Steel Coreless Induction Furnace Linings: A Complete Package

Introduction

Coreless induction furnaces are widely used to melt steel due to the inherent versatility, efficiency, and favourable environmental considerations versus other melting equipment. While coreless induction furnaces are an efficient means of melting steel and steel alloys, melting operations typically account for more than half of the energy consumption in foundries. Operating procedures and overall furnace conditions can have a significant impact on the overall level of energy consumption, safety, and casting quality.

Many factors contribute to safe and efficient operation of coreless induction furnaces, including proper material selection, installation, sintering, and operating practice[1]. Selecting the most appropriate composition of the working lining is the foundation for achieving optimal furnace performance. FOSECO offers a complete portfolio of advanced refractories for coreless induction furnace linings including our premium KELLUNDITE* dry-vibratable working linings, which are specifically designed to achieve long lining life and cleaner steel. Raw materials and manufacturing techniques have been optimised to yield compositions that are targeted to specific applications.

The use of purge plugs in coreless induction furnaces further enhances the lining life by removing unwanted oxides. Purge plugs also provide a more homogeneous melt through stirring as well as the minimisation of oxide inclusions through a cover of inert gas on the surface. When properly installed and operated, purge plug benefits include reduced slag generation, improved refractory lining life, increased molten metal fluidity, and overall improved casting quality. Purge plugs can be employed in existing furnaces without substantial capital expense.

FOSECO offers a complete package of materials, systems, and equipment that provide added value to steel foundries in terms of reduced cost, increased productivity and improved casting quality.

Furnace Lining Systems

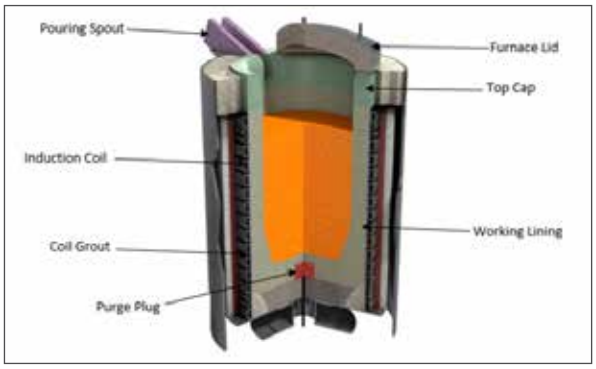

Figure 1. Typical steel induction Furnace Layout

Coreless furnaces require a package of materials to provide optimum life. Coil grout or screed, a cement-based product, is most often used as primary protection for the water cooled induction coil. Serving as a last line of defence for the coil, the grout also provides a cylindrical surface against which the slip plane and primary lining materials are placed. The coil grout is electrically insulating and able to withstand brief contact with molten metal.

A "Slip Plane" is a layer of electrically insulating, mica containing material that provides a barrier between the induction coil grout and primary lining allowing for expansion and contraction of the primary lining. Modern spinel forming dry vibratables undergo both reversible and irreversible expansion upon heating. To prevent cracking, the lining must be able to move independently of the furnace structure and coil. The slip plane is a key part of the lining and should be replaced with each reline.

The working lining is designed to withstand contact with molten steel and thermal cycling. In-situ spinel-forming dry vibratables are engineered to react when heated to form a dense hot face that resists attack by a variety of slag chemistries. Depending on the application temperature and alloy chemistry, the refractory matrix and aggregate are designed to react across a specific temperature range to provide optimum properties for the application. The composition will maintain a dense hot face with loose backup material that can withstand the stresses generated during thermal cycling.

The furnace "Top Cap" or topping, must be strong enough to resist mechanical abrasion from charging practice, yet be compatible with the working lining. Materials for this application vary from phosphate bonded plastic ramming materials to dry vibratables with low temperature sintering aids. The latter offer the ability to integrate the topping mix with the body and form a less abrupt joint between the working lining and top cap.

The furnace lid is a key to efficient operation of the induction furnace. A significant amount of heat is lost from the top of the furnace and a durable and insulating lid is needed to maximise the energy efficiency of the melting process.

The pouring spout, similar to the top cap needs to be able to withstand intermittent metal contact and be strong enough to withstand cleaning and metal skull removal. Typically this is lined with a plastic refractory that is phosphate bonded and designed to achieve a strong bond at relatively low temperature.

An optional component of the lining that can be used to provide improved lining life and clean metal is an argon purging plug. In coreless induction furnaces, purge plugs are installed below the hot face of the lining and are used to purge the steel in the furnace with an inert gas. Additional detail about the purge plugs is discussed in the next section.

Location	Product	Description
Coil Grout	SUREBOND COILCOTE KELLUNDITE G	Cement based product used to line/repair the coil
Slip Plane	Coreweave	Ceramic fibre weave
	Cogebi	Mica
Working Lining	KELLUNDITE 857	High purity, stoichiometric spinel designed for a wide variety of applications
	KELLUNDITE 859	High purity, spinel forming product with chrome addition for improved slag resistance
	KELLUNDITE 695 Plus	Spinel forming, basic matrix designed for a variety of alloys including manganese steels.
Top Cap	KELLUNDITE 85 Topping	Dry-vibratable, compatible with working linings designed for high strength
	BLU RAM HS	Phosphate bonded 70% alumina ramming material.
Furnace Lid	CERCAST 1600 HTF	Insulating and suitable for intermittent metal / slag contact
Purge Plugs	FPP-XX-CIF	Purge Plug (XX=height in mm)
	Ancilliaries & Systems	Earth Leakage Electrode, Adaptor Kits, Flow Control Panel / Systems

Table 1. The Foseco product portfolio for steel melting in coreless induction furnaces

Figure 2. KELLUNDITE lining after furnace tapping

Purge Plugs in Coreless Induction Furnaces

Inert gas or argon purging of steel is commonly used to achieve improved metal properties. In ladles, gas purging helps promote temperature uniformity while removing inclusions[2].

The same benefits can be achieved in the coreless induction melting furnace. Some of the benefits of inert gas purging in the CIF include:

- Improved refractory life – by reducing oxidation of the steel, aggressive oxides that typically form in the melting process are reduced or eliminated. A significant reduction in slag-line erosion can be realised. By prolonging furnace lining life, the time that the furnace is utilised is increased. Reduction in slag generation is also beneficial to downstream refractories such as ladles, stopper rods, nozzles, etc. Additionally, reduced lining disposal costs can be realised.
- Improved casting quality – a reduction in scrap rate can be attained through the reduction of inclusion and gas defects. In some cases, the ability to cast more complex shapes with more defined surfaces is possible. Reduction in rework and grinding are another benefit.
- Improved melt homogeneity – in the furnace the steel is more homogeneous with respect to temperature and chemistry. Alloying components and deoxidisers can be more efficiently distributed.

Figure 3. Purge plugs for coreless induction furnaces

Foseco provides a range of purge plug sizes for a variety of applications. Depending on the furnace bottom thickness, the plug can be ordered to provide the appropriate lining thickness above. Ancillary components such as earth spiders, a stainless steel attachment that allows for the incorporation of the earth detection system into the purge plugs are available.

Lining Thickness		Foseco Plug			
mm	inches	Product Name	Dwg. No.	Plug Height (mm)	Hot Face Diameter (mm)
< 75	< 3	FPP-38-CIF	QD01127	38	134
75 - 100	3 - 4	FPP-52-CIF	QD01135	52	132
100 - 150	4 - 6	FPP-82-CIF	QD01143	82	127
150 - 200	6 - 8	FPP-100-CIF	QD01184	100	125
200 - 250	8 - 10	FPP-155-CIF	QD01192	155	116

Table 2. Purge Plug selection guide for coreless induction furnaces

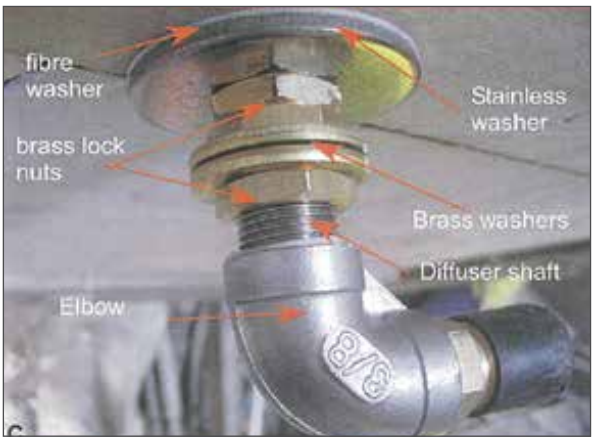

Figure 4. Typical purge plug connection

Figure 5. Ancillary components for purging systems

Conclusion

Lining materials for coreless induction furnaces need to be selected based on melting practice and alloy to provide optimum performance and safety. Foseco offers a complete package of lining materials for steel coreless induction furnaces. KELLUNDITE, spinel-forming high alumina dry vibratables with ancillary materials for the slip plane, coil grout and plastics give long life. Purge plugs are designed to complement the primary lining package providing improved life and steel quality. Foseco now offers a full line of products to maximise the induction furnace process.

References

1. "The Induction Furnace Safety Fundamentals Guide that May Save Your Life", Inductotherm Publication, 2011

2. Ghosh, A, Secondary Steelmaking: Principles and Applications, CRC Press, 2000