

Recent development in Submerged Arc Smelting Technology

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Introduction

The Submerged Arc Furnace (SAF) technology is continuously evolving toward the goal of bigger, safer, cleaner and more effective operations. Tenova Pyromet is supplying the industry with furnaces for ferroalloy smelting, base metal refining, slag cleaning, and waste product treatment. SAFs, up to 80MVA, are designed to each client's specific requirements. Tenova Pyromet technology includes accurate fully automated raw material feed and pre-heating systems, Pyromet or Tagliaferri electrode systems, refractory freeze linings and management systems. Options for gas cleaning include wet scrubber or baghouse systems as well flue gas desulphurisation. Gas cooling is achieved in trombone, water spray or forced draught coolers. All designs are safety and environmentally compliant in line with the requirements of local legislation.

Sidewall Lining/Cooling Systems

The latest developments in this area include our sidewall cooling systems SAFECOOL™ which is an ultra-safe sidewall copper cooling system installed at Bus Valera in France, and our MAXICOOL™ high intensity sidewall copper cooling system installed at Elkem Solar slag smelting furnace in Norway, as well as for the first ever ISACONVERT™ furnace in Zambia (under construction). The Elkem Solar furnace cooling system makes use of a high temperature oil based heat transfer fluid. All Tenova Pyromet's sidewall copper cooling systems are designed to maintain a stable slag freeze lining, resulting in an increased furnace campaign life.

For the SAFECOOL® system (See Figure 1) the copper cooling elements penetrate the furnace shell whilst the cooling water channels remain external to the furnace shell.. This system has been used in submerged arc furnaces for both slag cleaning and primary smelting.



Figure 1: SAFECOOL® sidewall copper cooling system

For applications with high heat loads combined with an aggressive liquid slag bath, a high intensity sidewall copper cooling system of the waffle or stave type was developed by Tenova Pyromet (MAXICOOL®), see (Figure 2). It consists of cast copper of high purity and conductivity with cast-in monel piping forming the cooling water circuits. A unique star pattern was designed for the hot face of the coolers to provide support initially for the monolithic refractory, and later on for the frozen slag layer. Tenova Pyromet first installed the MAXICOOL® system on a 30 MVA submerged arc platinum slag cleaning furnace for Anglo Platinum in South Africa.

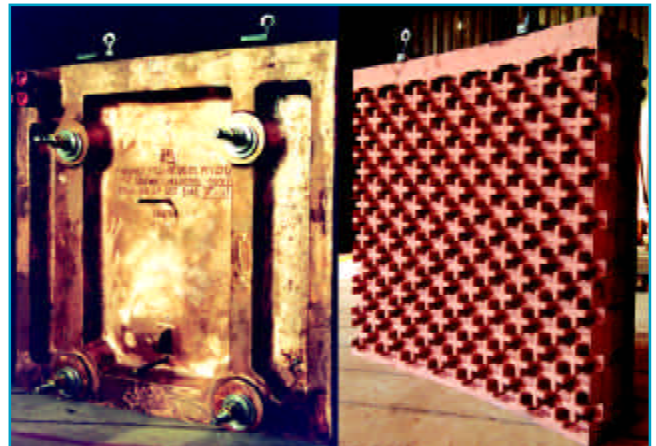


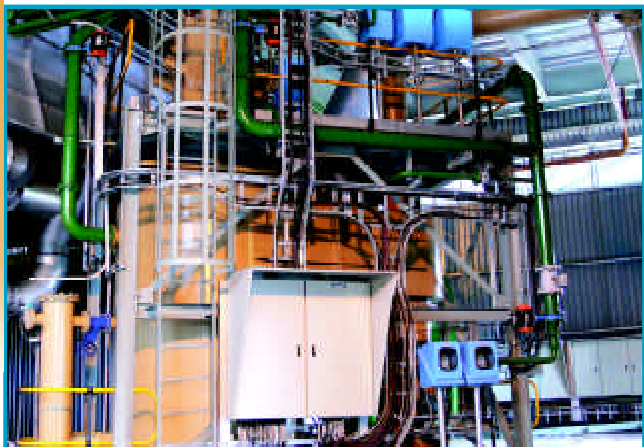
Figure 2: MAXICOOL® sidewall copper cooling system

New Generation SAF Controller

A new generation furnace controller has been developed by Tenova Pyromet. It is an advanced controller that uses sophisticated control algorithms to achieve maximum power input into the furnace. By adjusting electrode and transformer tap positions the controller optimises the furnace power input. The PC based controller uses an OPC to interface with the furnace PLC, allowing for easy installation on almost any type of PLC. The controller can be retrofitted to existing SAF installations. All operating information is stored in a SQL database and supports both local and remote connections. The controller is available for both standard 3 electrode furnaces (IFM, TATA, US Valera) as well as 6 in-line electrode SAFs (McMoran Copper & Gold). The latest system includes a new electrode management algorithm for Soederberg Electrodes.

Lining Management System

Tenova Pyromet developed a Lining Management System (LMS) used for monitoring the furnace lining. It provides the operating staff with a tool



Primary venturi and water seal for Tenova Pyromet scrubber

to predict long term lining life and acts as a process optimisation tool. It alarms and records upset furnace conditions. It includes vertical and horizontal furnace sections showing estimated isotherms through the lining as well as the furnace bath. It also shows calculated heat flux values, estimated lining wear and the freeze layer profile. A novel three-dimensional display provides the operator with a big picture view of the furnace crucible profile under real time operating conditions. It includes a powerful trending facility for analysing both measured and calculated values.

Since its development, the Lining Management System has been implemented on FeCr, SiMn and FeSi SAFs, the ISACONVERT™ furnace and on slag cleaning furnaces.

R&D Activities – Multiple Pre-heater

Tenova Pyromet continues with R&D activities. The newest technology is a new generation Multiple Pre-Heater (MPH) for Submerged Arc Furnaces, developed together with Outotec.

The purpose of preheating is to eliminate the moisture from the feed charge mixture and preheat it to in the order of 500–600 °C. The thermal power in preheating during normal operation is 10–12 MWh/h.

Preheating decreases the electrical energy consumption in the smelting process by about 10%, but it also increases the CO-content of the SAF off-gas and stabilises the resistance of the burden. Preheating improves the operation, production and safety of the smelting. The SAF production increases accordingly.

In the case of the MPH there are three preheating shafts above the furnace, each connected to three refractory lined charging tubes.

Each MPH has an individual feed bin. A rotating belt feeder distributes the charge material into each of the feed bins. Level indicators are used to control the material levels in the MPH shafts and feed bins. A tube feeder feeds the material into the MPH from the feed bin.

Furnace top gas is combusted as the heat source. The burnt gas is cooled by recalculating the MPH top gas and then fed counter current into the bottom of the MPH. Each MPH shaft temperature is controlled individually to obtain the correct material discharge temperature. The material flows by gravity through the MPH units into the feed tubes. The rate of material feed is controlled by the furnace smelting rate. The material in the feed tubes forms a gas seal between the furnace and MPH unit. The MPH off gas is cleaned in a venturi scrubber before being recycled or discharged to atmosphere.

There are benefits to using the MPH concept. The MPH units are located around the top of the SAF electrodes, significantly reducing the height of the furnace building and making it conducive for retrofitting to existing SAF's. This layout also reduces the feed tube lengths, decreasing the heat losses, resulting in hotter feed temperatures. The combustion system

is design for large turn down ratios enabling the MPH to remain on even when the furnace is operating at its lowest power input. The combustion system is reactive to furnace gas composition change which ensures correct combustion and minimal risk of excess air or CO in the MPH units. Volatiles released in the MPH units are recalculated to the combustion chamber and consumed thereby reducing tar build-up in the system.

Reduction of Waste

Tenova Pyromet has built ac and dc furnaces to treat waste products or tailings streams from metallurgical and other processes. These furnaces convert a waste product (such as steel plant dust) into a saleable pig iron or alloy, and a vitreous slag that can be used as road fill or a cement additive. The primary driver is usually the conversion of toxic waste into an inert slag that can safely be dumped, while the value of the alloy produced may be secondary.

Furnace Gas Cleaning

In line with global environmental requirements, Tenova Pyromet builds gas cleaning plants to treat the gaseous emissions from SAF plants. Our third generation two stage venturi scrubber design has been developed to clean hot furnace gas streams containing significant dust loading, with controls to ensure safe furnace operation.

Secondary fumes from taphole operations can be recovered in specialised bag filter plants or a low pressure venturi scrubber

Greenhouse Gas Emission Reduction

Rationale for Co-generation

Process gasses are generated from closed SAFs with a substantial percentage of Carbon Monoxide (CO) and hydrogen (H₂) which are currently flared into the atmosphere in the form of Carbon Dioxide (CO₂), a designated greenhouse gas (GHG), under Annex A of the Kyoto Protocol.

There exists the opportunity for the collation of these process gasses for use as the energy source for the generation of low-carbon electricity for sale into the electricity grid or for on-site consumption.

Cogeneration projects for the Ferro-Alloy industry can be implemented as Clean Development Mechanism (CDM) project within the provisions of the United Nations Framework Convention on Climate Change and its attendant Kyoto Protocol.

In China, Tenova Pyromet is involved in the supply of two Silicon Metal Furnaces that will supply hot gas to a Heat Recovery Steam Generator capable to power a 12 MW steam turbine.

In South Africa, Tenova Pyromet is working closely with AAP Carbon, an engineering-empowered investment-banking firm with specialist knowledge and experience in the field of Carbon Asset Management and Clean Development Mechanism (CDM) Project Development.

As an example typically 2 x 66MVA FeCr furnace producing 21 000Nm³/h of gas (72%CO, 3%H₂) has an annual electricity potential of 150 00MWh and annual CER potential of 135 000 + CO₂e

Conclusion

The Ferroalloy and Base Metal industry is undergoing a new era of technological development. Several technologies are being successfully tested to improve productivity, safety and reliability.

In particular, given the well-known world-wide challenges about energy, pollution and climate change, the industry is requesting the leading technology suppliers like Tenova Pyromet to deliver more advanced solutions in terms of energy and overall environmental impact.

R&D investments, the proper implementation of a continuous improvement policy and the association with reliable and technologically advanced partners are the key actions Tenova Pyromet has taken to deliver the results expected by today's and tomorrow's customers. ■