Calderys Refractory Lances
Applications and Benefits

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Calderys India has set up a state-of-the-art Refractory Lance manufacturing facility at its Katni works, Madhya Pradesh, India. The design and engineering of this plant was made in collaboration with Calderys Europe. The refractory plant is designed to manufacture all kinds of Monolithic Lances used for iron and steelmaking in line with European technology. The plant aims to manufacture different types of Refractory Lances with superior performance to withstand standard iron and steelmaking operating conditions.

A combination of design innovation in the center pipe and use of high technology refractory materials tailored to suit to various usage of Lance application. Essentially, the refractory mass that covers the center pipe is in contact with hot metal or steel and has the outlet so designed to dispense reagents like inert gas, oxygen and metallurgical powders, which helps in the treatment of the hot metal or steel ladle. It acts as a purifying agent for removal of unwanted elements or nonmetallic inclusions that arise during the process of steelmaking starting from Blast Furnace (BF) to Electric Arc Furnace (EOF).

Steel is manufactured from Iron by eliminating impurities such as Carbon, Silicon, Sulphur, Phosphorous, Manganese, etc., getting rid of them as gas or entrapping them in the form of a slag, floating on the surface of a molten metal. This is becoming important day by day, as cleaner steel is demanded by the end user. Steelmaking process primarily involves removal of Sulphur at the hot metal stage and thereafter homogenization, alloying and removal of non-metallic inclusions, aided by Monolithic Lances to a great extent. Use of inert gas bubbling at a low rate in the steel metallurgy is essential to remove non-metallic inclusions. In this article, the role of Monolithic Refractory for Lances manufacturing and its application has been highlighted, keeping in view the metallurgical requirements for making cleaner steel.

Introduction

Monolithic Lances are primarily used for following operations in steelmaking shops, depending on their final steel output. Steel manufacturer aims at manufacturing cleaner steel, removing unwanted elements, even if the complete removal is not possible. Efforts are made by each manufacturing unit to reach the lowest possible limit of unwanted elements in the finished steel.

Refractory Lances are used for removal of unwanted elements by two broad types of Lances, namely:

a) Powder Injection Lances

b) Gas Bubbling and Gas Stirring Lances

Following are the applications of Lance:

- Desulphurization of hot metal (DS-Lances)
- Homogenization of the melt (Argon-Lances)
- Compensation of the temperature in the ladle (Argon-Lances)
- Quick justification of the casting temperature (Argon-Lances)
- Better removal of non-metallic inclusions (Argon-Lances)
- Heating up the temperature of the melt (Oxygen-Lances)
- In case the purging plug does not work (Emergency-Lances)

Except the DS-Lance, which carries powder reagent for metallurgical treatment to reduce Sulphur in the finished steel, all other varieties are for steel treatment and the operating temperature is about 1650–1700ºC. For each type of use, the Monolithic refractory is designed keeping in view the application temperature, duration of treatment, pressure of injection/stirring gas, erosion due to steel turbulence and slag aggressiveness, which corrodes the slag band of the Lances.

DS Lance

Presence of Sulphur in finished steel causes surface defects and hence, removal of Sulphur from hot metal is mandatory. In Indian steel plants, Sulphur is mostly removed from the hot metal

ladle. Desulphurization agents are Lime (CaO), Calcium Carbide and Magnesium; either one of these agents or their combinations are used in desulphurization process. Nitrogen acts as a carrier gas and is generally used to convey the powders into hot metal. Most of the plants are equipped with automatic mixed injection of different agents for specified time and quantity of injection. The hot metal temperature is maintained at around 1350°C during desulphurization; hence, slag attack is not predominant for these types of Lance applications. The duration of treatment is also in the range of 10–15 minutes. The shops, which regularly use lance for desulphurization, ideally expect about 100–150 heats life under normal operating conditions.

Argon Lance

During the processing of steel in secondary metallurgy, the molten metal is subjected to different temperatures in the additional zone, forming localized difference. This phenomenon has a tendency to develop strata having different chemical compositions and temperature gradients. Homogenization of alloying elements and the temperature is attained through stirring of the molten metal at operating temperature in the range of 1650–1700°C. The stirring is effective when Argon gas is injected into the molten metal at a depth from its surface and a predefined position from bottom of the ladle. During the process of gas stirring, the bubbles expand and move upward, carrying non-metallic inclusions along with it. The non-metallic inclusions get entrapped in the slag layer at the top of the ladle. During stirring of the gas in the steel ladle, Lance experiences high temperature and stress. Some shops have aggressive slags and hence, the slag band of the Argon rinsing Lances gets corroded. Additionally, erosion due to turbulence often yields shorter lance life.

There are two ways to counter the corrosive effect of slag:

- By use of high purity high density corundum grains
- By having the diameter at the slag affected area higher by ~ 50–60 mm, compared to the metal zone

Other factors which affect the Lance life, in these varieties, are crack formation due to thermal shock and spalling due to repeated heating and cooling during the course of use. The gas outlets in these types of lances are placed in the inclined manner facing ladle bottom to have added advantage of better homogenization.

Oxygen Lance

During secondary metallurgy, some grade of steel manufacturing requires increase of temperature during alloying. This increase of temperature is done by the use of Oxygen Lances. In CAS-OB station Oxygen Lances are placed at about 500 mm above the steel ladle (slag layer) bath and oxygen is blown on to the metal surface through the inner metallic tube, preferably of stainless steel, to enhance the Lance life. In this case, the Lance tip erodes faster due to high temperature of burning of carbon, leading to melt down of the tip and in the process, length of the Lance shortens and becomes unusable.

Ladle Design

The design of the ladle plays an important role, as depth of powder or gas injection into it gets more time for reaction of reagents till it reaches slag layer. The surface area should be minimized to avoid air exposure and heat loss. To avoid splashing during injection or gas blowing, it is always better to have a hood to prevent any damage to the adjacent equipment, structure, etc. In case of powder injection into hot metal, the ladle lip design is important, since it assists in de-slagging, reduces iron losses and avoids splashing losses.

Lance Positioning in the Ladle

In treatment ladles, normally a refractory coated Lance is lowered vertically into the metal bath and positioned approximately above 500 mm above the bottom to maximize the injection depth and better homogenization. Most commonly used injection pipes are T-shaped. Two 10 to 20 mm diameter pipes are disposed in opposite direction, for easy cleaning of the holes.

Lance Center Pipe and its Role

Inner tube is a steel pipe designed to carry the metallurgical powders and gaseous reagents for hot metal or steel treatment. To dispense the reagent, the opening from the main pipe is made in T-shape, and to dispense powder injection straight shape can be used. While for stirring Lances, either T or angular pipes are used. In stirring, the efficiency is attained when Lance is placed in rigid condition and remains in its original geometry. During the use, Lances face torsional and flexural stresses caused by the melt movement, which is function of vessel capacity, Lance position and outlet design of the divergent opening of the Lance.

Refractory Monolithic

All types of Refractory Lances have a main metallic tube at the core refractory to protect the main tube and Tuyere area to the extent possible. During repetitive use of Refractory Lances, Lance body is subjected to various factors such as thermal shock,

Table 1: Refractory Criteria for Lance Application

APPLICATION	OPERATING CONDITIONS	SPECIAL CRITERIA REQUIREMENT
Powder injection in hot metal	High residence time in contact with hot metal in the temperature range of 1250–1350°C	Faster sintering of Monolithic is required for development of residual differential thermal expansion
Inert gas rinsing	Frequent thermal shock at 1650–1700°C, high turbulence at the Lance tip, and slag band corrosion	Gradual and slow reaction sintering for formation of a highly volume stable phase during treatment
Oxygen blowing	Splashing of slag at high temperature	High purity–high density phase to resist structural spalling

pressure fluctuations, turbulence of steel and corrosion. Each of these factors, singly or in combinations, affects the condition of refractory part, starting with formation of cracks, widening of cracks, penetration of liquid metal into the cracks, peeling off the refractory, etc., which leads to exposure or disconnection of the main metal tube. Operating conditions and critical parameters required for application of the above types of Lances are tabulated in Table 1, in the previous page, which describes the requirement criteria of refractory for each type of Lance application.

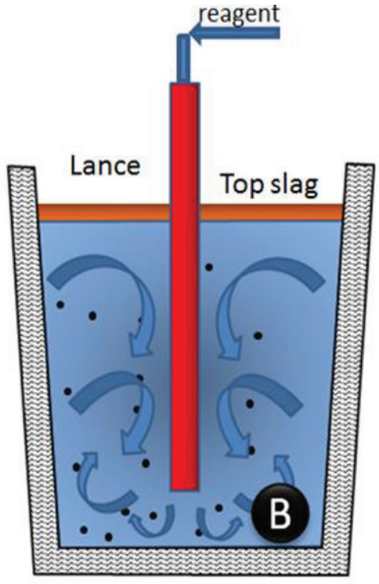

Fig. 1: Lance Operations

Reasons for Lance Replacement

Choking of all types of Lances is attributable to operational issues. Erosion and corrosion are inevitable, but wear rate should be minimal, which primarily depends on the Monolithic quality and its manufacturing process. Formation of cracks and its widening due to repeated thermal shock, is the major reason for reduced Lance life. Horizontal cracks are particularly harmful. Such cracks can be eliminated by optimization of Monolithic quality and its manufacturing process. In steel treatment Lances, Lance head experiences very high mechanical stress during breaking of the hard slag layers and may damage the refractory at times. When the slag in the ladle is very aggressive, excessive wear leads to premature failure of the Lance. The single most cause of failure is bending of Lance, which disturbs the geometry of the Lance. In such event, Lance is taken out of operation. Hence, suitable quality as well as design of main tube, its anchoring system, quality of refractory and processing methodology contribute to achieving optimum performance of the Lance. Lance with the best performance is the one, which goes out of operation in straight condition with uniform wear.

Lance performance depends on:

- The temperature of the hot metal or steel during treatment
- Treatment time, as longer treatment duration increases the refractory as well as center pipe temperature
- Higher purging pressure causes higher turbulence and thus, increases the refractory wear
- Slag zone obviously experiences higher corrosion due to presence of slag, in comparison to the metal zone

Calderys India optimizes the Lance design and Monolithic quality to meet customers' expectations. Tuyeres are the exit point for either powders or gases and its design, therefore, is crucial for Lance performance. Calderys India designs tuyeres taking the ladle size and its metal bath height into consideration, for best Lance performance.

Fig. 2: Finished Lance Pipes

Packing and Transport

Finished Lance pipes are checked for its defined quality, tuyere function and identification numbers for their traceability. Packaging of Calderys India Lances is done with polythene cap to protect them from moisture ingress during transportation and storage. Finally, it is put in the wooden crates with separators, so that undamaged Lances are delivered at the customers' warehouses.

Conclusion

Calderys, due to its consistent quality and superior performance, is a global leader for all types of Pre-cast Pre-fired (PCPF) products, including Refractory Monolithic Lances. Each customer has its own way of using the Lances and unique operating conditions suiting to their metallurgical requirements. Calderys, hence, engages itself to study the operating conditions and accordingly designs the Lances. Refractory used by Calderys, for manufacturing of the Lances, have high strength, controlled thermal expansion and shows minimal wear during successive uses. Calderys ensures robust design of center pipes and designs the anchors compatible with operating condition as well as adherence to engneering guidelines. Predictable lance performance, hence, is assured in a given operational envirnoment. Calderys India, from its facility at Katni, is fully geared to meet the customers' demand in quality, quantity and delivery conditions with assured performance. ■