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Induction Furnace- A Review

Mrunal A. Kukade[1], Nikesh G. Deshmukh[2], Hemant S. Chandravanshi[3], Shubham R. Kamble[4], Narendra B. Bagde[5], Vinod Banabakode[6], Prof. Amit L. Meshram[7]

(Department of Mechanical Engineering, Nagpur Institute of Technology, Nagpur.)

Abstract :- Non-uniform flame distribution, Oxidation of metal, Scale formation and Emission of pollutants are the various major problems found in oil-fired and coal-fired furnaces. Both of these furnaces have low productivity and longer start-up time.
The development of Industrial induction furnaces has taken place over a period of last 25 years. So, these problems can be avoided by using the new technology induction furnace. Present practices followed in Induction Furnaces are discussed in this paper. Due to non-availability of the proper instrumentations the effect of the ill practices cannot be precisely judged. If this is properly measured, the percentage of productivity improvement in steel melting Induction Furnace can be calculated.

Keywords – Induction furnace, Oxidation, oil-fired furnace, instrumentation, productivity

I. Introduction

Electric Induction heating is a non-contact heating process which is used to bond, harden or soften metals or other conductive materials. In advanced manufacturing processes, induction heating provides an appealing assemblage of speed, consistency and control. Induction heating has a good heating efficiency, high production rate and clean working environments. Increases in productivity through the adoption of more efficient and cleaner technologies in the manufacturing sector will be effective in merging economic, environmental, and social development objectives. Now a day's the demand of steel is increasing because of increase in infrastructure and globalization. That's why steel industries are looking for such a furnace which can produce good quality steel with high production rate, and controlling quality, composition, physical and chemical properties. This can be achieved by using "Induction Furnace".

Electric Induction heating is a non-contact heating process which is used to bond, harden or soften metals or other conductive materials. In advanced manufacturing processes, induction heating provides an appealing assemblage of speed, consistency and control. Induction heating has a good heating efficiency, high production rate and clean working environments. The fundamentals of induction heating have been utilized in manufacturing since the 19th century. Historically, the early development of Induction furnaces started from the discovery of the principle of electromagnetic induction by Michael Faraday. De Ferranti was the one to experiment with Induction Furnaces in 1870s in Europe.

De Ferranti in the late 1870s started experimenting with induction furnaces in Europe. Edward Allen Colby patented an induction furnace for melting metals in the year 1890 and produced the first steel the United States in 1907.

During World War II, the technology grew rapidly to satisfy pressing wartime demands for an authentic and quick method of hardening metal engine parts. Lately, the concentration on lean manufacturing techniques and emphasis on improved quality control have led to a rediscovery of induction technology, along with the development of precisely controlled solid-state induction power supplies. The most of the heating methods employs the application of a torch or an open flame to the metal part.

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On account of heat being transferred to the product through electromagnetic waves of which the part never comes into direct contact with any flame, there is no product contamination and when duly set up, the process can be replicated and controlled. This dissertation deals on the construction of an electric heat treatment furnace with easier and better control system and timing unit.

Typical applications of induction heating are melting of metals, heating of metals, welding, melting and all sorts of surface treatments. However, by using electric conductive recipients (e.g. graphite) also other materials like glass can be heated. Surface hardening techniques are suitable for steel with a carbon percentage of at least 0.3 %, where the work piece is heated up to approximately 900°C and after that it is chilled. This technique is used for the hardening of gear wheels, crankshafts, valve stems, saw blades, spades, rails, etc.

II. CONSTRUCTION AND WORKING

A number of different designs for the induction furnace are available, yet they are circled around the basic idea. The induction coil is mostly employed inside the crucible or around it. The crucible is divided into two different parts. The bottom portion of the crucible holds the metal in its purest form, in the same form with which the manufacturer desires it. Whilst the upper section of the crucible is used to remove the slag, the contaminants that rises up to the top surface of the melt. The crucibles can be equipped with the lids to define the amount of air access to the melting metal until it is poured out, making a very pure melt.

Metals such as Iron and steel, Copper, Aluminum and precious metals such as Gold and Silver are usually melted in induction furnace because it is a clean and non-contact process. The furnace can be used in inert or vacuum atmosphere. This methodology is utilized within the warming for production of special steel that might oxidize if heated within the presence of air. Warming is that the fundamental principle of the induction chamber. In an electric induction furnace the charge is produced by the electric coil. The used heating coils are usually needed to be replaced. The crucible in which the metal is placed is made up of stronger materials that can resist the required heat and the electric coil itself cooled by water system so that it does not overheat or melt.

The advantages of the induction chamber area unit a clean energy economical and well manageable melting method compared to most different means that of metal melting.

A. WORKING PRINCIPLE OF INDUCTION FURNACE

The principle of induction furnace is the Induction heating.

Induction Heating:

Electromagnetic induction is a heating technique for electrical conductive metals. Induction heating is frequently applied in several thermal processes such as the melting and the heating of metals. The heating speeds are extremely high because of the high power density. Conductive materials can be heated by the induction heating which is a non-contact type of heating. The following two phenomenon gives the base to the principle of induction heating:

1. Electromagnetic induction
2. The Joule effect

1. Electromagnetic induction:

The energy transfer to the thing to be heated happens by means that of magnetism induction. It's celebrated that in {an exceedingly in a very} loop of semiconducting material an electricity is induced, once this loop is placed in Associate in Nursing alternating magnetic flux. Once the loop is short-circuited, the induced voltage E can cause a current to flow that opposes its cause the alternating magnetic flux. This can be chemist - Lenz's law.

Joule's Effect:

If a huge conductor (e.g. a cylinder) is placed within the alternating force field rather than the short circuited loop, then eddy current are going to be iatrogenic. The eddy current heats up the conductor consistent with the Joule result. When a current I [A] flows through a conductor with resistance R (Ω), the power P [W] is dissipated in the conductor.

B. Types of Induction Furnace:

There are two main types of induction furnaces:

1. Coreless Induction Furnace
2. Channel Induction Furnace

Coreless induction furnace:

The heart of the coreless induction furnace is the coil, which consists of a hollow section of heavy duty, high conductivity copper tubing which is wound into a helical coil. Coil shape is contained within a steel shell. To protect it from overheating, the coil is water-cooled; the water being recirculates and cooled in a cooling tower. The crucible is formed by ramming a granular refractory between the coil and a hollow internal. The coreless induction furnace is commonly used to melt all grades of steels and irons as well as many non-ferrous alloys. The furnace is ideal for remelting and alloying because of the high degree of control over temperature and chemistry while the induction current provides good circulation of the melt.

Channel induction furnace:

The channel induction furnace consists of a refractory lined steel shell which contains the molten metal when it is attached to the steel shell and connected by a throat is an induction unit which forms the melting component of the furnace. The induction unit consists of an iron core in the form of a ring around which a primary induction coil is wound. This assembly forms a simple transformer in which the molten metal loop comprises the secondary component. The heat generated within the loop causes the metal to circulate into the main well of the furnace. The circulation of the molten metal effects a useful stirring action in the melt. Channel induction furnaces are commonly used for melting low melting point alloys and or as holding and superheating unit for higher melting point alloys such as cast iron. These furnaces basically consist of a vessel to which one or more inductors are attached.

The inductor is actually a transformer where by the secondary winding is formed with the help of a loop of liquid metal confined in a closed refractory channel. In the furnace the energy is transformed from the power system at line frequency through a power supply to the inductor and converted into heat.

III. Literature review

K. C. Bala [1] has done analysis of an electric induction furnace for melting aluminium scrap along with its design. They observed cleanliness and availability of electrical energy sources in Nigeria is of paramount importance to its use in foundries, hence the need for this design. Their study deals with the mechanical and electrical requirements for induction furnace production. The mechanical aspect gives consideration to the geometrical components, cooling system, and the tilting mechanism. The electrical aspect deals with the furnace power requirement to make it functional. The design was achieved through consideration of relevant theories and their practical application

Antao Rodrigo Valentim at al. [2] has done study on recovery of aluminium foil in the induction furnace. Their study investigates the efficiency of aluminium foil recycling process where each foil has a thickness of 0.03mm, using induction furnace, in the production of alloy SAE 329[14]. The aluminium foil did not suffer any treatment or grinding, and they were grouped and packed in the crucible of the furnace manually. In the total, 79 processes were developed, obtaining a recovery yield of 93%. Despite the small thickness of aluminium foil, which has directly influenced on reducing the yield of the process, the recovery in the induction furnace was efficient.

G.O. Verran at al. [3] presented the study investigates the influence of casting parameters on efficiency in aluminium can recycling using electric induction furnace. The cans were compacted in packages using high pressure. Initially, the flux amount was maintained constant (20 wt. %), but the temperature of the bath and melt treatment were changed. Next, using two different bath temperatures (750 and 850 °C) and melt treatment with an intensive mixture of flux in molten aluminium, flux amount was changed. The recovered aluminium was poured into permanent moulds. Results were assessed computing the efficiency of the recycling process. Results indicated that the use of bath temperatures above 750 °C and flux amount of at least 10 wt.% leads to good recovery of aluminium after the recycling of cans.

Fang-ni Shang at al. [4] have subjected 6061 aluminum alloy to heat treatment using a high-frequency induction heating apparatus in order to improve the mechanical properties and productivity. With the load of499 kg of the wok piece the melt took 82 minutes and specific energy consumption was 0.6506kWh/kg.

Vivek R. Gandhewar et al. [5] have done study on Induction Furnace. They have carried out pilot study in few industries in India, to verify the working practices and parameters of the Induction Furnaces. In few cases they have observed lack of standardisation of process. Hence for improving its efficiency and for reducing the losses they have made recommendation like scheduling of operations, molten metal delivery, preheating, no time delay in holding the molten metal, reuse of hot gases, using the good quality raw material, proper charging practice.

Chun Lou at al. [6] has done the analysis on experimental investigations on simultaneous measurement of temperature distribution, absorption coefficient of medium, and emissivity of wall surface in an oil-fired tunnel furnace. The measured temperatures of wall surface were compared with a thermocouple and the difference between the two methods was only about 20 K, which also proves that the measurement method based on radiative analysis is reliable. The measured results of temperature distributions in the furnace can be used to analyse the performance of the burner and to assess the heat exchange in the tunnel furnace. Furthermore, once the absorption coefficient and emissivity of wall are known, they can be used directly in calculation of radiative transfer for combustion computation otherwise, it will be a complicated task to get them, possibly with serious errors.

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Asif Ahmad Bhat at al. [7] has done the thermal analysis of induction furnace. They have shown how to solve the induction heating problem in the induction furnace with complex geometry. The results of their study have shown that the temperature of the crucible rises to 1500 °C in 2 hours of heating time at frequency of 8 kHz and current of 400 A. Hence these conditions are favourable for melting of copper (melting point = 1085 °C) in the crucible. Their studies reveal that copper-liner is effective in reducing the electromagnetic coupling between the coil and the vessel and thus prevents vessel from getting heated up by this effect.

Sneha P. Gadpayle et al. [8] have done study on electric melting furnace. The Induction furnace design and subsequently its fabrication should be promoted considering the abundant power sources, less maintenance cost and labour requirements. It is observed by them that resistance heating is appropriate and energy efficient for a variety of heat treating, preheating processes in terms of cost of the furnace. As the furnace for melting of metals require different set ups due to the purpose of use.

Prof. L.P. Bhamare at al. [9] has focused on furnace monitoring and billet cutting system in order to increase the efficiency. A new generation of industrial electrical furnace has been developed during the last 25-30 years. Present practices followed in electrical furnace were discussed by them. The Furnace control which is the most important part of any steel plant. Microcontroller is also used measure furnace temperature by using sensor (PT100). Steel plants require continuous monitoring and inspection at frequent intervals. In Automate a steel plant we can monitor the furnace temperature and minimize human intervention. Monitoring can be done on the furnace for observe/see the overview of the system seen on the PC. In project they have also work properly billet cutting of metal rod are properly
Rakesh S. Ambade et al. [10] have focused on energy conservation in an induction furnace. And to meet this demand we are looking for such foundry process which will produce high quality steel with minimum time. The main purpose of their study is to improve the overall performance of induction furnace and to improve melt rate with the optimum use of electricity. They mainly put attention on induction furnace as these are main consumer of electricity in foundry. In case of induction furnace efficiency is sensitive to many controllable features lie in operational practices, coil height; charge mix, furnace utilization etc. So with the help of recommendation, it is easy to find out the ways to lower the specific energy consumption in these furnaces.

Discussion

From the literature survey following point was needed to be discussed:

1. We have to focus on energy conservation, minimum consumption maximum output policy should be applied.
2. The improvement should be done in induction furnace and to improve melt rate with optimum use of electricity.
3. Finite Element Method (FEM) approach may be used to reduce the design cost, time and efforts for any other required induction furnace.
4. The furnace was constructed putting into consideration; its temperature attainment, capacity of metals it can hold, the depth/surface area to be heat treated, operators safety, space to be occupied in the workshop floor, cost restrictions, availability of the materials used, its maintainability and portability .
5. Optimum thickness for reducing heat loss in furnace with economical cost is needed.
6. There are huge losses in the existing furnace hence we have concluded that optimization is necessary.
7. Waste management as a alternate fuel is a trending and it also minimises the waste disposal.
8. The integration of the furnaces can be done to meet various requirements such as melting of metals. Various purposes can be achieved using the same furnace.
9. Spillage of metal additionally incorporates the burning loss, because the burning loss comes from loss of metal before gushing and while gushing, thus it’s pretty much necessary to cut back the spillage of metal whereas it's fusible kind.

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Conclusion

The basic operations of induction furnace and importance of its individual parameters are studied. The induction furnace should be designed, optimize and install carefully in order to maximize the rate of production and minimize cost of production.

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