Oil Fired Furnace and Induction Furnace: A Review

Bhaskar Dhiman, O.S. Bhatia

Abstract— Heat treatment is the linked process for treatment of machined and forging components. Furnaces can be used for heat treatment process. We have observed that the major problems in oil-fired furnace are non-uniform flame distribution, oxidation of metal, scale formation, carbon loss of metals and emission of pollutants. Oil fired furnaces have low productivity and long start-up time. To avoid these problems the new technology induction furnace should be used. By using the induction furnace instead of oil fired furnace the productivity may be increased and production cost may be reduced. So it is necessary to design, optimize and install the induction furnaces over the oil fired furnaces. This paper presents the reviews on latest trends and developments available in the area of furnaces so that the total equipment cost and losses can be minimized.

Index Terms— Design, Electromagnetic Induction, Furnace, Induction Furnace, Joule Effect, Oil Fired Furnace, Productivity.

1 INTRODUCTION

A furnace is an equipment used to melt metals for casting or to heat materials to change their shape (e.g. forging, rolling) or properties (heat treatment) [45], [52], [49]. Since exhaust gases from the fuel comes in contact with the surface of materials. Then type of fuel used is important because some materials will not tolerate sulphur in the fuel. Solid fuels generate particulate matter, which will interfere the materials placed inside the furnace. For this reason most furnaces use liquid fuel, gaseous fuel or electricity as energy input. Melting furnaces for nonferrous materials use fuel oil. Furnace ideally should heat as much of material as possible to a uniform temperature with the least possible fuel and labour.The key to efficient furnace operation lies in complete combustion of fuel with minimum excess air. Furnaces operate with relatively low efficiencies (as low as 7%) compared to other combustion equipment such as the boiler (with efficiencies higher than 90%). This is caused by the high operating temperatures in the furnace. For example, a furnace heating materials to 1200 °C will emit exhaust gases at 1200 °C or more, which results insignificant heat losses through the chimney.

Steel is a part of our everyday life, in both the developed and developing world [50]. Now-a-days demand of steel is increasing due to increase in infrastructure and globalization. Natural gas fired furnaces have installation cost advantage and induction furnaces have the advantage of less scale formation on the surface of the work. In present world customers are more conscious about the quality of steel mean slower levels of residuals such as sulphur, phosphorus, oxygen, hydrogen, nitrogen and tramp elements. The quality steels are most efficiently produced in electric furnaces (EAF / IF), because they have proved its worthiness in production of a wide variety of special alloy steels having controlled chemistry and better deoxidation procedures.

1.1 Oil Fired Furnace

This furnace is mounted on two pedestals above the floor level. For pouring the molten metal, the furnace is rotated by the geared hand wheel [46], [47], [49]. Oil and air are admitted with pressure through a nozzle. The crucible is placed in the heating chamber and is heated by the flame. The furnace can be stopped whenever needed & temperature can be controlled easily. They give lesser pollution. However, improvements in efficiencies have been brought about by methods such as preheating of stock, preheating of combustion air and other waste heat recovery systems. Oil-fired furnaces mostly use furnace oil, especially for reheating and heat treatment of materials. Light diesel oil (LDO) is used in furnaces where sulphur is undesirable.

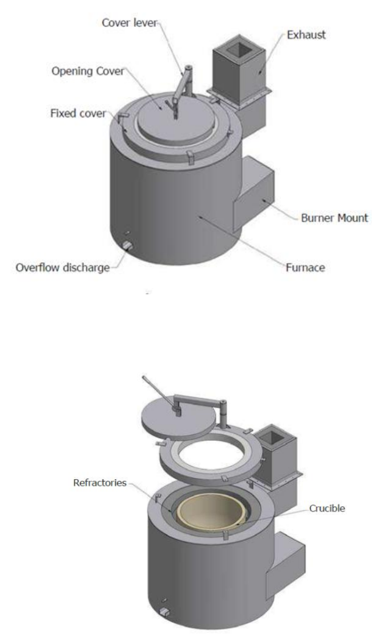

Fig. 1. Oil Fired Furnace [51]

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1.2 Electric Induction Furnace

Induction furnace is an electrical furnace in which the heat is applied by induction heating of a conductive medium (usually a metal) in a crucible placed in a water-cooled alternating current solenoid coil [56]. Induction and arc furnaces use electricity to melt steel and cast iron. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. The electric induction furnace uses electric currents to melt metal. Induction furnaces are ideal for melting and alloying a wide variety of metals with minimum melt losses.

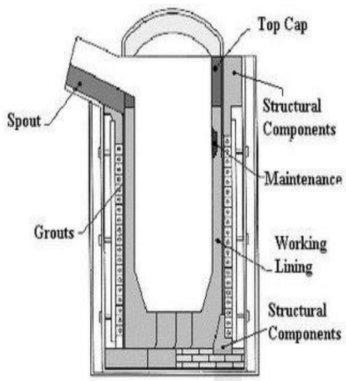

Fig. 2. Electric Induction Furnace [53]

In the liquid steel is produced in Induction Furnace (IF) cast into ingots or continuously cast into blooms / billets / slabs for further rolling into desired product [50]. The steel mills employing this process route are generally called as mini or midi steel plants. Since liquid steel after melting contains impurities like sulphur and phosphorus beyond desirable limits and no refining is generally possible in induction furnace. The structural steel produced through this process is inferior in quality. Quality can be further improved by secondary refining in the ladle furnace, vacuum degassing unit or vacuum arc-degassing (VAD) unit.

1.2.1 Principle of Induction Furnace

The principle of induction furnace is the Induction heating.

Induction Heating: -

Electromagnetic induction is a heating technique for electrical conductive materials (metals) [54]. 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. Induction heating is a form of non-contact heating for conductive materials. The principle of induction heating is mainly based on two well-known physical phenomena:

1. Electromagnetic induction
2. The Joule effect

Electromagnetic induction

The energy transfer to the object to be heated occurs by means of electromagnetic induction. It is known that in a loop of conductive material an alternating current is induced, when this loop is placed in an alternating magnetic field [54, 56].When the loop is short-circuited, the induced voltage E will cause a current to flow that opposes its cause the alternating magnetic field. This is Faraday - Lenz's law. The formula is $=d\phi/dt$; U = voltage (V); ϕ = magnetic flux (Wb); t = time (s)

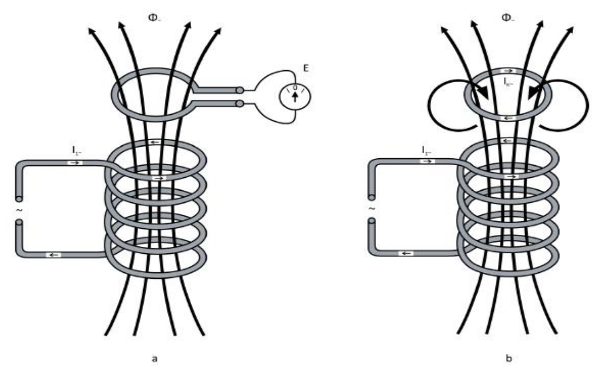

Fig. 3. Law of Electromagnetic Induction [54]

Joule's Effect

If a massive conductor (e.g. a cylinder) is placed in the alternating magnetic field instead of the sort circuited loop, then eddy current will be induced [54],[56]. The eddy current heat up the conductor according to the Joule effect. When a current I [A] flows through a conductor with resistance R [Ω], the power P [W] is dissipated in the conductor. $P=R\times I^2$ [W].

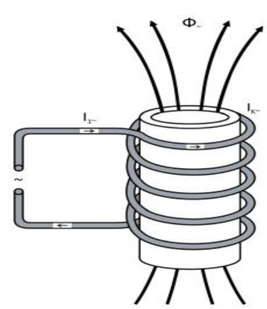

Fig. 4. Joule Effect or induction of Eddy currents [54]

1.3 Types of Induction Furnace

There are two main types of induction furnaces:

1. Coreless Induction Furnace
2. Channel Induction Furnace

1.3.1 Coreless induction furnaces

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 [57]. Coil shape is contained within a steel shell. To protect it from overheating, the coil is water-cooled, the water being recirculated 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.

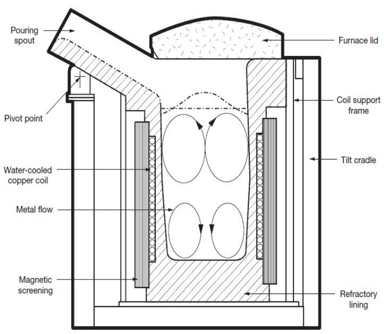

Fig. 5. Coreless Induction Furnace [58]

1.3.2 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 [57]. 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 loops 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.

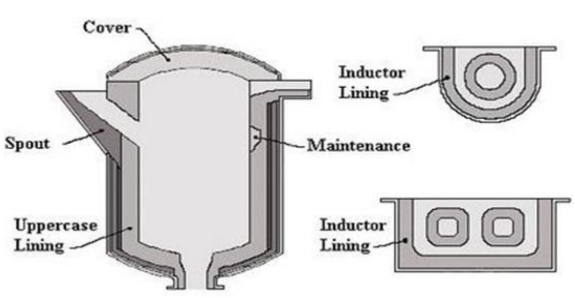

Fig. 8 Channel Induction Furnace [53]

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.

2. OBJECTIVES

The aims and objectives of the present study are as follows:-

1. To reduce production cost and improve productivity.
2. Providing better quality of products.
3. Reaching to higher levels of reliability.
4. Avoiding or reducing downtime and wastage of material.
5. To identify the locations of bottlenecks and eliminate them.
6. To minimizing the heat losses.
7. To find opportunities to energy conservations.

3. LITERATURE SURVEY

S. Jena at al. (1992) has studied the exposure to higher temperatures. Inductive power has been applied to the melting of high carbon ferrochromium fines at Zimasco [1]. They have focused on improving product quality, reducing the cost of production and new methods of casting the alloy separately from the slag. Investigations were carried out by them on the possibility of reducing the carbon content in the alloy. Attention was paid to increasing the number of heats obtained from each campaign by extending the life of the refractory lining. They have also devoted to optimizing the melting operation by automatic linkage of key process-control parameters.

Pritibhushan Sinha at al. (1998) have made an optimum design of the lining of a medium frequency induction melting furnace[2].They have found an operational problem of these furnaces is the need to repair and rebuild the lining of the crucible frequently. They present a methodical approach for better design and maintenance to decrease such problems. The erosion process of the lining is modeled by them as a renewal reward process. They have discussed the problems related to the erosion of the lining of an MFIM furnace, with a view to evolving practices which may improve the efficiency of such a furnace.

M.S. liu at al.(2001) have analysed startup of oil- fired furnace by using the smoothing Monte Carlo model approach.They have developed multidimensional mathematical model to calculate the temperature distribution and the heat flux distribution of an oil fired furnace from its start-up period to the steady state operation[3]. This model integrates the conduction model, radiation model, combustion model and soot model, which are the major aspects affecting the thermal performance of the oil-fired furnace. In the radiation model, they have integrate the Monte Carlo method with the least square smoothing technique to provide a more effective and reliable method in calculating the total exchange areas between surface and gas zones of furnace with greater accuracy.

S.K. Dutta at al. (2004) have done studies on direct reduced iron melting in induction furnace. They have examined melting of DRI (direct reduced iron) in a laboratory size induction furnace using molten steel bath as hot heel [5].The effect of partial replacement of scrap by DRI on various melting parameters has been studied by them. Also kinetic studies were made to evaluate net melting rate. It was revealed that since melting and refining are taking place simultaneously, the increasing proportion of DRI in the input charge increases net melting rate and metallic yield. They have concluded that higher proportion of DRI, as a replacement to scrap, contributes to improve mechanical properties with no segregation of carbon content and the decrease in sulphur and tramp elements in the product that improves steel quality.

K. C. Bala (2005) have done analysisof an electric induction furnace for melting aluminium scrap along with its design [6]. 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.

Roman Weber at al. (2005) have examined combustion of natural gas (NG), light fuel oil (LFO), heavy fuel oil (HFO), and coal with 1300°C comburent containing 20% oxygen, 60% nitrogen, 14% water vapour, and 6% carbon dioxide [7]. The combustion process of light oil was very similar to that of natural gas. The entire furnace was visible illuminated, with no evidence of visibly flames being observed by them. However, combustion of heavy fuel oil and coal was significantly different, and the flames were always visible. They have observed, due to a slow combustion process, the temperature and the chemistry fields are uniform throughout the experimental furnace. CO was not found in the furnace exit for any of the experimental fuels. Axially, along the whole furnace, a high radiative heat flux of 300–400 kW/m2 was measured.

H. Tauchmann (2005) have done the analysis on of utilities fuel choice andfiring the furnace. He attempts to estimate how the fuel mix of German electricity producers does react to fuel price changes [8]. Two different aspects of fuel choice are distinguished: at the one hand, the construction of usually fuel-specific capacities for electric power generation, i.e. investment decisions that determine the fuel mix in the long run; at the other, fuel use conditional on existing generation capacities, i.e. short-run inter-fuel substitution. Their estimation results suggest that the fuel mix of electric utilities is price inelastic either if long-term investment or short-term inter-fuel substitution is considered. Finally, the empirical results were used to predict the potential impacts of CO2 emissions trading on fuel choice in the German electric power industry.

G.O. Verran at al. (2007) presented the study investigates the influence of casting parameters on efficiency in aluminum can recycling using electric induction furnace [9]. 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 aluminum, flux amount was changed. The recovered aluminum was poured into permanent molds. 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 aluminum after the recycling of cans.

Alfredo Berm Udez at al. (2009) have used a finite-element method to solve an eddy current problem arising from the modelling of an induction furnace [11]. By taking advantage of the cylindrical symmetry, the three dimensional problem reduces to a two-dimensional one on a meridional section, provided that the current density, written in cylindrical coordinates, has only an azimuthal component. A mixed formulation in appropriate weighted sobolev spaces was given by them. The existence and uniqueness of the solution are proved by analyzing an equivalent weak formulation. Moreover, an additional regularity result is proved under suitable assumptions on the physical coefficients. The problem is discretized by standard finite elements and apriorierror estimates are proved. Finally, some numerical experiments that allow an assessment of the performance of the method are reported by them.

O.K. Abubakre and R.A (2009) have made mathematical model for optimizing charge and heel levels in steel remelting induction furnace .Heat energy balance equation in an induction furnace was developed along with computer program (model) written in basic programming language to optimize the charge/heel level in the furnace, using the hypoeutectic AISI-SAE 1042 alloy steel as charge material[12]. Time and cost of electrical energy consumption were considered as the decision variables. The model results showed that Charge (solid scrap) and Heel (molten steel) levels of ratio 3:2 was the optimum for an economical productivity.

Anuwat Pansuwan at al. (2009) have done work on temperature estimation of liquid steel in induction furnace. They presents the indirect measures of temperature by measuring the energy put into the furnace, temperature and flow rate of cooling water and temperature at the outer wall lining of the induction furnace in order to estimate the temperature of the liquid steel in the furnace[13]. The technique for estimating the temperature relies on the consideration of the heat balance equation of the furnace and the use of several parameters for the furnace during the processes in order to estimate the losses of heat from the furnace in order to calculate the heat balance equation. From this method, we can estimate the temperature of liquid steel in the induction furnace accurately.

Antao Rodrigo Valentim at al. (2010) have done study on recovery of aluminum foil in the induction furnace. Their study investigates the efficiency of aluminum foil recycling process where each foil has a thickness of 0.03mm, using induction furnace, in the production of alloy SAE 329[14].

The aluminum 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 aluminum foil, which has directly influenced on reducing the yield of the process, the recovery in the induction furnace was efficient.

Fang-ni Shang at al. (2011) have subjected 6061 aluminum alloy to heat treatment using a high-frequency induction heating apparatus in order to improve the mechanical properties and productivity[16].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. (2011) 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 [18]. 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. (2011) have 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.

E. Kardas (2012) have worked in evaluation of efficiency of working time of equipment in blast furnace. They have performed OEE and PAMCO analysis, which enabled to assess and identify factors which had great effect on efficiency of blast furnace department under study [21]. The level of efficiency is influenced by many factors. Among them there are: Situation on the steel market in Poland and the world: changes in demand for steel products cause changes in the volume of production of pig iron, what effects on the efficiency of blast furnaces department. Demand for raw materials: changes in demand for raw materials on the market often cause situation when steel plants are forced to order raw materials which are low quality, what effects the quantity and quality of produced pig iron and quantity of slag. Work organization of blast furnace - to maintain continuity of production and equipment in proper condition, company accepted the rule that while two blast furnaces work, the third undergoes renovation.

Asif Ahmad Bhat at al. (2012) have done the thermal analysis of induction furnace. They have shown how to solve the induction heating problem in the induction furnace with complex geometry [23]. 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.

Viralkumar Solanki at al. (2013) have done the simulation of induction furnace and done it’s comparison with actual induction furnace. At first, a mat lab simulation of induction furnace model optimized resonant capacitor is designed for a practical induction furnace with parallel resonant inverter [24]. Then rectifier and inverter snubber circuit are designed and voltage, current, THD (total harmonic distortion) and power were measured. This measured value is compared with actual working industry furnace data and conclusion is made that when furnace is not operate at full load that time its power factor is very low and THD is high.

Ansu John at al. (2013) have studied the partial replacement of fine aggregate using induction furnace slag. The compressive strength of mortar and concrete containing induction furnace slag up to 30 percent is found to be comparable with the strength of corresponding control mortar mix with super plasticizer containing no slag [25]. The compressive strength of mortar and concrete containing induction furnace slag greater 30 percent is found to be lower than the corresponding control mortar mix containing no slag. The slump of concrete containing induction furnace slag up to 30 percent is found to be greater compared to all other mixes. Hence it may be concluded that the slag fines can be used as fine aggregate in concrete.

S. L. Gbadamosi et al. (2013) have developed new block which is proved to be effective in harmonic distortion analysis in a steel plant. They have measured harmonic distortion (THD) was measure by the THD block in Simulink [26]. The distortion for both voltage and current due to the steel plant were excessive and could be mitigated using filter of commensurable design as herein proposed. Due to the estimated level of distortions in power supply network, it is certain that other loads supplied from the same network will be affected. Moreover, the reduction of the distortion by passive filter was simulated and effective in mitigating distortion to below tolerance limit. The simulation of the installation of the designed passive filter shows that the filter reduced the distortions by approximately 60%.

Bhujbal Nitin B. at al. (2013) concluded that induction furnaces are most commonly used for melting of metals. Especially silica ramming mass is used as refractory material to prevent losses. Hence proper optimization is needed in thickness [27]. Increase in thickness plays an important role in effectiveness of the furnace. As the thickness increases the heat losses goes on decreasing up to a certain limit. Optimum thickness reducing heat loss in furnace with economical cost is needed. Their work deals with optimization of wall thickness and material for minimum heat losses during melting iron. ANSYS Software was used by them for optimization which gave more accurate results in minimum time consumption.

Sunil M. Jaralikar (2013) have studied the performance of an induction furnace in a steel melting industrial unit by employing a 12 pulse converter in its power supply unit [28]. Thus the furnace forms a nonlinear load and reflects all the negative effects associated with the inductive loads and power electronics based converter circuits. The performance analysis and harmonic measurements of the induction furnace under consideration with the existing setup of 12 pulse converter indicates that the specific consumption of the furnace is high when compared with the rated consumption, the distortions in the current and voltage waveform (THD) is beyond the permissible limits and that there is good scope for improvement in its performance and economy of operation. For improving the performance of this furnace, it is proposed to replace the existing 12 pulse converter with 24 pulse converter.

Vipul Gondaliya at al. (2013) have done study on transient heat transfer analysis of induction furnace by using finite element analysis [29]. The aim of their work study was to prepare a finite element model of induction furnace. The result of finite element modelwill be validating with experimental investigation carried out in industry (Austin bearing-junagadh). After comparing results FEA model we can change the refractory material or by taking 3-10 mm thick insulation and results compare with FEA results.

Nihar P Bara (2013) have done study on finite element analysis of induction furnace for optimum heat transfer. They have analysed the effective heat transfer of the induction process [30]. His results shows the effectiveness of ramming mass in the melting process. Simulation was performed by him which shows the proper thickness and conductivity of it would enhance the melting and optimizes the heat process. The result also highlights the application of FEM in the computation calculations of induction process. He evaluated the heat transfer characteristics of the composite walls of the induction furnace in order to get more efficiency.

Ramesh Babu P. et al. (2013); have simulated a MATLAB based model of the hybrid active power filter for the induction furnace [31]. The simulation result shows that the supply current harmonics are compensated very effectively by using the hybrid selective active filter.

Nihar Bara (2013) have done study on numerical analysis of induction furnace. A new [32] generation of industrial induction melting furnaces has been developed during the last 25 years. Present practices followed in Induction Furnaces were discussed by them. Their study related with the modelling of induction process and its development. The computational techniques available for the modelling the process and the various methods for optimization was also discussed by them.

Shri P. K. Thakur at al. (2014) have done work on efficient energy optimization in reheating furnaces [33]. The aim of their study was to analyse the possibilities for energy efficiency improvements through utilization of measurement and automatic control. This includes both direct fuel savings and indirect savings due to product quality improvements. Focus is on energy use in steel reheating furnaces for rolling mills. The demands on the reheating process and the operational conditions that are essential for its control are described. There is another area for reducing energy consumption is by waste heat recovery from flue gases and the reduction in specific fuel consumption / ton of finished products, scale losses during reheating and rolling process and the advantages of walking beam furnace over pusher type reheating furnaces. Their study also deals the control of surface oxidation by improving the combustion efficiency, controlling temperature for minimizing fuel consumption and better utilization of energy in terms of specific fuel consumption / ton of finished steel.

Binoy C N at al. (2014) have done analysis on cost reduction using alternative fuel in a forging industry [34]. Their study includes waste plastic pyrolysis oil, waste plastic pyrolysis oil and its blend as an alternative fuel for a forging industry has been introduced. In their study, Applicability of waste tyre pyrolysis oil was studied basis on a forging industry. Pyrolysis oil which is derived from waste rubber tyres was analysed as an alternative fuel in forging industry. Pyrolysis oil was tested for the required specifications and compared with existing fuel. As because of its low flash point an attempt was done to blend pyrolysis oil and furnace oil to get the required flash point. Satisfactory result was got & Cost analysis on the basis of results was made. Cost analysis proves that using of pyrolysis tyre oil instead of current furnace oil will be beneficial for the forging industry.

Dr. R.K. Jain (2014) have experimentally investigated the effect of flame temperature on performanceof rotary furnace [35]. The natural sources of energy coal, oil, gas etc. are depleting fast. His study deals with the importance of an LDO fired rotary furnace for ferrous foundries .The experimental investigations revealed that by reducing the excess air to 10 % and using preheated air of 2000 °C not only the fuel consumption was drastically reduced but also the melting rate was considerably increased.

Dr. Ali K. M. Alshaikhli at al. (2014) have done analysis on design and construction of the coreless induction furnace [36]. Many analytical methods could be applied to induction heating and melting problems. The most suitable method for their work was equivalent circuit method, a second approach is the superposition method, to check the results of the first method in one step of the design. Prior to the use of these two methods the dimensions of the furnace, the operating frequency and the required power must be determined as a prerequisite. A design procedure was developed as computer programs, these programs accomplished a general design which can be utilized to design coreless furnaces of variable specifications. Then, a design, meeting certain specification was prepared, taking into consideration the available facilities. Ultimately the furnace was constructed and the final aim, which is melting the metal, was achieved.

Sneha P. Gadpayle et al. (2014) 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 [37]. 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.

O.A. Adeyemi1 et al. (2014) have done study on production of ductile iron using indigenously manufactured rotary furnace. Production of ductile iron using an indigenous 100kg rotary furnace was achieved using the ladle treatment/sandwich cover ladle method [38]. Powdered Ferrosilicon magnesium of 400g was used as a nodularizer together with powdered Ferrosilicon of 20g was used as innoculant. The nodularizer was put in a cylindrical pocket at the base of the ladle with a circular fitting steel plate cover welded to a handle which was removedimmediately after tapping the molten metal from the rotary furnace. The resulting melt was subsequently pouredinto the mould after the violent reaction between the molten metal and the nodularizer. Samples of the as-castwere subjected to metallographic process and characterized using a Nikon Eclipse metallurgical microscopeand a Hilger Analytic atomic mass absorption spectrometer for percentage elemental analysis. The average epercentage element weight of the samples and microstructures of 200X and 400X compared favourably with the ductile iron produced from standard procedure.

Kushal G. Ambli at al. (2014) have done experimental analysis and optimization of material consumption. The initial consumption of metal was high. The average burning loss earlier was 11.56%. In the first experiment, the burning loss was reduced to the average of 5.68% [39]. In the second experiment, the burning loss was reduced to 4.28%. The burning loss generated now is also high, as the maximum burning loss which is to be got is 3%. Different composition of metals can be used without altering the grade of metal, so as to reduce the burning losses to minimum as possible.

Prof .Uma Kulkarni at al. (2014) works on design & control of medium frequency induction furnace for solar grade silicon. Induction melting for ferrous alloys is known and popular among masses. Silicon and its properties have been the topic of research since the advent of IC design [40]. The VLSI design has undergone changes and has seen a huge success. Production of silicon wafers somehow has not changed much over the years. Their study gives an insight to an innovative method of producing silicon wafers. If all aspects are successful then it will be a revolution in the silicon production industry. Making use of induction melting for silicon to obtain wafers for PV cells is proposed. This would definitely require the design of a furnace with the required control and also a setup for drawing the silicon wafers. Part by part implementation is taken up and the integration will be the final stage. The scope of their study presented here is limited to giving an overview of the innovative idea and the implementation details of the power circuit.

Uma Kulkarni at al. (2014) have work on design and control of medium frequency induction furnace for silicon melting. Their project is an effort to design an induction furnace with better controllability and power efficiency [41]. The hardware implementation considered the fallowing points while designing i.e. Solid state power sources used to drive induction heating loads are very efficient when the load is driven at its natural resonant frequency. This allows zero voltage (ZVS) and or zero current (ZCS) switching of the converter, resulting in reduced power losses in the semiconductor switches. Another advantage of driving a load at resonance is to enable an input power factor close to unity allowing minimal KVA consumption. Environmental cleanliness is another added advantage.

Prof. L.P. Bhamare at al.(2015) have 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 [42]. 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). In Automate a steel plant we can monitor the furnace temperature and minimize human intervention. Steel plants require continuous monitoring and inspection at frequent intervals. The objective of their proposed work is to develop steel plant. 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 billet cutting of metal rod are properly.

Ufuoma Peter Anaidhuno et al. (2015) concentrate on development of an electric induction furnace for heat treatment of ferrous and non-ferrous alloys. Their motive to design and develop an electric induction heat treatment furnace for undergraduate students for giving demonstrations on heat treatment processes such as annealing, normalizing, case hardening, tempering, sphereoidizing etc. [43]. In the Mechanical Engineering Foundry Shop. 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 . Finally, the actualization and realization of this project is a boost to the development and reliability.

Isam M. Abdulbaqi at al. (2015) have done detailed analysis on design and implementation of an induction furnace. The design of a certain induction furnace for a certain application depends mostly on empirical formulas and experience [44]. The purpose of their study is to use the Finite Element Method (FEM) approach to perform an electromagnetic-thermal coupled analysis for a suggested coil with certain billet and studying its performance during the heating period. This will lead to the ability of expecting the required coil current and its frequency, to heat certain part of a certain billet to a certain temperature at the predetermined time. Then, the simulation results can be used to build the coil and leads to design the power supply for the induction furnace. The practical measurement of the designed system agrees with that of the theoretical design results. Hence, this approach assists to reduce the design cost, time and efforts for any other required induction furnace.

Rakesh S. Ambade et al. (2015) have focused on energy conservation in an induction furnace [45]. And to meet this demand we are looking for such foundry process which will produce high quality steel with minimum time. The aim of their study is to improve the overall performance of induction furnace and to improve melt rate with 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.

4. SUMMARY OF LITERATURE SURVEY

The summery of researches done by experts in the area of Design, Optimization and Installation of Induction Furnaces and Oil Fired Furnaces have been presented in Table1 which carries the author name, year and investigated problem types.

TABLE 1

Summary of the developments in Oil Fired Furnaces and Induction Furnaces on literature survey.

Sr. no.	Author Name (Year)	*Investigated Problem Type*
1	S. Jena at al. (1992)	Commissioning and Operating an Induction Furnace at Zimasco (KweKwe Division) to Melt High-carbon Ferrochromium
2	Pritibhushan Sinha at al. (1998)	An Optimum Design of the Lining of a Medium Frequency Induction MeltingFurnace
3	M.S. liu at al.(2001)	Startup Analysis of Oil- Fired Furnace – The Smoothing Monte Carlo Model Approach
4	S. Palanco at al. (2004)	Analytical Control of Liquid Steel in an Induction Melting Furnace Using a Remote Laser Induced Plasma Spectrometer
5	S.K. Dutta at al. (2004)	Studies on Direct Reduced Iron Melting inInduction Furnace
6	K. C. Bala (2005)	Design Analysis of an Electric Induction Furnacefor Melting Aluminium Scrap
7	Roman Weber at al. (2005)	On the (MILD) Combustion of Gaseous, Liquid, and Solid Fuels in High Temperature Preheated Air
8	H. Tauchmann(2005)	Firing the Furnace? An Econometric Analysis of Utilities Fuel Choice
9	G.O. Verran at al. (2007)	An Experimental Study of Aluminium Can Recycling Using Fusion in Induction Furnace
10	Arimichi Morita at al. (2008)	Melting Automation Using a Medium FrequencyInduction Furnace
11	Alfredo BermUdez at al. (2009)	Numerical Analysis of a Finite-Element Method for The Axisymmetric Eddy Current Model of an Induction Furnace
12	O.K. Abubakre and R.A (2009)	Mathematical Model for Optimizing Charge and Heel Levels in Steel Remelting Induction Furnace for Foundry Shop
13	AnuwatPansuwan at al. (2009)	Temperature Estimation of Liquid Steel in Induction Furnace
14	Antão Rodrigo Valentim at al. (2010)	Recovery of Aluminium Foil in The Induction Furnace
15	PashupatiDhakal at al. (2012)	Design and Performance of a New Induction Furnace for Heat Treatment of Superconducting Radiofrequency Niobium Cavities
16	Fang-ni Shang at al. (2011)	Application of High-Frequency Induction Heating Apparatus to Heat Treatment of 6061 Aluminium Alloy
17	JaroslavBublík at al. (2011)	Specific Energy Consumption of Induction Crucible Furnace
18	Vivek R. Gandhewar et al. (2011)	Induction Furnace - A Review
19	R. Przyłucki at al. (2011)	Influence of an Induction Furnaces Electric Parameters on Mass Transfer Velocity in The Liquid Phase
20	Chun Lou at al. (2011)	Experimental Investigation on Simultaneous Measurement of Temperature Distributions and Radiative Properties in an Oil-Fired Tunnel Furnace by Radiation Analysis
21	E. Kardas (2012)	Evaluation of Efficiency of Working Time of Equipment in Blast Furnace Department
22	J. Mróz (2012)	Current Situation and Predictions Further Development of Blast Furnace Technology
23	Asif Ahmad Bhat at al. (2012)	Thermal Analysis of Induction Furnace
24	Viralkumar Solanki at al.(2013)	Simulation of Induction Furnace and Comparisonwith Actual Induction Furnace
25	Ansu John at al. (2013)	Study on The Partial Replacement of Fine Aggregate Using Induction Furnace Slag
26	S.L.Gbadamosi et al. (2013)	Harmonic Distortion From Induction Furnace Loads in a Steel Production Plant

27	BhujbalNitin B. at al. (2013)	Optimization of Wall Thickness and Material for Minimum Heat Losses for Induction Furnace by FEA
28	Sunil M. Jaralikar (2013)	Performance Analysis of an Induction FurnaceEmploying 12 Pulse Converter- A Case Study
29	VipulGondaliya at al. (2013)	Transient Heat transfer Analysis of Induction Furnace by Using Finite Element Analysis
30	Nihar P Bara (2013)	Finite Element Analysis Of Induction Furnace For Optimum Heat Transfer
31	Ramesh Babu P. et al. (2013)	Elimination Of Harmonics Of Induction Furnace By applying PQ-Theory for The Control Of Hybrid Active Selective Filter
32	Nihar Bara (2013)	Review Paper on Numerical Analysis of Induction Furnace
33	Shri P.K.Thakur at al. (2014)	A Review On: Efficient Energy Optimization in Reheating Furnaces
34	Binoy C N at al. (2014)	Cost Reduction Using Alternative Fuel in a ForgingIndustry
35	Dr. R.K. Jain (2014)	Experimentally Investigated Effect of FlameTemperature on Performance of RotaryFurnace
36	Dr. Ali K. M. Alshaikhli at al. (2014)	Design and Construction of the Coreless Induction Furnace
37	Sneha P. Gadpayle et al. (2014)	Electric Melting Furnace - A Review
38	O.A. Adeyemi1 et al. (2014)	Production of Ductile Iron Using Indigenously Manufactured Rotary Furnace
39	Kushal G. Ambli at al. (2014)	Experimental Analysis and Optimization of Material Consumption
40	Prof .Uma Kulkarni at al. (2014)	Design & Control of Medium Frequency Induction Furnace-For Solar Grade Silicon
41	Uma Kulkarni at al. (2014)	Design and Control of Medium Frequency Induction Furnace for Silicon Melting
42	Prof. L.P. Bhamare at al.(2015)	Furnace Monitoring and Billet Cutting System
43	Ufuoma Peter Anaidhuno et al. (2015)	Development of an Electric Induction Furnace for Heat Treatment of Ferrous and Non-Ferrous Alloys
44	Isam M. Abdulbaqi at al. (2015)	Design and Implementation of an Induction Furnace
45	Rakesh S. Ambadeet al. (2015)	Energy Conservation In An Induction Furnace: A New Approach

5. DISCUSSIONS

From the literature survey following points are needs to be discussed:-

1. We have to focus on energy conservation, minimum consumption maximum output policy should be applied.
2. Now-a-days demand of steel is increasing due to increase in infrastructure and globalization. And to meet this demand we are looking for such foundry process which will produce high quality steel with minimum time.
3. The improvement should be done in induction furnace and to improve melt rate with optimum use of electricity.
4. Finite Element Method (FEM) approach my be used to reduce the design cost, time and efforts for any other required induction furnace.
5. 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 .
6. Furnace monitoring and billet cutting system may be adapted in order to increase the efficiency.
7. Optimum thickness for reducing heat loss in furnace with economical cost is needed.
8. There are huge losses in the existing furnace hence we have concluded that optimization is necessary.
9. Conversion of waste to energy is one of the recent trends in minimizing not only the waste disposal but also could be used as an alternate fuel for industries.
10. Latest techniques and machines should be used.
11. 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.
12. Spillage of metal also incorporates the burning loss, as the burning loss is derived from loss of metal before pouring and after pouring, therefore it is very much necessary to reduce the spillage of metal while it is melted form.

6. CONCLUSION

Through the exhaustive review of literature, the basic operations of induction furnace and importance of its individual parameters are studied. Through the literature we have observed that the efficiency of oil fired furnaces is less because of heat losses. So there exists the opportunities for improving the efficiency of steel melting processes by using the induction process. 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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