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Induction Furnace Liner Improvement

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Abstract: This article analyzes the technology of liquefaction of metals and alloys on the basis of resource – saving by improving the lining of the induction furnace. Refractory materials were selected in order to increase the service life of the lining of the furnace. By using selected refractory materials, the furnace lining is resistant to corrosion.

Keywords: induction furnace, furnace lining, smelting process, elements, magnesium, calcium, zirconium, silicon.

INTRODUCTION

In the last 25 years, a new generation of industrial induction melting furnaces has been developed. Current practices used in induction furnaces have been discussed in this article [1, 2, 3]. This article provides an overview of the various practices currently in use in the steel industry using induction furnaces. Induction furnaces are becoming competitive furnaces. Chemical reactions in induction furnaces are less than in other furnaces, which allows to achieve the specified chemical composition of the product [4 – 7].

Low – carbon steel alloys refer to steels used for the manufacture of details and structures in machinery and structural engineering. Such steels can be carbon or alloyed [8]. Carbon content in structural steels is not high, but sometimes it can reach 0.8 – 0.85%.

Induction furnaces are becoming competitive furnaces. Chemical reactions in induction furnaces are less than in ceramic furnaces, which allows to achieve the specified chemical composition of the obtained product. Continuous melting methods are widely used in modern foundries as a result of the development of the flexibility of medium frequency induction furnace DC power sources. They are used with an electrical efficiency above 97% capable of producing the required frequency and amperage for the set [9 – 13]. This is a significant improvement over the previous efficiency of 85%. Allows for better fluidization control and maximum utilization during liquid alloy monitoring [14, 15].

MATERIALS AND METHODS

Today, liquefaction of high – quality structural steels in an induction furnace is widely used [16]. Therefore, the IST – 0.02 Induction furnace was selected in laboratory conditions to obtain a quality structural steel alloy. This furnace operates at a low frequency, i.e. industrial 50 – 60 hertz, and is designed for liquefaction in laboratory conditions [17 – 24]. The lining of this furnace has been selected from basic materials. Before starting the furnace, it is necessary to check that it is suitable for work. Once the steel is liquefied, the furnace lining may be corroded.

If such a situation is observed, a mixture made of magnesite powder is poured into the base furnace on the damaged areas [25 – 32].

An induction furnace liquefies solid materials by creating a magnetic field around the material using eddy current [33]. It has an electric inductor with a number of turns that is in direct contact with the electric coil.

Crucible induction furnaces have environmentally friendly properties and can be used as transfer or casting furnaces [34].

1 – picture. The process of ladle liquid metal from an induction furnace [35]

Fire – resistant materials retain their strength even at high temperatures. Magnesium, calcium, zirconium and silicon carbide oxides are known as furnace lining refractory materials [36]. These materials are classified as acidic, basic or neutral based on their chemical composition. Zirconium, fireclay, silica is acidic, magnesite is basic, aluminum, chromite, carbon, and silicon carbide are neutral [37]. If the lining is made of fire – resistant materials, i.e. acid, it quickly decomposes due to the chemical interaction of the main slag. If it is an acidic process, it can liquefy even at low temperatures.

Refractory materials have the following mechanical properties: [38]

1. Keeps its strength even at high temperatures
2. Keeps its strength even at high temperatures
3. Resistance to chemically inert gases
4. Resistance to thermal treatments
5. Low thermal conductivity
6. Expansion coefficients.

Refractory materials may or may not be pressed. Dry vibration is used to cover the inner part of induction furnaces, i.e. lining. For the monolithic process, in addition to compaction, it was used in filling, cleaning and sandblasting. The service life of the fire – resistant material depends on the dryness of the lining and the densification process. Significant cost savings have been achieved by properly compacting refractories. In addition to this advantage, the process of densification of refractory materials was developed, which was much faster with the help of a plastering machine.

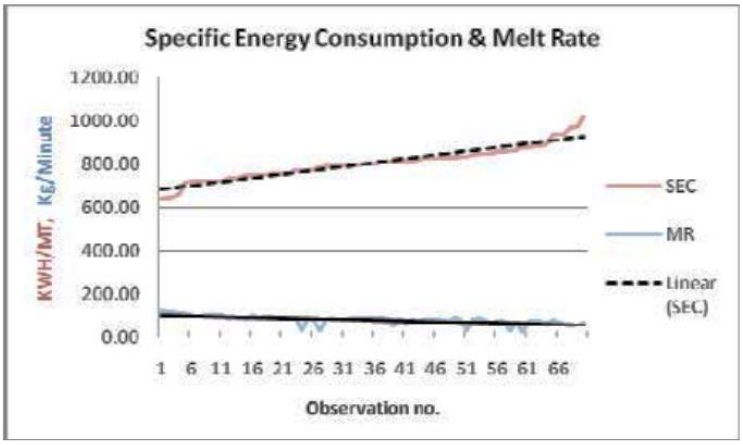
Table 1. Comparative properties of high and low density refractory materials are presented

Power	High thermal mass (high density refractory materials)	Low thermal mass (ceramic fiber)
Thermal conductivity (W M K)	1.2	0,3
Specific heat (J kg K)	1000	1000
Density (kg/m^3)	2300	130

Then the slurry is loaded through the upper part of the furnace. In normal practice, after heat removal, initial slag loading is done manually with shovels or loaded with several large pieces of scrap metal or compacted bundles of low grade slag. In some cases, with the help of a crane, the slags were loaded into the furnace through buckets. Because of this practice, even when the furnace is fully loaded, it will not be fully loaded, and after a while, it is noticed that the furnace does not use full power. This results in more heating time and more energy. In an induction electric furnace, an alternating electric current passes through copper tubes. In the furnace, an electric current passes through refractory materials and a magnetic field is created due to the excitation of metal charges. This causes an electric current to flow through the metal charge itself, generating rapid heat and causing the metal to liquefy. Although some surfaces of the furnace may become hot enough to pose a risk of burns, the inductors focus on liquefying the charge, not the furnace.

RESULTS

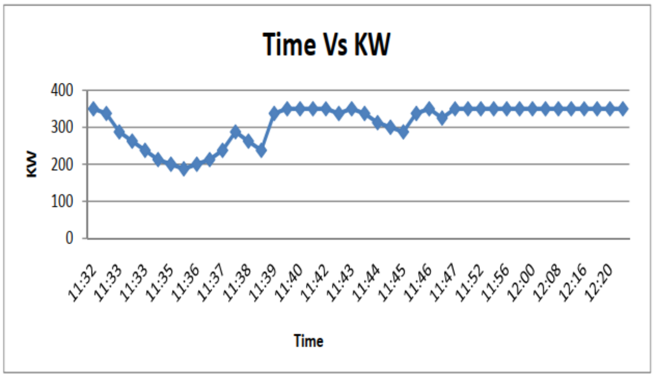
The design and calculation of various methods of operation of induction furnaces were carried out. A number of research studies have been conducted under laboratory conditions.



2 – picture. Liquefaction rate kg/min compared to kW/t MS

Picture 2, we can conclude that even if the furnace and other operating parameters are the same, we can see a change in the liquefaction rate.

In addition, there is a significant change in specific energy consumption. As the liquefaction rate increases, the specific energy consumption decreases.



3 – picture. Time depending on kW

As can be seen from the KW readings, the furnace is not at full power at this early stage, which results in increased energy losses and a longer time for slag to form at the bottom of the crucible. for the process. After that, when removing the slag, the charging stops for about 3 – 5 minutes, the metal is overheated, because the entrance of the metal is zero. If the voltage is not reduced with the help of a potentiometer, the molten metal will begin to boil due to excessive temperature. In this case, the melter turns off the power supply, which causes the water flowing through the inductor to lose heat.

CONCLUSION

In the period of liquefaction of the alloy, the technology of liquefaction was developed based on the introduction of flux into the furnace, which ensures the technology of obtaining high-quality cast products. As a result, the liquid metal content is used to develop the technology of loading flux elements into the furnace.

During the operation of electric induction melting furnaces, non-metallic substances are produced from the various sources described above. Depending on the specific process used and the type of alloy being liquefied, the composition of the slag varies.

The composition of slags is often very complex, and the slags formed during metal melting in electric furnaces are the result of reactions with silicon dioxide, iron oxides from steel scraps, other oxidation and refractory layers formed as a result of melting. Thus, the resulting slag consists of a complex liquid phase of iron and manganese oxides.

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