerator corbels through regenerator chamber inspection ports when required, and closely monitoring and responding immediately to the temperature trends in the repair area. The adoption of these techniques assists in maintaining the existing silica above its

critical temperature and has minimized extended down time and ensured greater potential for long life of repairs. If required, a Fosbel Lancescope inspection of the oven walls, gas risers and flue ports ensures all blockages are removed so that proper heating can be restored.

The difficulty associated with the installation of conventional silica product into hot ovens is thermal shock and the inability to control the rate of heat up for this brick, especially in horizontal flue batteries. Endflue repairs with MICOWALL Zero Expansion Brick technology allow for end walls to be built tight into hot expanded ovens with no need for complex expansion calculations. No provision is needed for expansion between old and new brickwork as the zero expansion characteristics of the new brick mated with existing hot silica has very little differential movement. The use of zero expansion products enables a rapid turnaround in oven repairs with ovens pushed within 24 hours of brickwork completion.

The implementation of condition monitoring in a preventative maintenance plan minimizes the potential for the likelihood of extensive remedial repairs. But, when the general condition of the oven brickwork is such that it can no longer be maintained long term by ceramic welding or other conventional means, the adoption of MICOWALL technology for either endflue or thruwall repairs incorporates techniques to minimize downtime and ensure optimal repair life. MICOWALL technology is a proven cost-effective repair and the performance of the walls in heating, leakage reduction and pushing improvements have been excellent.

3 CONCLUSION

Today oven productivity is the most important aspect of battery maintenance due to global coke shortages and the high cost of market coke. At a number of integrated steel plants, an alliance has been formed between refractory and coke oven personnel to implement refractory repair strategies aimed at promoting long battery life. The Fosbel CBM program provides condition monitoring and comprehensive preventative and remedial maintenance that is tailored to meet specific needs. The use of a CBM program significantly reduces emissions because daily condition monitoring identifies problems areas so that damaged areas can be addressed and further damage prevented. Not only does the utilization of the CBM program maintain and optimize production, overall maintenance costs over time are reduced.