To extend the service life of refractory linings in high-temperature furnaces, it is becoming common to embed copper cooling devices in the lining. These devices extract enough heat from the hearth of the furnace to freeze a protective thin layer of slag onto the surface of the lining. However, the cooling devices may lose their efficiency over time. It is believed that high-temperature oxidation of copper is responsible for the loss in heat-extraction capacity. To test coolers under severe conditions, immersion tests were carried out in molten matte and slag of laboratory-scale cooling elements protected by various means. A composite cooler was developed that consists of a copper core shielded by a Cu-4 wt.% Al alloy sheet. Although the rate of heat extraction is not as high as that of the un-alloyed copper, this cooler still extracts heat at a very high rate.

INTRODUCTION

Current copper, nickel, and lead smelting and converting are characterized by high intensity and productivity. However, this has lead to increasing demands on the refractory linings that result in possible shortening of the service life of furnace linings. To counteract this, several cooling systems have been designed and implemented in many nonferrous smelters. The different cooling systems can be grouped according to their ability to remove heat from the hearth of the furnace, as shown in Table I. Since the embedded systems are closer to the furnace’s hot face, they are able to extract more energy (10–100 kW/m²) than those acting on the furnace’s outer shell (~10 kW/m²). Figure 1 shows data collected by Merry et al. on the energy that can be removed by different cooling systems.

Modern smelting processes such as flash, bath, or electric furnace technologies make external cooling unsuitable for implementation. Instead, embedded systems are required due to their capacity to extract more heat and thus protect the refractory walls. However, these cooling systems present some major operational problems, such as:

- Water leaking through the refractory lining, possibly resulting in catastrophic explosions (worst-case scenario); water leaks may also react with the process gas (especially SO₂), resulting in corrosion of the cooling devices.
- Uneven control of the wall heat transfer resulting in either increased refractory wear or heat losses.
- Air gaps formed as a result of the thermal cycles experienced by the furnace or due to manufacturing problems of the cooling devices, leading to contact resistance and decreasing the cooling efficiency.

Another problem with embedded cooling systems is the inability to maintain a continuous flow of cooling water due to the high pressure required. This can lead to water leaks and corrosion of the cooling devices.

Figure 1. The energy removal of different cooling systems. Figure 2. The hot end of a water-cooled copper finger after being removed from a flash furnace: (a) front view and (b) lateral view. The dotted lines represent the initial section of the cooler.