High Speed Infra Red Furnace

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ABSTRACT *This project is designed to improve Electrical versus Thermal efficiency. Nowadays electrical heating system converts 65% of the electrical power into thermal power. We have introduced infrared penetration heating system to improve efficiency up to 95% thermal efficiency and 100% electrical efficiency.*

We are going to construct a furnace model to improve our system. A real fabrication model is to analyze IR heating system. The capacity of infrared lamps used inside the furnace will be about 500watts. IR lamps will be used to provide heat.

From the furnace, the temperature is sensed by the thermocouple, which is based on the principle of Seeback effect. The function of a thermocouple is to convert heat energy to mill voltage and it is fed to a signal conditioner to improve the sensitivity and also to improve the non-linear Property of thermocouple. Temperature acquired from the thermocouple is indicated on the screen of the computer. The computer will also compare the temperature acquired with the set temperature and control action if any will be done by the solid-state relay that avoids instantaneous heating. The infrared (IR) heating has the potential to be used for solutionizing of metal forgings with benefits of reduced energy consumption, increased productivity, and improved microstructure and mechanical properties.

In our project, we have integrated heat treatment, annealing, oven and furnace operations are done in a single device. So that the cost of equipment for each process and time taken are reduced.

Key words: *Infrared lamp; Radiation; Furnace; Heat transfer.*

I. INTRODUCTION

1.1. GENERAL

A furnace is a device used for heating. The term furnace is used exclusively to mean industrial furnaces which are used for many things, such as the extraction of metal from ore (smelting) or in oil refineries and other chemical plants, for example as the heat source for fractional distillation columns.

The term furnace can also refer to a direct fired heater, used in boiler applications in chemical industries or for providing heat to chemical reactions for processes like cracking. The benefits of infrared (IR) heating, including short heat-up times, good temperature control, and energy efficiency. Significantly higher heating rates and better temperature control is possible than in conventional convection furnaces. Since heating is on a demand basis, reduced energy consumption is a major advantage, in addition to the shorter production times. For solution treating of forged alloy parts, the improved control at higher heating rates provides the flexibility to solutionize at temperatures closer to the solidus, and for shorter soak times.

The projected savings from IR heating for this application due to reductions in energy consumptions and lead times are about 50%. In addition, it has been shown that enhanced mechanical properties can be obtained by using infrared heating for processing of forgings.

The absence of standard solutionizing procedures using IR furnaces prevents industry from implementing and taking full advantage of this process.

Short soak solution treatment, and fluidized bed solution treatment of aluminum alloy castings are some of the current related work exploring improvements in thermal processing. Improvements in microstructure and mechanical properties using rapid heating have also been explored for other alloy system.

II. FURNACE

2.1 HISTORY

A furnace is a device used for heating. The term furnace is used exclusively to mean industrial furnaces which are used for many things, such as the extraction of metal from ore (smelting) or in oil refineries and other chemical plants, for example as the heat source for fractional distillation columns. The term furnace can also refer to a direct fired heater, used in boiler applications in chemical industries or for providing heat to chemical reactions for processes like cracking and are part of the Standard English names for many metallurgical furnaces worldwide, upto 1709, furnaces could only use charcoal to produce iron. However, wood (which is what charcoal is made from) was becoming more expensive, as forests were being cleared for farmland and timber.

Coal was a possible alternative to wood, but although it was cheap and plentiful, it wasn't a feasible fuel for making iron, because it contained sulphur, and this made the iron too brittle to be of any use.

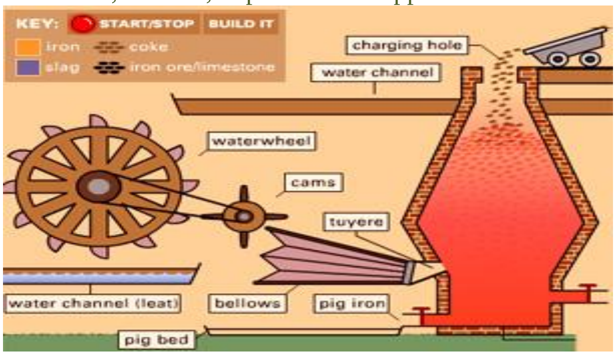

Fig.1

However, in 1709, a man called Abraham Darby finally succeeded in smelting iron using coke (see list of terms below) as fuel, and he bought all his workers beer, in celebration of his discovery. This technological achievement allowed a major expansion of the iron trade, and ultimately it helped lead to the Industrial Revolution. After 1709, Coalbrookdale saw other achievements, such as the first cast-iron bridge - built over the River Severn - and the first cast-iron framed building - built in Shrewsbury.

2.2 TYPES

2.2.1BELLEFONTE FURNACE

Bellefonte Furnace was a hot blast iron furnace located in Bellefonte, Pennsylvania. Founded in 1888, it was the first hot blast, coke-fuelled iron furnace to be built in Centre County, Pennsylvania. While its founders hoped to transform Centre County's iron industry with modern technology, the furnace struggled to operate at a profit and was out of operation from 1893 until 1899. Thereafter, it operated more or less continuously until 1910, and was demolished four years later. It should not be confused with the charcoal-fuelled Bellefonte Furnace and Forge on Logan Branch, which was replaced by Valentine Furnace.

2.2.2INDUCTION FURNACE

An induction furnace is an electrical furnace in which the heat is applied by induction heating of metal. The advantage of the induction furnace is a clean, energy-efficient and well-controllable melting process compared to most other means of metal melting. Most modern foundries use this type of furnace and now also more iron foundries are replacing cupolas with induction furnaces to melt cast iron, as the former emit lots of dust and other pollutants. Induction furnace capacities range from less than one kilogram to one hundred tonnes capacity and are used to melt iron and steel, copper, aluminium and precious metals.

Since no arc or combustion is used, the temperature of the material is no higher than required to melt it; this can prevent loss of valuable alloying elements.

The one major drawback to induction furnace usage in a foundry is the lack of refining capacity; charge materials must be clean of oxidation products and of a known composition and some alloying elements may be lost due to oxidation (and must be re-added to the melt).

Operating frequencies range from utility frequency (50 or 60 Hz) to 400 kHz or higher, usually depending on the material being melted, the capacity (volume) of the furnace and the melting speed required. Generally, the smaller the volume of the melts, the higher the frequency of the furnace used; this is due to the skin depth which is a measure of the distance an alternating current can penetrate beneath the surface of a conductor. For the same conductivity, the higher frequencies have a shallow skin depth - that is less penetration into the melt. Lower frequencies can generate stirring or turbulence in the metal.

2.2.3ELECTRIC ARC FURNACE (EAF)

An electric arc furnace (EAF) is a furnace that heats charged material by means of an electric arc. Arc furnaces range in size from small units of approximately one ton capacity up to about 400 ton units used for secondary steelmaking. Arc furnaces used in research laboratories and by dentists may have a capacity of only a few dozen grams. Industrial electric arc furnace temperatures can be up to 1,800 ° C, (3272 °F) while laboratory units can exceed 3,000 °C. (5432 °F) Arc furnaces differ from induction furnaces in that the charge material is directly exposed to an electric arc, and the current in the furnace terminals passes through the charged material.

2.2.4BLAST FURNACE

A blast furnace is a type of metallurgical furnace used for smelting to produce industrial metals, generally iron. In a blast furnace, fuel, ore, and flux (limestone) are continuously supplied through the top of the furnace, while air (sometimes with oxygen enrichment) is blown into the bottom of the chamber, so that the chemical reactions take place throughout the furnace as the material moves downward.

The end products are usually molten metal and slag phases tapped from the bottom, and flue gases exiting from the top of the furnace. The downward flow of the ore and flux in contact with an up flow of hot, carbon monoxide rich combustion gases is a counter current exchange process. However, the term has usually been limited to those used for smelting iron ore to produce pig iron, an intermediate material used in the production of commercial iron and steel.

2.3 IR FURNACE HISTORY

In 1800 William Herschel, a German astronomer and composer, while testing filters to observe sun spots passed sunlight through a prism, observed a heating effect in the visible red portion of the spectrum. Testing further, he detected the presence of the greatest amount of heat in the area just beyond the red end of the visible spectrum now called Near-Infrared (NIR). He wrote two papers detailing his findings and later that year, presented his discovery of invisible "Calorific rays" to the Royal Society of London. Thirty-five years later Andre-Marie Ampere employed the newly invented thermocouple to demonstrate that near-IR (NIR) radiation was in fact invisible light. It wasn't until 1900 that the term infrared was applied to the part of invisible spectrum contiguous to the red end of the visible spectrum that comprises wavelengths from 0.74 microns to 300 microns.

- Near IR

IR was first used in an industrial process in the 1930's in automotive paint curing applications. It was discovered that NIR (Near Infrared) wavelengths, which are the shortest form of infrared radiation generate the greatest amount of heat. NIR can penetrate most

- Near IR Furnaces

Over 30 years ago, Radiant Technology Corporation pioneered the development of short wavelength infrared continuous belt ovens and furnaces. In the '70's RTC introduced the first high-temperature infrared furnace capable of operating at 1000°C with extremely tight temperature control from 1972 to 2006 RTC became the undisputed leader in infrared heating technology and developed precise, efficient, and reliable thermal processing equipment for the photovoltaic, semiconductor processing.

2.4 OVEN

An oven is a thermally insulated chamber used for the heating, baking or drying of a substance. It is most commonly used for cooking. Kilns and furnaces are special-purpose ovens. The first being used mainly for the fabrication of pottery and the second being used for forging.

A furnace can be used either to provide heat to a building or used to melt substances such as glass or metal for further processing. A blast furnace is a particular type of furnace generally associated with metal smelting (particularly steel manufacture) using refined coke or similar hot-burning substance as a fuel, with air pumped in under pressure to increase the temperature of the fire.

A kiln is a high-temperature oven used in wood drying, ceramics and cement manufacturing to convert mineral feedstock (in the form of clay or calcium or aluminum rocks) into a glassier, more solid form. In the case of ceramic kilns, a shaped clay object is the final result, while cement kilns produce a substance called clinker that is crushed to make the final cement product. (Certain types of drying ovens used in food manufacture, especially those used in malting, are also referred to as kilns.)

An autoclave is an oven-like device with features similar to a pressure cooker that allows the heating of aqueous solutions to higher temperatures than water's boiling point in order to sterilize the contents of the autoclave.

Industrial ovens are similar to their culinary equivalents and are used for a number of different applications that do not require the high temperatures of a kiln or furnace. A wood-fired pizza oven, a type of masonry oven.

III. DESIGN OF WORKING MODEL

3.1 OBJECTIVE

In our project we intend using Infra Red Heating. Heating process is attained through infra red lamps. At a wavelength of 680nm of the infra red lamp, the heating effect starts. We are applying a wavelength of 980 nm. This method offers following advantages over the conventional heating:

- 90% of energy is transmitted as infrared
- Lamp lifetime 5000 hours
- Instant, accurately controllable radiant heat
- Easy installation
- Simple, safe and clean heat source
- High-efficiency, low energy costs

Apart from the heating accuracy and speed provided by the Infra Red lamps the solid state relay also has major advantages in controlling the temperature. Temperature in the furnace is usually controlled by a conventional relay. But a conventional relay is said to work for only one million operations and hence the lifetime is very less. In order to avoid this difficulty and control the temperature for N number of operations and N number of years, we are using a solid-state relay, which is a combination of OPTO TRIAC and SCR connected back to back.

The furnace consists of the infra red lamp which is the heat source. The temperature of the component which is heated is measured using a thermocouple. The output of the thermocouple is conditioned and amplified using signal conditioning equipment. The amplified output is sent to the controller.

The controller receives the signal and displays the temperature for the user to see. It also compares the temperature to the required set point temperature and controls the solid state relay accordingly.

The solid state relay controls the input to the lamp in the furnace according to the command of the controller. If the actual temperature is lesser than the set temperature, the lam is switched ON. If the actual temperature exceeds the required temperature then power to the infra red lamp is cut OFF.

3.2 SPECIFICATIONS

3.2.1 FURNACE SPECIFICATION

- Max. Temperature : 325°C.
- Furnace cube material :Mildsteel sheet(18gauges)
- Insulation material : Mineral wool.
- Inner coating : Berger Alloy coating.
- Area occupied : 1 ½ Feet square.
- Utilization area : 1 feet square

3.2.2 INFRA RED LAMP SPECIFICATION

- Number of lamps : 2.
- Heating type : Radiation heating.
- Input power : 500 watts.
- Wavelength : 980 nm.
- Max. Temperature : Up to 1000°C.

3.2.3 THERMOCOUPLE SPECIFICATION

- Type : K type thermocouple.
- Composition : Ni Chromel- Ni Alumel.
- Range : 0 - 1350°C.
- Speed : 1 microsecond

3.2.4 CIRCUIT SPECIFICATION

- Control action : ± 1°C.
- Interface : LCD/PC display.
- Switching : Solid state relay.
- A to D converter : 12- BIT Channel.
- Interface : embedded controller with serial port.

3.3 COMPONENTS USED

- Furnace cubes
- Insulator material
- Furnace door
- Infra red lamps
- Lamp holders
- Berger alloy coating
- External paint
- Thermocouple

3.3.1 FURNACE CUBES

The furnace cubes are made from mild steel sheets of thickness 18 gauge. The oven is of double walled construction, the gap between the two walls being 50 mm. The sheets are folded and welded to form two identical cubes. One of the cubes is made larger than the other. The inner cube is made closed on all sides except the front. It is made to the dimensions of 1 feet cube. That is 1 feet on all sides. The outer cube is made 1 ½ feet on all sides. The edges are welded and the closing side of the outer cube is bolted closed. Mild steel sheets can handle high temperatures and also form a hard structure to the furnace.

3.3.2 INSULATOR MATERIAL

The insulator used in the furnace is mineral wool. This is a very effective insulator. It is similar to glass wool but more effective. Insulator material is packed in between the outer and inner mild steel cabins. The insulator is loosely packed. It has very low thermal conductivity of k = 0.06 W/mk. Since the mineral wool is loosely packed, the air packets will further increase the thermal resistance, thereby reducing the conduction losses. It may be pointed that air is an excellent insulator having k = 0.02 W/mk. Mineral wool is also called marganite wool. This insulator is so effective that when the inner cabin is at a temperature of around 325°C, the outer surface of the cabin remains only slightly higher than the room temperature. This makes this type of furnace safer and environment friendly.

3.3.3 FURNACE DOOR

The furnace door is made similar to the furnace cube itself. The door is made like a hollow mild steel block by welding the mild steel plates in that form. A gap of half an inch is maintained between the steel plates on both sides. One side of the door is left open initially to insert the insulator material. After the insulator is filled the side is closed using bolts. The door is screwed to the furnace on one side using normal hinges and a small handle is also provided. The door remains closed with the help of a ball-socket type of joint. This allows the door to opened and closed easily

3.3.4 POWER RATING:

The oven has a rating of 500W and can be operated on 230V, single phase, AC supply. The maximum temperature inside the oven is restricted to 325 degree Celsius.

3.3.5 INFRA RED LAMP:

Industrial manufacturing processes are becoming more and more rationalized. Automation increases and production rates rise. To gain the competitive edge, industry today demands innovative, effective heating solutions that will optimize cost of ownership. Infrared heat is transferred from the heat source to the object to be heated without any intermediary.

In our project we have used two Infra Red Lamps each having a capacity of 250 Watts. They transfer heat on to component by means of radiation heat transfer as described in the operation section of our project.

Features:

- 90% of energy is transmitted as infrared
- Lamp lifetime 5000 hours
- Instant, accurately controllable radiant heat
- Easy installation

3.3.6 THERMOCOUPLE

- Two strips of dissimilar metals joined to form junction called thermocouple. If the junction is heated and a milli-voltmeter is connected across the free ends away from the junction, there will be found a voltage present. This voltage is caused by the different work -function of the metals forming the junction and is dependent upon both the temperature and the types of metals used.
- Since the voltage across the thermocouple junction is proportional to temperature we may use it in thermometry. The standard metals and pairs have been adopted for thermocouple construction.

These are:

- Chrome - Alumel
- Iron - Constantan
- Copper - Constantan
- Platinum - Platinum-Rhodium

Additional properties:

It is extremely important that polarity be observed when making connections. There is only one method of determining polarity and that is by knowing which wire is which the wires can be identified by testing them with a permanent magnet. Alumel is slightly magnetic; iron is strongly magnetic, constantan not at all. Copper can be identified by its color.

K TYPE THERMOCOUPLE:

Type K (chromel–alumel) is the most commonly used general purpose thermocouple. It is inexpensive and owing to its popularity They are available in the −200 °C to +1200 °C range. The type K was specified at a time when metallurgy was less advanced than it is today. Another potential problem arises in some situations since one of the constituent metals is magnetic. The characteristic of the thermocouple undergoes a step change when a magnetic material reaches its Curie point. This occurs for this thermocouple at 354°C.

IV. FABRICATION OF WORKING MODEL

4.1 MANUFACTURING PROCESSES

- Furnace fabrication involves bulk deformation processes like sheet metal bending, deep drawing, etc. to obtain the outer casing of the furnace. The first process is the bending of sheet using highly precise anvil. The material used is 18 SWG Mild Steel sheet. This material is strong to enough to withstand very high temperatures and also well suited for the manufacture furnace casing. Since the material is to be deformed to bring it to the required shape, plastic deformation and yield criteria need to be developed upon.
- Plastic deformation of a material depends upon two principal laws of solid mechanics namely, Von – Misces Theory and Guest – Tresca Theory. Both these theories give us the yielding criteria for a specimen based on maximum shear stress and maximum normal stress respectively.
- The process involves bending and deforming the sheet to the required specifications and dimensions as given by the customer. Sheets of sizes 400mm and 300mm are made from huge cold rolled sheet to make the furnace casing. The reason behind using cold rolled sheets is that material undergoes heat treatment processes in cold rolling process and hence is devoid of any porosity. The sheets are bent to the required dimensions. Once the shaped is obtained the inner and outer casing are welded together using clamps within the gap between the walls. The joining process used here welding is highly precis.

4.2 OPERATION

Mass production of painted components can be achieved either by dip coating on a conveyor or spray painting using spray painting booths. After spray painting the component has to be baked at a required temperature as recommended by the paint manufacturer.

This being a project, the operation is intended to be carried out on small components using a prototype oven. The initial warm-up time may be about 30 minutes to 45 minutes. After this the component is placed inside the oven. There will be a temperature drop and it may take about 10 minutes for the oven to attain the set temperature. The subsequent holding time in conventional heating is about 20 minutes to make sure that the baking has been uniform. In Infra Red heating, because of the advantages outlined in section it is seen that the time for baking is only 7 minutes.

4.3 MECHANISM OF HEAT TRANSFER

RADIATION:

The method of heat transfer is primarily through radiation which is governed by Stefan- Boltzmann law, Wien's law and Planck distribution law. Radiation heat transfer is caused as a result of vibrational and rotational movements of molecules, atoms and electrons. The energy is transported by electromagnetic waves (photons). Radiation requires no medium for propagation, therefore can take place also in vacuum. All matters emit radiation as long they have a finite temperature.

The rate at which radiation energy is emitted is usually quantified by Stefan – Boltzmann law

$q = \varepsilon\sigma AT4$

Where the emissivity ε, is a property of the surface characterizing how effectively the surface radiates compared to a black body.

- σ – Stefan - Boltzmann constant (W/m2 K4).
- T - absolute temperature of the surface in Kelvin.

A portion of the electromagnetic radiation spectrum is shown below. Thermal radiation lies in the range of 0.1 to 100 micro metres. It includes ultra – violet radiation, visible light and Infra Red radiation. As said above the propagation of thermal radiation takes place in the form of discrete quanta, each having energy of

$E = h\nu$

Where h is the Planck's constant given by h = 6.625*10^-34 joule second.

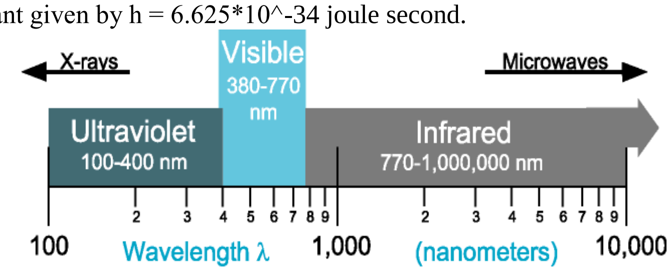

Fig. 1.1 The optical portion of the electromagnetic spectrum

4.4 CIRCUIT OPERATION

- The temperature of the component is measured by a thermocouple which works on the principle of seebeck effect.
- According to seebeck " When two dissimilar metals in a circuit are maintained at different temperatures an emf is produced in the circuit"
- The emf obtained can be calibrated to give the temperature of the component.
- The e.m.f induced is of small amplitude and there is no linearity. This problem is solved by using a signal conditioner.
- The signal conditioning equipment may be required to perform linear processes such as amplification, attenuation, integration, differentiation, addition or subtraction. They are also required to do non linear processes such as modulation, demodulation, sampling, filtering, clipping, clamping and etc.
- After suitable conditioning, the signal is sent to the microcontroller. The micro controller in a small size controller which is embedded into the system to control the input to the furnace.
- The micro controller is linked to a LCD display through an analog to digital converter to provide interface for easier operation.
- The TRIAC is a kind of transistor and SCR stands for Silicon Controlled Rectifiers. The solid state relay is used control the power supply to the furnace. They receive input from the micro controller.
- Conventional heaters work indirectly by warming the air in a room which in turn warms the people and the objects in it. This type of convection heat not only wastes energy by having to warm the air first before the heat is felt, but you also don't feel the benefits of the heater as soon as it is turned on. It might take quite a few minutes for a room to heat up before you feel warmth.
- Infrared heat on the other hand is a radiant heat which heats you and the objects in the room directly at the speed of light and is not dependent on heating the air first in order for you to feel warmth. You feel the warmth almost instantly once the heater is turned on. This principle makes infrared heaters far more efficient than conventional heaters.
- Another unique property of infrared heat that makes it so efficient and effective is that the heat is distributed evenly throughout the space and from floor to ceiling. The infrared waves heat the water molecules in the air directly and quickly and because water molecules are denser than air, the heat stays more evenly distributed throughout the room.

Also, water and objects retain heat longer than air, so the heat is not lost as quickly through poor insulation, windows, doors and cracks. The heated air is quickly dissipated through windows, doors, cracks and gaps, so a conventional heater has to work much harder to keep the room at a constant temperature than an infrared heater, making conventional heating methods less efficient and less effective.

V. PROCESS

5.1 HEAT TREATMENT

Heat treating is a group of industrial and metalworking processes used to alter the physical, and sometimes chemical, properties of a material. The most common application is metallurgical. Heat treatments are also used in the manufacture of many other materials, such as glass. Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve a desired result such as hardening or softening of a material. Heat treatment techniques include annealing, case hardening, precipitation strengthening, tempering and quenching. It is noteworthy that while the term heat treatment applies only to processes where the heating and cooling are done for the specific purpose of altering properties intentionally, heating and cooling often occur incidentally during other manufacturing processes such as hot forming or welding.

5.2 Annealing

Annealing is a rather generalized term. Annealing consists of heating a metal to a specific temperature and then cooling at a rate that will produce a refined microstructure. Annealing is most often used to soften a metal for cold working, to improve machinability, or to enhance properties like electrical conductivity.

In ferrous alloys annealing is usually accomplished by heating the metal beyond the upper critical temperature and then cooling very slowly, resulting in the formation of pearlite. In both pure metals and many alloys that can not be heat treated, annealing is used to remove the hardness caused by cold working. The metal is heated to a temperature where recrystallization can occur, thereby repairing the defects caused by plastic deformation. In these metals, the rate of cooling will usually have little effect. Most non-ferrous alloys that are heat-treatable are also annealed to relieve the hardness of cold working. These may be slowly cooled to allow full precipitation of the constituents and produce a refined microstructure.

Ferrous alloys are usually either "full annealed" or "process annealed." Full annealing requires very slow cooling rates, in order to form coarse pearlite. In process annealing, the cooling rate may be faster; up to, and including normalizing. The main goal of process annealing is to produce a uniform microstructure. Non-ferrous alloys are often subjected to a variety of annealing techniques, including "recrystallization annealing," "partial annealing," "full annealing," and "final annealing." Not all annealing techniques involve recrystallization, such as stress relieving.[17]

5.3 Normalizing

Normalizing is a technique used to provide uniformity in grain size and composition throughout an alloy. The term is often used for ferrous alloys that have been heated above the upper critical temperature and then cooled in open air.[17] Normalizing gives harder and stronger steel, but with less ductility for same composition, than full annealing.

5.4 Quenching

Quenching is a process of cooling a metal very quickly. This is most often done to produce a martensite transformation. In ferrous alloys, this will often produce a harder metal, while non-ferrous alloys will usually become softer than normal.

To harden by quenching, a metal (usually steel or cast iron) must be heated above the upper critical temperature and then quickly cooled. Depending on the alloy and other considerations (such as concern for maximum hardness vs. cracking and distortion), cooling may be done with forced air or other gases, (such as nitrogen). Liquids may be used, due to their better thermal conductivity, such as water, oil, a polymer dissolved in water, or a brine. Upon being rapidly cooled, a portion of austenite (dependent on alloy composition) will transform to martensite, a hard, brittle crystalline structure. The quenched hardness of a metal depends on its chemical composition and quenching method. Cooling speeds, from fastest to slowest, go from polymer (i.e.silicon), brine, fresh water, oil, and forced air.

VI. PURPOSE OF THE PERFORMANCE TEST

• To find out the efficiency of the furnace
• To find out the Specific energy consumption

The purpose of the performance test is to determine efficiency of the furnace and specific energy consumption for comparing with design values or best practice norms. There are many factors affecting furnace performance such as capacity utilization of furnaces, excess air ratio, final heating temperature etc. It is the key for assessing current level of performances and finding the scope for improvements and productivity.

Heat Balance of a Furnace

Heat balance helps us to numerically understand the present heat loss and efficiency and improve the furnace operation using these data. Thus, preparation of heat balance is a pre-requirement for assessing energy conservation potential.

Performance Terms and Definitions

1. Furnace Efficiency, η $= \frac{\text{Heat output}}{\text{Heat input}} x100$

$= \frac{\text{Heat in stock (material)(kCals)}}{\text{Heat in fuel / electricity (kCals)}} x100$

2. Specific Energy Consumption $= \frac{\text{Quantity of fuel or energy consumed}}{\text{Quantity of material processed}}$

Reference Standards

In addition to conventional methods, Japanese Industrial Standard (JIS) GO702 "Method of heat balance for continuous furnaces for steel" is used for the purpose of establishing the heat losses and efficiency of reheating furnaces.

Furnace Efficiency Testing Method

The energy required to increase the temperature of a material is the product of the mass, the change in temperature and the specific heat. i.e. Energy = Mass x Specific Heat x rise in temperature. The specific heat of the material can be obtained from a reference manual and describes the amount of energy required by different materials to raise a unit of weight through one degree of temperature.

If the process requires a change in state from solid to liquid, or liquid to gas, then an additional quantity of energy is required called the latent heat of fusion or latent heat of evaporation and this quantity of energy needs to be added to the total energy requirement. However in this section melting furnaces are not considered.

The total heat input is provided in the form of fuel or power. The desired output is the heat supplied for heating the material or process. Other heat outputs in the furnaces are undesirable heat losses.

The various losses that occur in the furnace are listed below.

1. Heat lost through exhaust gases either as sensible heat or as incomplete combustion
2. Heat loss through furnace walls and hearth
3. Heat loss to the surroundings by radiation and convection from the outer surface of the walls
4. Heat loss through gases leaking through cracks, openings and doors.

The efficiency of a furnace is the ratio of useful output to heat input. The furnace efficiency can be determined by both direct and indirect method.

Direct Method Testing

The efficiency of the furnace can be computed by measuring the amount of fuel consumed per unit weight of material produced from the furnace.

$$\text{Thermal efficiency of the furnace} = \frac{\text{Heat in the stock}}{\textit{Heat in the fuel consumed}}$$

The quantity of heat to be imparted (Q) to the stock can be found from the formula

$$Q = m\,x\,C_p\,x(t_2 - t_1)$$

Where

Q = Quantity of heat in kCal

m = Weight of the material in kg

C_p = Mean specific heat, kCal/kg^{o}C

t_2 = Final temperature desired, ^{o}C

t_1 = Initial temperature of the charge before it enters the furnace ^{o}C

Indirect Method Testing

Similar to the method of evaluating boiler efficiency by indirect method, furnace efficiency can also be calculated by indirect method. Furnace efficiency is calculated after subtracting sensible heat loss in flue gas, loss due to moisture in flue gas, heat loss due to openings in furnace, heat loss through furnace skin and other unaccounted losses from the input to the furnace.

In order to find out furnace efficiency using indirect method, various parameters that are required are hourly furnace oil consumption, material output, excess air quantity, temperature of flue gas, temperature of furnace at various zones, skin temperature and hot combustion air temperature. Efficiency is determined by subtracting all the heat losses from 100.

Measurement Parameters

The following measurements are to be made for doing the energy balance in oil fired reheating furnaces (e.g. Heating Furnace)

- Weight of stock / Number of billets heated
- Temperature of furnace walls, roof etc
- Flue gas temperature
- Flue gas analysis
- Electricity consumption Instruments like infrared thermometer, fuel consumption monitor, surface thermocouple and other measuring devices are required to measure the above parameters.

Reference manual should be referred for data like specific heat, humidity etc.

VII. ADVANTAGES

- Rigidness
- No chance of short circuit failure
- Globally compatible transducer
-

VIII. DISADVANTAGES

- Nonlinear
- Requires cold junction compensation
- Poor sensitivity

IX. CONCLUSION

We have designed and fabricated a prototype of an infra red furnace in which heat radiated from infra red lamp is used to achieve quicker and effective heating. Thus we have developed a method to improve the heat treatment process and at the same time decrease the cost of production. Moreover the life of the furnace and components is also increased. The electrical circuit is also accurate and durable hence reducing the cost of maintenance and repair which is a problem with the existing furnaces.

REFERENCES

[1] Phillip F. Ostwald, Jairo Muñoz, Manufacturing Processes and Systems (9th Edition), John Wiley & Sons, 1997 ISBN
[2] 1st Electric Arc *Furnace*; ^ www.worldsteel.org; ^ Preston, R., American Steel. Avon Books, New York, 1991;
[3] Pennsylvania Iron *Furnace* Sourcebook, bibliographical *reference* sources to the Iron *Furnaces* and Iron Works of Pennsylvania.
[4] http://www.freek*heaters*.com/products/infrared_heaters/infrared_heaters.php; ^ Hirsch, Edwin Walter (1922)
[5] History of *Infrared Heating* **...** In good old ancient tradition in postwar Germany, 'stone *heaters*'
[6] Raymond Kane, Heinz Sell Revolution in *lamps*: a chronicleof50**...**http://www.prothermind.com/*InfraredQuartzTubeHeaters*
.
[7] Welty, James R.; Wicks, Charles E.; Wilson, Robert Elliott (1976). Fundamentals of momentum, *heat*, and mass *transfer* (2 ed.).
[8] H. C.: *Radiant Heat* Transmission, in William H. McAdams (ed.) **...** of Some Common Spacecraft Thermal-Control Coatings," NASA *Reference* Publication 1121.