LATEST ELECTRODE TECHNOLOGY DELIVERING IMPROVED ELECTRODE PERFORMANCE IN SUBMERGED ARC FURNACES

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ABSTRACT

The electrode column is the heart of the submerged arc furnace. Superior electrode performance provides improved furnace performance. This paper describes the main features of the electrode column that delivers superior performance in furnaces worldwide, developed by Pyromet.

Pyromet's electrode comprises the compact slipping device, lower electrode assembly, upper and lower mantles, self-adjusting electrode seal, paste heaters, and Pyromet's patented innovative electrode breakage detection and length determination system.

Pyromet's slipping device features compact interlocking clamping rings, incorporating fail-safe spring-loaded design. The interlocked clamping rings distribute the clamping force over a larger area of the electrode casing, preventing damage. The slipping device assembly features a low maintenance modular design that allows rapid slipping cycle times, back slipping, and compatibility with Pyromet's electrode breakage detection and length determination system.

Pyromet's lower electrode assembly consists of the contact shoes, pressure bellows, pressure ring and heat shields. The contact shoes and pressure ring are designed for long, trouble free operation whilst the pressure bellow configuration equalise contact pressure and current distribution. Furthermore, the contact shoes incorporate a self cleaning feature, ensuring optimum electrical contact. The segmented design offers easy maintenance. Pyromet's clients experience less down time due to longer component life.

Pyromet's remote adjusted electrode seal assembly reduces the rope seal working temperature, increasing rope life. The self compensating rope seal clamping force ensures an effective seal as the rope wears.

Pyromet's electrode breakage detection and length determination system detects electrode breaks utilising Pyromet's electrode holder and data processing system. The length measurement system controls electrode length, eliminating the occurrence of short electrodes. The length measurement system furthermore eliminates the need for manual electrode length measurement, reducing associated production losses during furnace burn downs.

1. INTRODUCTION

Pyromet is one of the leading players in the field of smelting technology and equipment. Over a period of 22 years, Pyromet has provided dependable and innovative smelting technology, high quality equipment and sound project execution to a worldwide client base.

Pyromet's core knowledge and expertise was developed in the South African ferroalloy and platinum smelting industries, both of which are very large and technically advanced in the world.

In addition to the South African industry, Pyromet has supplied furnace plants in Europe, North America, South America, the Middle East, and in India.

Pyromet has spent considerable effort on development, and has contributed significantly to improve the state of the smelting industry. Since the launch of Pyromet's patented electrode column in 1998, it has become

widely renowned and is now providing significant benefits, especially in increased furnace availability, to many smelting furnace operators.

The electrode column is the heart of the submerged arc furnace, as it conveys a controlled magnitude of the electric current to the optimum depth in the burden for the smelting process.

Every furnace is custom designed to the specific operating range and optimal furnace operating point of that furnace. Figure 1 shows a typical large size ferrochrome furnace operating graph. It also shows that the operating power input in MW and the electrode resistance in mOhm largely determine the efficiency of the furnace. Both these parameters are directly related to the electrode performance. Thus superior electrode performance will result in improved furnace performance.

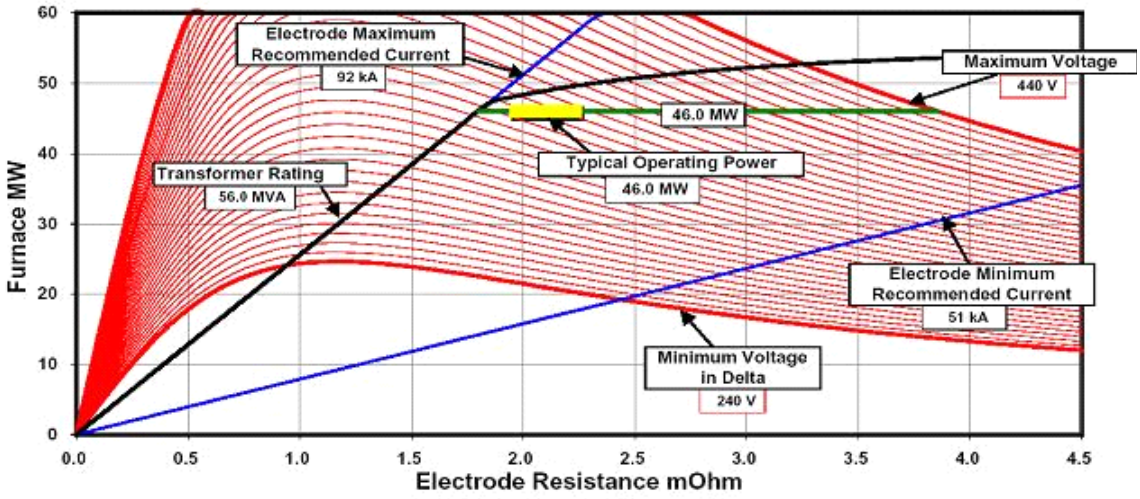

Figure 1: Furnace Operating Graph

This paper describes the main features of the Pyromet electrode equipment that was developed and proven to deliver superior performance in furnaces across the world.

The Pyromet electrode equipment includes the compact electrode holder, maintenance friendly lower electrode assembly, self-adjusting electrode seal, electrode paste heaters and innovative electrode breakage detection and length determination system.

2. TECHNICAL OVERVIEW OF PYROMET ELECTRODE EQUIPMENT

Pyromet has built many large submerged arc furnaces in South Africa. This provided Pyromet with the opportunity to continuously improve its electrode column design to improve electrode availability and electrode performance, even in very harsh operating environments. This allowed Pyromet to patent its electrode column design with unique features that makes it less prone to failure and easier to maintain.

2.1 Pyromet Upper Electrode Assembly

The upper electrode assembly comprises three main functional components: The slipping device, the electrode guide and the upper mantle. See Figure 2 underneath.

The Pyromet slipping device, shown in Figure 3, comprises two clamping rings that are configured to be interlocking, resulting to a compact design that reduces the required headroom. The two rings are connected with hydraulic cylinders that enable relative movement between the top and bottom clamping rings. This action enables slipping through of the electrode casing whilst always maintaining a positive grip on the casing.

Pyromet's slipping device fully supports back slipping (where the electrode is lifted up) without requiring a reduction in contact shoe clamping force.

The clamping rings features fail-safe spring clamping. The primary clamping force is supplied by specially designed springs, whilst hydraulic power is used to retract the clamping shoes from the electrode casing. In the event of hydraulic pressure failure, the electrode will always be securely clamped by the clamping springs. The specially designed springs allow the Pyromet slipping device to be less sensitive to casing diameter fluctuations.

Unique to the Pyromet design, the clamping shoes interlock and overlap, reducing localised casing stresses, particularly during slipping. This also allows the use of thinner wall thickness casings than would normally be considered for specific applications.

The modular design of Pyromet's slipping device allows interchangeability of components, resulting in easy maintenance and reducing spares requirements.

Figure 2: Upper Electrode Assembly

Figure 3: Slipping Devices

Hydraulic regulating cylinders support the slipping device. Two different configurations are possible: The regulating cylinders can either support the electrode (cylinders in compression) or suspend the electrode (cylinders in tension). The specific furnace's building structure determines the choice. A supporting layout provides superior guiding characteristics and is the preferred choice.

Two, three or four regulating cylinders per electrode can be selected, though four is the preferred quantity. The advantage of using four cylinders is that any one of the four can be removed for maintenance, without having to provide additional support for the electrode assembly.

The electrode is guided at two levels, on the casing floor with a guide tube and on the slipping floor with rings of guide rollers.

2.2 Pyromet Lower Electrode Assembly

Pyromet's lower electrode assembly, shown in Figure 4, comprises six main functional components: The contact shoes, pressure bellows, pressure ring assembly, heat shield assembly, bus-tube and cooling water risers, and the lower mantle.

Pyromet's lower electrode assembly features a robust design that is less prone to failures, as the key equipment is protected against adverse furnace conditions. With the contact shoes protected from the furnace environment, a uniform ambient temperature and electrical current distribution within the electrode baking zone is ensured.

The pressure ring has an efficiently cooled protection skirt that is covering and protecting the contact shoes and other components. The protection skirts are manufactured from forged copper slabs that allow more efficient cooling through increased thermal conductivity.

The pressure ring is assembled with the pressure bellows bridging between contact shoes to equalise contact pressure and electric current. This prevents hot spots around the contact shoes in high current applications, resulting in lower electrical losses associated with high circulating currents.

The bellows are independent and can be changed without removing the pressure ring segment. The bellows have a separate water circuit operating at low velocity and high pressure, which provides a high bellows force, generating the necessary contact pressure.

Pyromet's contact shoe design incorporates a self cleaning feature, ensuring optimum electrical contact between the contact shoe and the casing.

The lower electrode design incorporates a segmented design that allows easy access to components, so that if there is a need to work on or remove a component, this can be easily done.

Figure 4: Lower Electrode Assembly

The heat shield protects the internal electrode components from the hot furnace environment. The unique design features a segmented heat shield with a quick release mechanism for individual segments, allowing easy removal during maintenance shutdowns.

The bus-tube risers are water cooled and fabricated from copper. The cooling water risers are fabricated in stainless steel.

The lower mantle is fabricated in stainless steel and provides the support for the pressure ring assembly, heat-shield assembly, bus-tube and cooling water risers.

2.3 Pyromet Electrode Smoke Seal

The Pyromet electrode smoke seal, shown in Figure 5, ensures effective sealing of the electrode where it passes through the furnace roof (smoke hood).

The seal has a water-cooled copper base that withdraws heat from the rope seal, reducing the rope working temperature and leading to longer rope life.

The upper clamping ring (made from stainless steel), clamps the rope seal by means of water-operated actuators. The furnace operator can adjust the water pressure without shutting down the furnace. The water-operated actuators self compensates the clamping force as the rope seal wears.

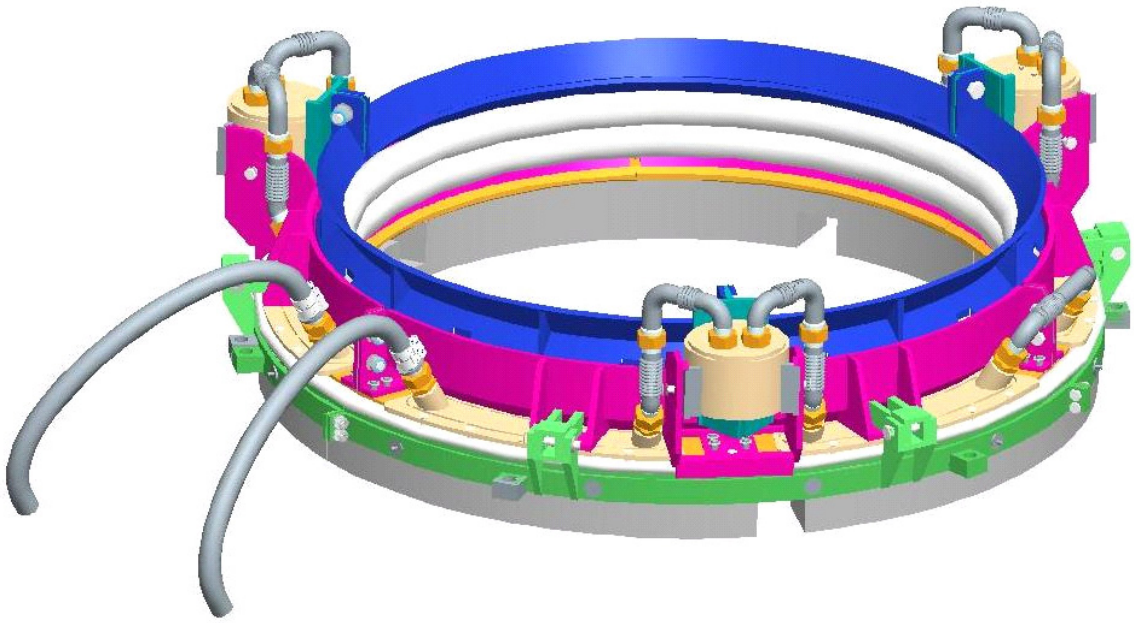

Figure 5: Electrode Smoke Seal

2.4 Pyromet Electrode Paste Heaters

The electrode paste heater is used for improving baking of the electrode. The paste heaters heat the air supplied by the mantle fans. This warm air passes between the electrode casing and the mantle. The increased ambient temperature around the electrode casing assists with increasing the liquid paste level and helps to improve the overall baking process. The heaters are supplied with a control unit for automatic control of temperature.

2.5 Pyromet Electrode Breakage Detection and Length Determination System (EBDS)

The EBDS uses the electrode slipping device and a data processing system to accurately determine the mass of the electrode. Factoring in the electrode geometry, paste levels and regulating position, the electrode length is accurately determined and provides the operator with a recommended slipping procedure for each electrode at that particular time.

The system will detect any electrode breakage immediately before or during the next slipping action and recommend the baking schedule to extrude the electrode to the desired length. With the electrode length known to the operator, the electrode control can be optimized for more stable furnace operation.

2. RECENT EXPERIENCE & TRACK RECORD

Since the launch of Pyromet's new electrode column in 1998, Pyromet accepted orders for electrodes on 20 furnaces ranging from open and closed ferroalloy furnaces, to circular and six-in-line furnaces in the base metals industry. Table 1 below indicates some of the more prominent references.

Table 1: Clientele/Project Reference

Date	*Client*	*Furnace power (each)*	*Project Description*
2007	Outokumpu, Zambia	20 MVA	6 x Electrode Columns
2007	Tata Steel, Richards Bay, RSA	38 MVA	2 x Furnaces & 6 x Electrode Columns
2007	Bus Valera, FRANCE	12 MVA	3 x Electrode Columns
2006	Visa Steel, INDIA (through GESPL)	16.5 MVA	6 x Electrode Columns
2006	International Ferro Metals, RSA	66 MVA	2 x Furnaces & 6 x Electrode Columns
2006	Xstrata, Lion, RSA	63 MVA	2 x Furnaces & 6 x Electrode Columns
2005	Samancor Cr, Ferrometals, RSA	63 MVA	3 x Electrode Slipping Device
2005	Transalloys, RSA	48 MVA	3 x Lower Electrode Columns
2005	Nava Bharat Ferro Alloys, INDIA	18 MVA	6 x Lower Electrode Columns
2004	Nava Bharat Ferro Alloys, INDIA	24 MVA	3 x Electrode Columns
2004	Transalloys, RSA	48 MVA	3 x Lower Electrode Columns
2003	ASA Metals, RSA	45 MVA	1 x Furnace & 3 x Electrode Columns
2002	Assmang, RSA	30 MVA	3 x Lower Electrode Columns
2001	Anglo Platinum, RSA	30 MVA	1 x Furnace, 3 x Electrode Columns
1999	Anglo Platinum, Swartklip smelter, Six-in-line furnace, RSA	19 MVA	6 x Lower Electrode Columns
1998	ASA Metals, RSA	33 MVA	1 x Furnace & 3 x Electrode Columns

4. PYROMET IN INDIA

Pyromet is following the developments in the Ferroalloy industry in India with great interest and apprehends the impact that the Pyromet electrode technology can have on the industry.

Pyromet also recognise that there are a few furnace builders servicing the Indian market. In recognition of the furnace technology already available in India and due to the price competitive nature of the market, Pyromet elected to cooperate with furnace builders in India.

Pyromet identified Ghalsasi Engineering Systems Pvt. Ltd. (GESPL) as one of India's active furnace builders and already proceeded with a project where Pyromet's electrode technology compliments GESPL's local project execution and after sales service.

5. CONCLUSION

Capitalising on its 22 years of experience in the submerged arc furnace industry, Pyromet launched their new electrode column in 1998. Pyromet's electrode column incorporates many features into its electrode design that increased the performance thereof, resulting to end user benefit:

- The compact and casing friendly slipping device.
- Pressure and current equalising pressure bellow configuration.
- Self cleaning contact shoes.
- Self compensating smoke seal.
- Electrode breakage detection and length determination system (EBDS).

Pyromet's patented electrode columns have become widely renowned and are now providing significant benefits, especially in increased furnace availability, to many smelting furnace operators.