



# Composite Furnace Module Cooling Systems in the Electric Slag Cleaning Furnace

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## Abstract

Electric slag cleaning furnaces have generally suffered high rates of refractory wear in the area of the lower sidewalls that are in contact with slag. Campaign lives of around 12 months are quite common. Repairing and relining the furnace often involves a complete cool-down, stripping out the worn refractory, installing new bricks, re-heating and bringing the furnace back into service. This has typically taken up to 30 days each year and requires alternate arrangements be made to handle the primary slag.

Following successful trial work involving the installation of test Composite Furnace Modules in the sidewall of the copper slag-cleaning furnace at Olympic Dam, including an element that was operated as a slag taphole, a decision was made to install a full Composite Furnace Module lining in the lower sidewall area of the furnace.

The elements were designed to extend from the skewback brick in the furnace hearth, to a height of 1610 mm above the skewback. The design included three slag tapholes and three blister copper tapholes. The slag taphole design was helped by the earlier trial reported previously [1].

Seventeen months into the campaign the CFM's are performing satisfactorily, with evidence that they have achieved equilibrium and should continue to perform well for some years to come.



## Introduction

For the past several years, the slag cleaning furnace at the Olympic Dam smelter has required relining on an annual basis. This causes the furnace to be out of service for approximately one month every year as well as a material cost in the region of A\$12,000,000. While the furnace is out of service the slag from the flash furnace is granulated and stored until it can be added as cold charge to the slag cleaning furnace once it is restarted.

Over the last twelve years, WMC Resources and the G.K. Williams Research Centre have developed and tested the Composite Furnace Module Cooling System. Initial testing was carried out in nickel and copper flash furnaces, but recent tests have been in the sidewalls of the electric slag cleaning furnace [1,2]. The success of these trials indicated that a full installation of the cooling system in the furnace sidewalls would provide a significant improvement in furnace life.

## CFM concept

The central concept in the design of the Composite Furnace Module Cooling System is to achieve an essentially uniform hot face temperature. This will reduce the extremely uneven wear patterns seen in installations using large copper blocks or rings. The design consists of a water-cooled backing plate from which a number of copper rods extend towards the hot face of the furnace (shown schematically in Figure 1). The region around the rods is filled with a castable refractory, which is also extended beyond the tips of the rods. This composite construction provides cooling and physical strength through the copper rods, and thermal and chemical protection through the refractory. The modules can also be designed to match the expected heat loads in the particular area where it will be installed, by varying the length, diameter and spacing of the rods, as well as through the selection of a refractory material with appropriate thermal properties and the thickness of the refractory cap.

The primary aim of the design process is to attain a hot face temperature that is below the freezing point of the bath material, such that a layer of material will solidify on the surface of the module. This freeze layer provides extra protection for the refractory, as well as giving an increased resistance to the effects of large temperature fluctuations.

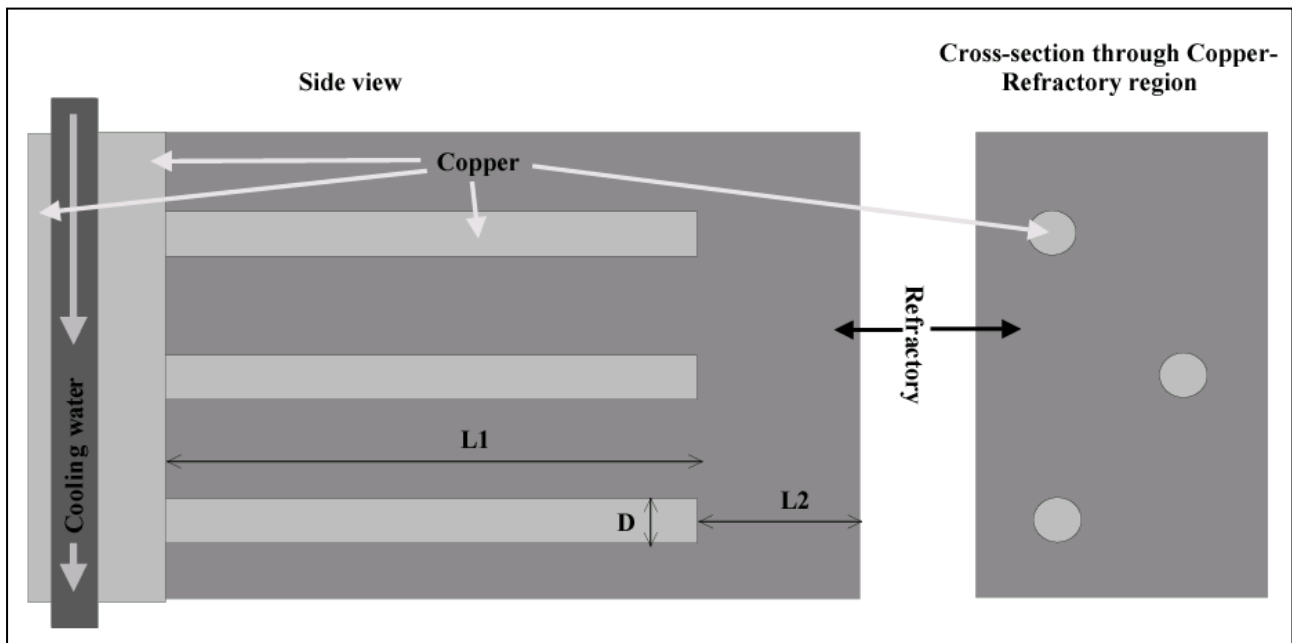


Figure 1: Schematic of the Composite Furnace Module Design

## ODO design and installation

The design of the modules for the slag cleaning furnace was based on the original trial module [2]. In that trial it was determined that the modules should be longer to give increased protection to the high wear zones in contact with the slag and coke layers. The rod spacing used in the trials was determined to be sufficient to form a freeze layer, so was retained for the full installation. To reduce the likelihood of a shear plane developing parallel to the hot face at the tips of the rods, alternating rods were cast with different lengths. This is expected to have some effect on the cooling efficiency of the module as a whole, but should reduce the possibility of the refractory cap spalling, particularly if it is necessary to cool down the furnace.

A set of 32 modules were used to form the complete sidewall, including three slag tapholes and three blister copper tapholes. The modules were cast from high purity copper. Each module stretched 1610 mm from the skewback to above the surface of the bath as shown in figures 2-4. Because the previous campaigns on the furnace had caused significant hearth “ratchetting”, a new hearth was installed at the same time as the CFM’s. This “ratchetting” had been noted previously on the first generation slag cleaning furnace at Olympic Dam and is believed to be caused by the deep thermal cycling of the hearth when the furnace is shut down for annual re-lines. It is not expected to be an issue in a furnace that is not expected to be cooled down for 6 years.

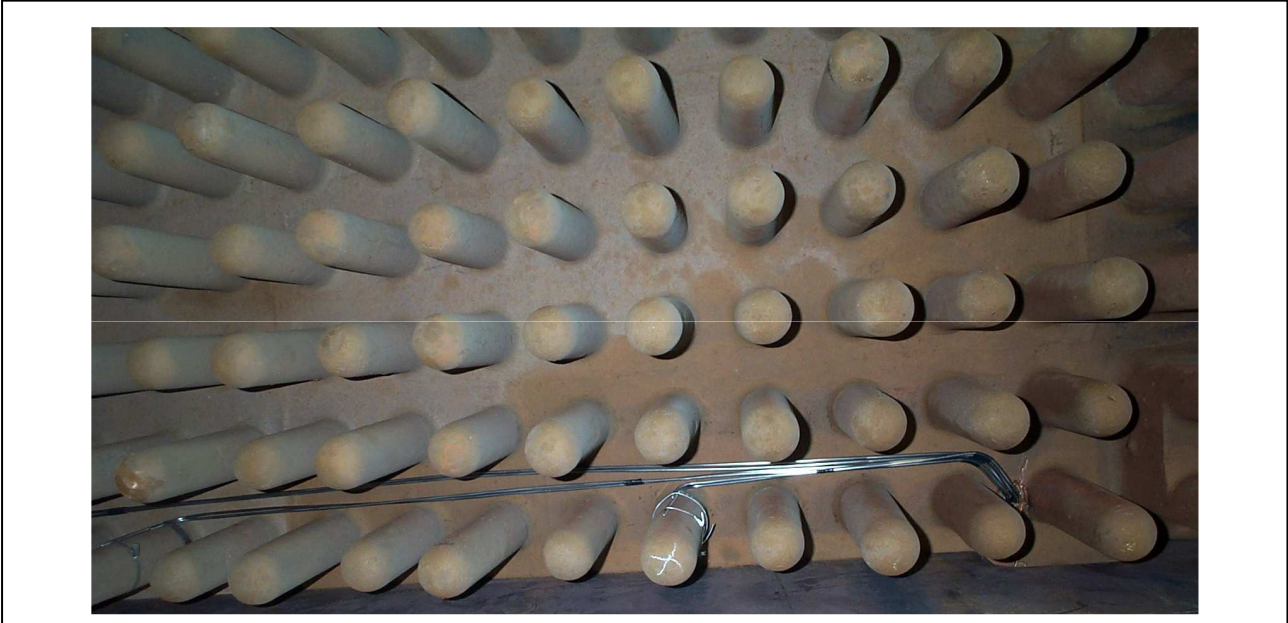


Figure 2: Rod layout and thermocouple wiring



Figure 3: A CFM ready for installation

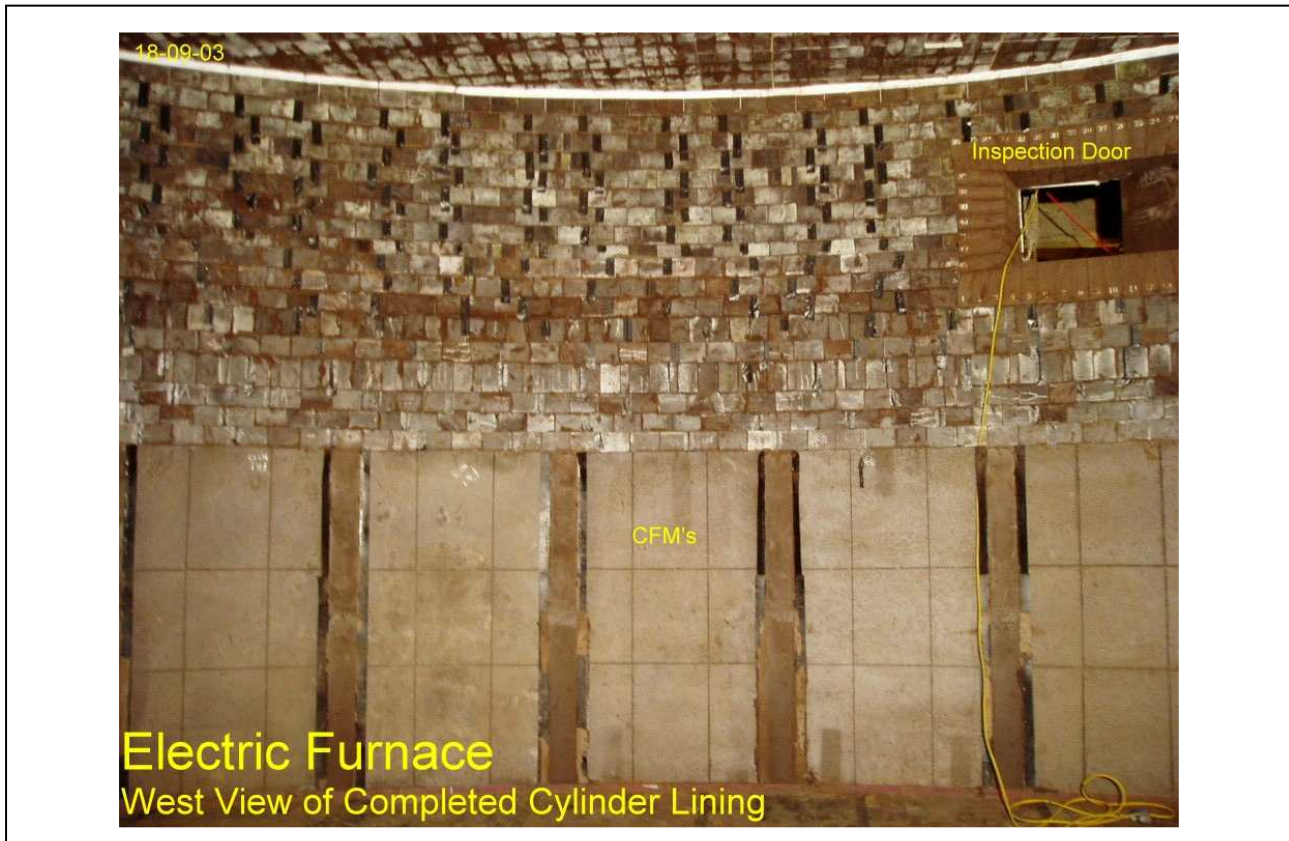


Figure 4: Completed CFM installation with bricked upper wall and roof.

## Furnace operation

The furnace performance can not be directly compared with previous years, due to changes in some operating procedures. In particular, there has been an increase in the amount of cold charge fed to the furnace. This material is the granulated slag stockpiled during previous periods the electric furnace was off line. The melting of the cold charge required an increase in power levels, so a direct comparison of power consumption would not be valid. However, this increased throughput was made possible by the use of CFMs reducing concern regarding refractory life, particularly at increased power levels.

Throughout the year periodic furnace inspections showed that there were no significant erosion problems. Continuous temperature monitoring also indicated that there were no hotspots and that a steady-state operating condition had been achieved. This indicates that the modules should be able to continue in operation for several years.

A detailed inspection of the furnace was carried out after the first year of operation, when the furnace would normally require relining. As Figures 6 and 7 show, the modules are still in good condition although there is evidence of preferential wear over the short rods, giving an uneven surface profile. The continued stability of the sidewalls has also kept the walls in the furnace freeboard and the roof in good condition, allowing the furnace to continue operating with very little maintenance.



Figure 6: View inside slag cleaning furnace with bath level lowered



Figure 7: Close view of slag cleaning furnace sidewall showing freeze layer.



## Conclusions

The installation of the Composite Furnace Module Cooling System in the sidewall of the electric slag cleaning furnace at Olympic Dam has been a success. The furnace has been operated at higher cold charge levels and, hence, power levels with no problems relating to the refractories. The modules are still in good condition and appear to have reached steady-state conditions, under which they should be able to operate for several more years, at an annual saving of at least A\$12,000,000.

## Acknowledgment

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