A Project Report on

MANUFACTURING OF INDUCTION FURNACE AND HEATING EQUIPMENTS

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For the partial fulfilment for the award of B. TECH in Mechanical Engineering.

By

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MEGATHERM INDUCTION PVT LTD.

Plot NO: H1, Vidyasagar Industrial Park;

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CERTIFICATE OF APPROVAL

This is to certify that the work presented in this project report entitled **"MANUFACTURING OF INDUCTION FURNACE AND HEATING EQUIPMENTS"**, submitted by SAYAN KUMAR GUPTA & SHAON MONDAL, has been carried out under our supervision for the partial fulfilment of the degree of Bachelor of Technology in Mechanical Engineering during 13th DECEMBER to 30th DECEMBER in MEGATHERM INDUCTION PVT LTD.

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We would like to express our gratitude towards Mr. SANJAY SARKAR, Sales and Service Head of SMS Projects (South Asia), Megatherm Induction Pvt Ltd. to arrange the beautiful opportunity of industrial training with company.

We would like to thank Mrs. SHASWATI DATTA, HR Megatherm, for giving us this wonderful opportunity to learn about Induction Furnace and Heating components and also for ensuring smooth passage of technical formalities/documents before starting the training.

We would express our heartfelt gratitude to Mr. KOUSHIK GHOSH, Quality Assurance Dept, for guiding us at every point during the project so far and helping us in preparing this project report.

The Industrial training that we got with Megatherm Induction Private limited, was itself a great chance to flourish our Industrial knowledge and Professional development. We consider ourselves as lucky individuals as we have got such great opportunity to meet some wonderful people who were very helpful throughout this whole training.

We perceive this training as a big milestone in our career development. We will strive to use gained skills and knowledge in the best possible way, and we will continue to work on their improvement in order to attain desired career objectives.

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About Megatherm –

o The Organisation

Megatherm deals in Metal Heating & Melting Equipment and possesses the strength to meet Thermal Challenges through Induction.

In 1989 they started with a modest beginning, banking on their team of Electro Thermal Processing experts and the capital of experience that they had gathered since the 1970. They made their presence felt across steel, foundry, forging and various other Metal Working Sectors, surging forward with spirits held high and the fire burning within.

Today, Megatherm is recognised and preferred by its ever-extending list of domestic and International Clientele. Their installations are spread over 40 countries around the globe. Their credentials within a short tenure of a mere two years with a mindboggling turn over 400%. This amazing growth maintained its decorum in the later years, and today the company is for a leading ISO 9001:2000 certified manufacturer and exporter of Induction Furnace, Induction Melting Furnace.

They have proved to be one of the most successful, in the field of Medium Frequency Induction Melting Furnace and Equipment, catering to the modern foundries and Mini Steel Plants as well as Induction Heating & Hardening Equipment for the Automobile and Forging Industries.

Induction furnace is fabricated in simple design for utilizing the utmost power all along the melting cycle meanwhile having great control over stirring. Further, it ensures the immediate melt for large casting and the attainment of excellent melt composition. In addition to this, Induction Melting Furnace, developed by them, provides high-frequency Induction power, power efficiency and versatile power tracking with an outstanding capacity and higher melting speed, making it preferred choice for modern foundries and giant industry units.

The motive of the company is **“MEETING THERMAL CHALLENGES THROUGH INDUCTION”.**

o Product Range

- MELTING
  Induction Furnace
- HEATING
  Hardening – Rail Hardening, Pipe Hardening, Vertical Scanner.
  Forging - Billet Heating, Bar end Heater.
- ONLINE BILLET HEATER
- WIRE HARDENING

o Market Served

- The steel sector melt shops using sponge iron & steel scraps as feed stock.
- The foundry sector melt shops producing casting for Automobile & Engineering sector.
- The forging sector producing rings for Bearing & Automobile Industries besides the various forged Auto Engineering parts.
- Various metal melting praxes encompassing extrusion, forging, pipe drawing, section rolling annealing, tempering & solidifying.
- Exclusive applications like melting and heating pig iron, ferrous and non-ferrous alloys for casting varied metals and spin forming of electrodes, etc.

Megatherm is recognised and preferred by its ever-extending list of domestic and International Clientele. Their installations are spread over 40 countries around the globe.

Some Domestic Branches Of The Megatherm

- Megatherm Electronics Pvt Ltd. Saltlake, Kolkata, India.
- EMT Megatherm Pvt Ltd. Engle India Machine & Tools Ltd. Taratala, Kolkata, India.
- EMT Megatherm Pvt Ltd. Ankurhati, Kolkata.

Some International Branches Of The Megatherm

- Megatherm Group Brazil Ltd. Estrada do Gramado n° 132, Jardim Sadie-Embu CEP: 06833-080, Sao Paulo- Brazil.
- Megatherm FZE, P.O. Box 31291, Al- Jazeera Al-Hamra Ras Al Khaimah, U.A.E.
- Megatherm USA, 825 S Trade Centre PKWY, TEXAS 77385, United States.

Introduction –

The history of mankind shows that, in order to achieve more efficiency from tools man invented metal and bringing the end of stone age. From that time till now we are continuously trying to improve the quality of metal to get optimum performance from it, in terms of tools. In earlier days, most popular methods of metal melting or heating was to use of coal or gas. But in now days the markets are more competitive, that's why the use of modern furnaces and heaters along with their modified designs are in action to compete.

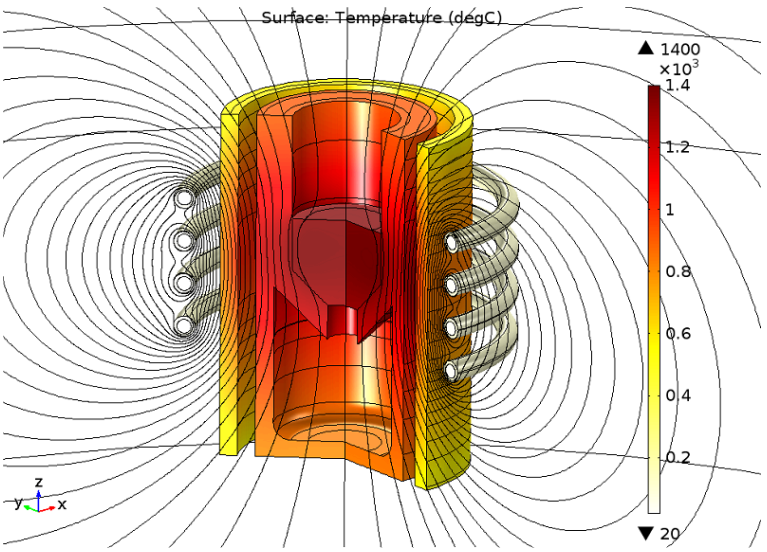
This project is about the fundamentals of Induction Furnaces and heaters along with their assembly and various working stations with machining shops present in the plant.

The available range of products manufactured here are given below:

- 200 Hz – 350 Hz for large capacity melting applications.
- 500 Hz – 3 kHz for medium and small capacity melting and certain heating applications.
- 10 kHz – 30 kHz for induction heating applications.

o Principle of Induction Furnace

An induction furnace consists of a nonconductive crucible holding the charge of metal to be melted, surrounded by a coil of copper wire. A powerful alternating current flow through the wire. The coil creates a rapidly reversing magnetic field that penetrates the metal. The magnetic field induces eddy current inside the metal, by electromagnetic induction. The eddy current flowing through the electrical resistance of the bulk metal, heat it by Joule heating. The ferromagnetic metals (like iron) are used to melt this way. Once melted, the eddy currents cause vigorous stirring of the melt, assuring good mixing.



An advantage of induction melting is that the heat is generated within the furnace's charge itself rather than applied by a burning fuel or other external heat source, which can be important in applications where contamination is an issue.

In Megatherm operating frequencies range from 200 Hz to 3 kHz, 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 and vice versa.

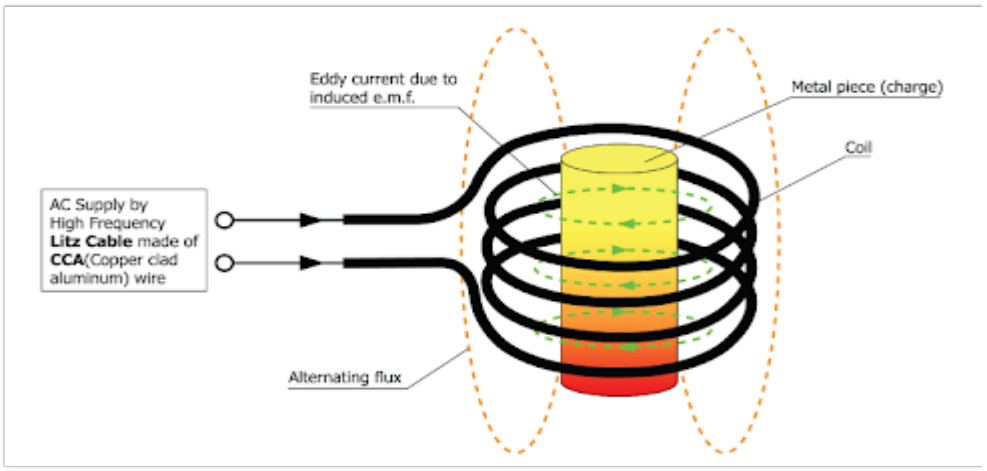
Joule heating, also known as ohmic heating and resistive heating, is the process by which the passage of an electric current through a conductor releases heat.
The heat produced is proportional to the square of the current multiplied by the electrical resistance.

$$Q \propto I^2 \cdot R$$

Induction heating relies on the unique characteristics of radio frequency (RF) energy. Since heat is transferred to the product via electromagnetic waves, the part never comes into direct contact with any flame, and there is no product contamination. Induction heating is a rapid, clean, and non-polluting heating.

o Principle Of Induction Heating Equipment

The principle of heating and melting are more or less the same, but in case of heating the operating frequency is set very high as compared to melting applications. In heating devices there is no melting pot like crucible, instead of the container the heating devices has a continuously moving feed belt which holds and feeds the job into the heating zone. In the heating zone the solenoidal copper coil surrounds the feuded job and the feed rate defines the amount of heat to be supplied to the job.



Here also, powerful alternating current flow through the wire. The coil creates a rapidly reversing magnetic field that penetrates the metal. The magnetic field

induces eddy current inside the metal, by electromagnetic induction. The eddy current flowing through the electrical resistance of the bulk metal, heat it by Joule heating, $\mathbf{Q \propto I^2 \cdot R}$

The main operational difference between an induction furnace and heater is the operating frequency of the two. In furnace, metal at a bulk need to be melted down under a required frequency, very lower than the frequency required for heating. Because melting process is more time consuming than heating. Melting needs concentrated heat for longer time, but in case of heating the job is continuously feuded to the heating zone, that's why faster heating of the job is necessary, and higher frequency is used in order to achieve faster heating.

Induction Furnace Operating

Induction Heater Operating

Components Of Crucible And Associated Workshops –

Megatherm is such a facility where they import raw materials only, like MS sheets of various thickness, Stainless steel tubes, Copper tubes, and Copper sheets of various thickness, CRNGO sheets, Epoxy bars etc. The plant is capable enough to manufacture its entire product range within the facility for the sake of its skilled man power and wide set of work stations.

The work stations are –

o Fabrication Department

We all know the importance of Fabrication Dept. in Mechanical Engineering. It is the backbone of any production unit. In this plant the fabricator's responsibility is to build the entire structural framework of the crucible and heating equipment.

The frame work includes Support structure, Top plate, Cradle assembly, Side & Back desks etc.

Support Structure

Cradle Assembly (upside down)

The support structure's purpose is as the name suggests to supports the entire crucible parts and it's also the acts as the base of the tilting mechanism. The Cradle assembly on the other hand holds the coil, melting pot, lamination packets in it. The top plate is fixed with two side and back desk and thereby joins with the cradle assembly to form the tilting structure. After that the tilting structure is joined with the support structure with two hydraulic cylinders. The cylinders help to lift and tilt the tilting structure up to 95°. This extra 5° of tilt helps to decamp the entire molten metal out of the pot.

The fabricators are equipped with Arc welding, MIG welding, Gas cutting, Fitter equipment and cranes (2T to 63T).

MIG Welding

Gas cutting

Arc Welding

Factors to keep in mind –

Two different welding techniques are used, Arc welding and MIG welding, the main difference between this two is the rate of metal deposition. In case of arc welding the rate of welding is low but the bond is stronger, on the other hand MIG's welding rate is much higher but the joint made is slightly less strong. That's why in industry the fabricators always use MIG welding instead of Arc welding to match with production demand.

In case of vertical welding, the **Down hand** welding process is not at all acceptable. In case of **Down hand** welding the molten metal just sticks to the parent metal, providing zero hold. That's why welder should always prefer **Up hand** welding in case of vertical welding joints.

In case of alignment (right angle with each other) of heavy metal channels, Pythagoras theorem is used to fix them at 90° with each other. The length of the

base and height is known, and hypotenuse is calculated. Then the magnitude of hypotenuse is marked on the base with a string tied at the top of the vertical column making a triangle which is automatically a right angle, and the base and the column is fixed at that point.

At the assembly of support structure with tilting structure a bush is used to create the movable hinge. The bush is made up of **Phosphorus Bronze**, giving it enough flexibility and withstand ability to wear and tear and the washer is made up of **Gunmetal** to make it softer to protect the bush.

The crucibles are mainly of two types, one having water side on left side and the electric side on the right side, and the other one is absolute mirror object of the previous one. Water side on the left is called '**j – type'** and water side on the right is called **'k – type'**. The significance of making two types of crucibles is to keep the electric side of the two consecutive crucibles at the common area, which allows to connect both the furnaces with a common power source i.e., the capacitor bank. This set up allows to free up some necessary space at the factory.

Electric Side

Water Side

o Coil Department

The coil is made up of copper, due to its better inductive nature. Megatherm imports copper as plates having different thickness also in the form of circular, rectangular tubes. The diameter of the coil depends upon the capacity and space available for the foundation. If capacity is higher the diameter is automatically higher, but in case of smaller accommodation space the designers keep the diameter smaller giving the coil extra height to fulfil the need of required capacity, as preferred by the customer.

Coil is made up of hollow copper tubes having rectangular cross section. The tubes are then heated till they get soften, and circular shape is obtained by the coiling machine.

When the circular shape is obtained, the coils are brazed one after another and the required solenoid structure is formed. In modern day crucibles two solenoids joined together to form the entire coil. One of them is **clockwise** and the other one is **anti-clockwise.**

The coil then wrapped with a special fabric, insulating in nature. It also helps the coil to bear with the immense heat generated by the crucible. Epoxy bars are used as spacer between two consecutive coils. It generates the required gap for the induction. After that the entire coil is coated with a special paint to further bear with the heat. The coil is ready to use.

In case of heating equipment one single solenoidal coil is used instead of two different coils brazed together.

Factors to keep in mind –

Copper is soft and ductile in nature, that's why it tends to deform after coiling process and prone to attain its initial linear form. So, **annealing** is done at 600° to 750° C, which gives enough strength to the coil to sustain its form.

Annealing Chamber

Copper melts at 1085°C, which is much lower than steel and other metal's melting pt. which is to be melted in the crucible. To prevent copper coil itself from melting, the coils are made hollow that allows to flow cooled **de-mineralize** water through it. Inlets and outlets throughout the coil allow better flow of the water, all the inlets and the outlets are connected with the water side of the crucible. Water side is connected with a heat exchanger, which extracts the heat from the outlet water. After that the pump forces the cooled water from the heat exchanger through the inlets to the coil for further cooling.

In case of heating devices one single solenoidal coil is used but in furnaces two coils having different turns are used. Because two reversely tunned coils if joined together leads to condensation of flux and amplification of induction causes much more heat than heating coils, which is much more desired for melting operation.

The coil made up of a number of circular copper tubes but 3 to 4 turns of the top and the bottom are done in **Stainless Steel**. The reason behind it is, nothing but to save the **mild steel** structure of the crucible itself from the heat generated at the core. If the entire coil is made up copper, then the induction generated at the centre would reach to the top and the bottom of the crucible made up of mild steel and melt down the entire structure of the crucible. The Stainless steel restricts the

induction from reaching the structural parts of the furnace, due to its non-magnetic nature.

o Foundry Department

In Induction Furnaces mainly steel is being melted, the temperature required for melting is near about 1500°C. That's why the heat generated at the pot is required to be restricted at the furnace itself. The solution is installation of cement castings at the top and the bottom of the crucible. Cement is a great insulator of heat and the melting temperature of cement is higher than steel. Availability of cement and being cheap it perfectly suits as the insulating material. In case of failure, it is easy to replace the casting blocks and the furnace is ready to use.

Materials used for the castings are mainly cement, adhesives and some other materials(confidential) that gives the blocks enough heat with standability and flexibility to bear with the stress generated due to the immense heat generated in the crucible.

The cement is mixed with those materials and put in the metal moulds then vibrator is used to eliminate all the air gaps for better filling. After that those moulds are kept for a while to settle the casting. And the solidified castings are ready to use.

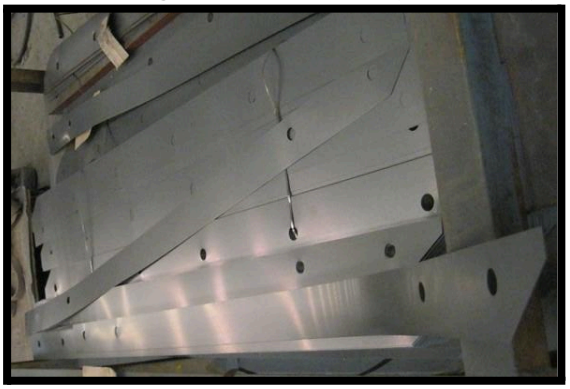
Factors to keep in mind –

The casting pot where the scraps turn into molten metal, is also made up of cement casting. Generally, the lamming (thickness) of the casting pot is 6 inch and by the time after continuous operation it tends to undergo wear and tear. Cracks are also formed in the pot. If the lamming is near about 5 inch after all the wear and tear then it is replaced with a new pot for continue operation.

The covering of the cradle top is made up of Stainless steel and it is called **Top Plate**. It covers the entire crucible top except the casting pot. The shape of the top plate is like a ring but the plate is not made like a single unit. Instead of making it a single unit the plate is made into pieces. The pieces are of the same shape of the top castings. Those pieces form the ring-shaped top plate when put together. It also helps to replace a top casting in case of failure without lifting up the entire top plate.

o Lamination Packet Department

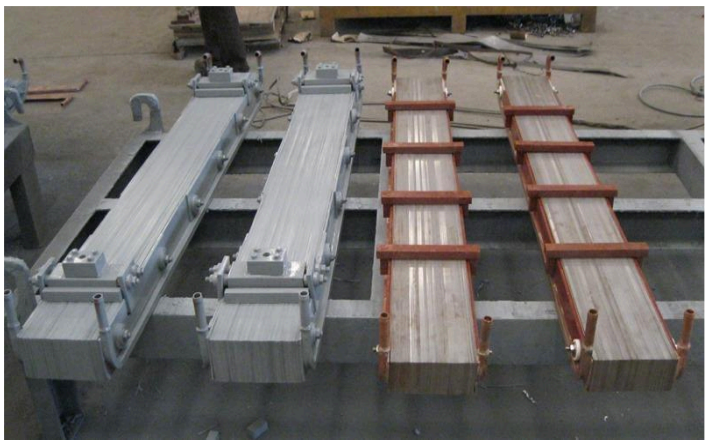
The crucible frame is made up of mild steel, that's why it is necessary to restrict the induction before it reaches the steel frame otherwise the frame itself can get melted causing construction failure. That's why the company uses Cold-rolled-non-grain-oriented (CRNGO) sheets to restrict the induction going beyond the coil area. It also helps to achieve proper melting by concentrating the induction into the melting pot.



The CRNGO sheets are 0.35mm thick. Several CRNGO sheets are tied together and then fitted into C-clamps. The cooling line is then fitted to the system. The sheets are coated with a special paint giving it heat withstand ability and insulating effect from electric conductivity up to an extent. Now the entire system is called a Lamination packet.

CRNGO Sheets

One cradle post holds two lamination packets. Based on the no. of cradle posts the lamination packets needed is simply 2N. Two lamination packets are fixed with a special type of clamp and the clamp is then fixed with a cradle post by a roller system. The roller system allows to push the lam packs towards the coil for better hold. De- mineralized water is being pumped through the cooling lines to cool down the lamination packets.



Lamination packets (paint coated on the left and non-coated on the right)

Factors to keep in mind-

In case of failure of one or two lamination packets, when a crucible is operating, it is safe to continue melting but the electricity loss is huge at that time and the load at the SFC is much higher. But in case of three or more than failures it is recommended to replace the lamination packets before further operation or there will be damages in the crucible frame for sure.

Epoxy bushes are used in the joints, bolts and other contacts to prevent conduction of electricity. Otherwise, system failure may occur.

o Machining Department

Megatherm is a good facility with a no. of skilled manpower and a large workshop

equipped with various manual and automated machinery and machine tools. Almost all types of mechanical operations for material removal are available here like cutting, boring, facing, milling, edge preparation etc. Some of the joining processes are ARC welding, MIG welding, brazing, aluminium welding etc.

Manual processes –

The manual machines and operations are Drilling machine, Magnetic drill, Gas cutter, joining processes, copper cutting, lathe etc.

Automated processes –

The automated operations are Plasma cutter, CNC Lathe, Vertical Boring etc.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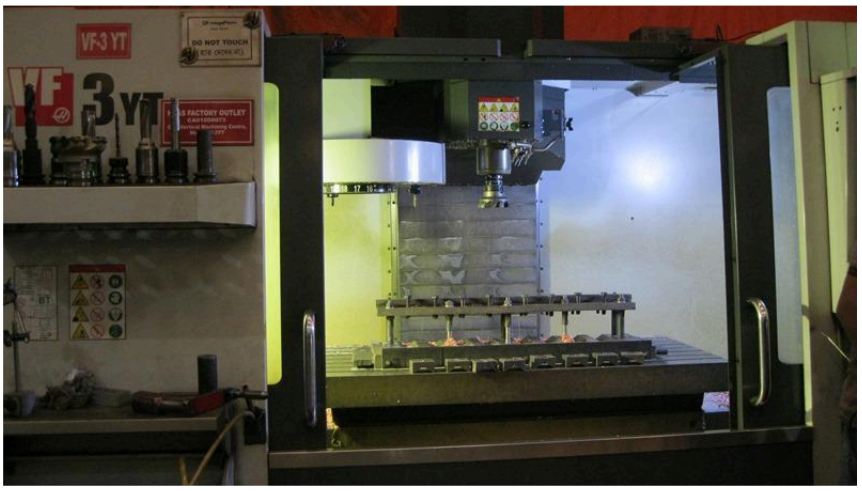
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o Crucible Assembly Department

The components of a furnace like, support structure, cradle assembly, coil, cement castings, top plate, lamination packs, side and back decks, hydraulic lifter, water side and electric sides are assembled together for making of an entire crucible.

The instalment of water and electric side depends upon the required type of the furnace depending upon the space available at the installation site. Depending upon the customer requirement the crucibles manufactured here are from 5kg to 50 ton.

Department

Assembly sequence –

- Setting up the support structure.
- Joining of cradle assembly with top frame along with side and back decks, Forming the tilting structure.
- Joining of support structure with tilting structure.
- Bottom castings along with aluminium plating is placed at the cradle bottom.
- The antenna is placed at the centre of the bottom casting through a hole.
- Lamination packets are installed at cradle posts with the help of rollers.
- Now the coil is installed in the furnace and tightened with lamination packs by pushing the roller system towards the coil.
- Top castings are placed and so the top plate.
- Water and electric side are attached with the crucible.
- Cooling lines are now attached with all the openings.
- Now the crucible undergoes paint coating.
- Hydraulic lifters are fixed with the support structure and tilting structure.

The crucible is ready to despatch.

Factors to keep in mind –

In case of manufacturing of a furnace, the design engineers always prioritize the available space at the installation site, where the furnace is to be installed after making. Depending upon the available space they decide the base area of the furnace. If the space is not enough, but the capacity of the furnace is higher then the height of the furnace is larger than usual and the structural design of the furnace changes accordingly.

At the time of fixing the support structure with tilting structure, the hinge is made such a way that after melting, when the molten metal is being poured into a mould or tray the tilting structure can tilt up to 95° instead of 90°. This special feature helps in evacuating all the molten metal from the melting pot.

In case of edge preparation at the time of assembly, the electrode shall confront to IS: 9595, at the time of Arc Welding.

Thickness of welding A = 0.7T (Where T = minimum thickness between two connecting plates.)

In case of installation of the crucibles at the operating site, the installation is made such a way that the electric side of both the crucibles are towards the common space. So, the capacitor rack is also placed at the common space. This type of installation helps in operating two crucibles alternatively while connected with a common power supply. Two types of crucibles are installed at the two sides of the capacitor rack, one is exact the mirror object of the other one.

Heating Equipment –

Megatherm also provides various heating equipment to the market, each one of them perform different operations. Although the plan of action is more or less the same, as stated in the introductory part of the project report.

A heating equipment is divided into three parts –

1. Pusher Side: It is the entrance of the heating device, from where the metal/object is pushed inside the heater to the operation site. Some examples are- Manual push, Hydraulic push, Belt push, Chain push.

2. Heating Part: After entering in the heater, pusher takes the metal piece in the solenoidal copper coil. Induction generated at the core of the coil helps to heat up the metal.

3. Exit Side: The heated-up metal is then taken out of the heater with help of a high-speed chain conveyer, which is the exit side of a heater.

Heating equipment manufactured here can be classified into two parts,

1. **Hardening Equipment**, like **Rail hardener**, **Pipe hardener**, **Wire hardener**, **Vertical scanner**.
2. **Forging Equipment**, like **Billet heater**, **Bar end heater**.

Apart from these two types of heating devices they also make **Online Billet Heater**.

The coil parameters are determined as per the customer need. Coil diameter depends upon the job diameter and the orientation (vertical coil/horizontal coil) of the coil depends upon the installation space available and the operation procedure of the consumer.

Billet
Heater

Copper coil used here is a single solenoidal coil and it is also in hollow tubular form. Demineralized water is used in the copper tube for cooling, otherwise generated heat may cause structural failure of the coil and the heater itself.

There is an **inner lining** placed inside the coil, made up of cement casting. Which has a thickness about 10mm. Its purpose is to insulate the coil by preventing direct contact from the core. It also prevents all possible deformation or failure to the copper coil by providing insulation from heat generated at the core.

Hardening Equipment –

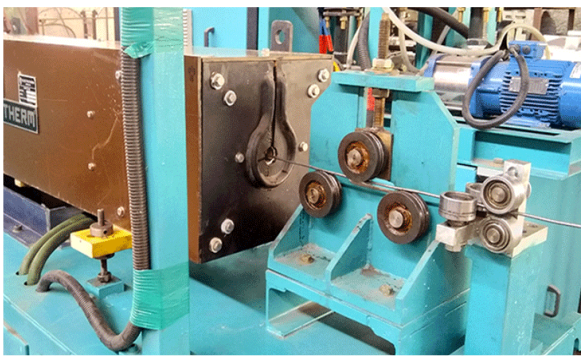
The main purpose of a hardening equipment is to increase the surface hardness of the object. The main objective of this operation is to amplify the brittleness of the

object surface in order to increase resistance to corrosion, wear and tear etc. In this facility various hardening equipments are manufactured. Like –

Rail Hardener: As per the name suggests, this equipment's objective is to harden the outer surface of the rail track.

Pipe and Wire Hardener: These two equipments deal with overall increase in hardness of pipes and wires respectively.

Hardener



Hardener

Vertical Scanner: It is a special type of hardening equipment made up of SFC and the heater itself. This equipment is capable of harden cylindrical jobs mainly. A vertically movable copper coil (single turn) creates the necessary induction to heat the job, it starts to heat the job from the bottom and gradually moves upward at a fixed speed, set in the SFC. Two rotating holders holds the job firmly inside the coil and rotate the job for uniform heating.

Scanner

The key feature of a vertical scanner is that, it is capable controlled hardening or in other words it provides surface hardness to a certain depth. This hardness depth is known as **Case Depth**. In case of set the case depth of a job, it totally depends upon the customer preference. Case depth is controlled by choosing the appropriate frequency and implementing continuous quenching process. Frequency controls the penetration capacity of the induction, as more frequency leads to more penetrating power. Thus, a suitable frequency is set at the SFC and continuous quenching helps to restrict the heat up to the desired case depth.

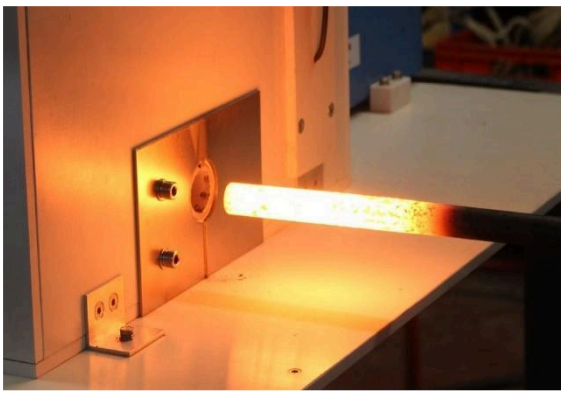
The coil used in vertical scanner is equipped with small tubular openings, which projects demineralized water (flowing through the coil for cooling purpose) slightly below the heated zone to complete the quenching process.

Forging Equipment –

The main purpose of a forging equipment is to heat the job to a suitable temperature that is desirable for a forming process, that the job is about to undergo. These equipments basically heats the entire job or a part of the job to its red-hot state and the job is ready for hot rolling, punching and other forming processes. Forging equipments always placed right before the forming unit.

Megatherm mainly provides billet heater and bar-end heater as forging equipments.

In **Billet heater** the job is gradually pushed into the heating zone by the pusher side and the heating is done on the entire job body. Billet heater mainly comes into play before hot rolling.



Heater

In **bar-end heaters** the end part of a job is feuded to the heating zone by pusher, that part only heated up for further procedure. The working range of the pusher is adjusted as per job demand.

Factors to keep in mind –

We know that the coil used in melting furnace is a double solenoidal coil, made up of clockwise and anti-clockwise coils joined together. But in case of heating equipments the coil used is a single solenoidal coil unlike the other one. The main reason behind it, when double solenoidal coil of a crucible is applied with low frequency configuration, the two different coils having opposite turns concentrates the flux at the centre of the furnace, where two coils are joined causes melting of the metal at bulk. But in case of heating equipment, single solenoidal coil is charged with higher frequency configuration that's why no flux concentration happens due to lack of the other coil results in heating of material till red hot temperature.

The cooling system used in these heating equipments is based on closed loop circuit type. Two types of close loop cooling are used here,

1. **Close loop**: Water continuously flows through the coil and other heated parts of the heater. Then the heated water enters the heat exchanger to release heat.
2. **Open loop**: In open loop system the water through the copper tubes goes to the heat exchanger to release the heat then it is exposed in a chamber tank. The tank water is again sent to the copper tubes for cooling. Because the water is exposed in a chamber tank, it is called as an open system. Although the water is never exposed to the environment.

The water used in the cooling system is **De-mineralised** water obviously. Generally, heat exchangers are used to extract the heat from the water, but if customer demands for more efficient cooling **chillers** are used instead of heat exchangers.

Power Controlling –

o Static Frequency Converter

A frequency converter is an electronic or electromechanical device that converts alternating current (AC) of one frequency to alternating current of another frequency. The device may also change the voltage, but if it does, that is incidental to its principal purpose.

The Static Frequency Converter converts 3 phase normal Frequency AC power supplied from Furnace transformer to single phase medium frequency AC Power. It can either be operated from itself or from the operator platform by means of Remote-Control Desk (RCD).

A frequency converter generally consists of a Rectifier Stage (output of which will be a DC) which is then inverted to produce AC of required frequency.

The invertor may use Thyristor, IGBT's etc. If voltage conversion is needed then a transformer can be included in the input circuitry which will also provide the necessary isolation between input and output AC circuits.

The major blocks of static frequency converter are as follow:

1. **INCOMING ISOLATOR.**
2. **SCR AND THREE PHASE RECTIFIER BRIDGE.**
3. **DC CHOPPER.**
4. **DC CHOKE.**
5. **INVERTER CIRCUIT.**

How Static Frequency Converter works –

- First, switch on the rectifier circuit through Heat on button.
- Now as the heat on button is pressed and an additional current path is established parallel to the inverter circuit through contactor and the priming resistance. These resistances act as load for short duration on the DC busbars till the contactor is ON. After the required level of current (10-15 amperes through the priming resistance not the busbars) is achieved the contactor gets off and the invertors comes into play.

- Now, we fire any two opposite branches of the inverter.
- As we don’t know the frequency of the operation (As the load is unknown-empty or fully loaded) hence the feedback circuit for the inverter pulse generator cannot operate. So now we can take the help of the starting circuit.
- Suppose, a 250volts AC is supplied to the rectifier and the converter is open at this point of time, a voltage of 354 volts DC will appear across the capacitor. When a minimum current of 100-200 Amps flow through the busbar and minimum energy is supplied to the LC parallel circuit then the thyristor will be turned ON.
- A pulse of 40μs is given to the gate of thyristor. Simultaneously, the contactor is closed and after 50μs it is reopened again.
- After the starting circuit is closed, because of the series LC circuit, current starts flowing in the load circuit. The load capacitor was initially discharged and hence behaving as a short circuit. Thus, the current is very high, which slowly decreased as the capacitor gets charged up.
- Once the current falls below the holding current of the thyristor, it turns off and hence the starting circuit becomes open.
- The voltage across the load is approximately 300 volts.
- Now there is no power supply to the LC parallel load. Hence it will start to resonate. There will be some loss in the LC parallel circuit and the sinusoidal resonance voltage will decay.
- Now the feedback circuit detects the frequency of the damped sinusoidal oscillations (the first 2 peaks) and at this frequency the other two thyristors are turned ON.

NOTE: A minimum current has to be maintained in the DC busbar before the inverter is fired for the very first second.

- ## Switch-on Sequence

1. The furnace should be filled with cold metal, preferably bars placed vertically in the crucible, to prevent bridging or scaffolding. The larger the individual pieces, and the more densely they are packed, the better.
2. Close the Main Circuit-breaker.
3. Operate the key selector switch at the required operating station.
4. Check the MAINS ON indicator is illuminated.
5. Check that LOW WATER FLOW indicator has been extinguished.
6. Depress the HEAT OFF push-buttons rest all interlocks.
7. Check the READY indicator is illuminated. If not, check water pressure and, temperature, air temperature, and associated fuses.
8. At the selected control station, set the POWER CONTROL to minimum.
9. Depress the HEAT ON push-button and adjust the POWER CONTROL for the required power as indicated on the meter, or until the VOLTAGE or CURRENT LIMIT indicator is illuminated.
10. For sintering, the power should be increased slowly over a long period, but for a normal melt, the power should be adjusted to the maximum in order to achieve the shortest possible melting time.
11. AS the melt proceeds, more cold charge should be added until the furnace is filled with the desired quantity of metal at the required temperature. Power may then be reduced to that required for holding and/or alloying as the case may be.

Conclusion –

From the eve of Human Civilization people are trying to modify himself according to their wish which ultimately cause EVOLUTION. The journey of evolution started when the human first lit the fire using stones. That fire causes the change of state which ultimate build the modern society. But development still continues and we are now in a scenario where we require heating without any fire as well as without any gas. Thus, the concept of induction heating comes into account. Being the 2nd largest alloy steel producing country, INDIA requires a proper way to melt the scrap at a temperature in which steel even melts. Thus, requirement of Induction heating increases. This huge requirement is met by one of the leading manufacturers of furnace company "MEGATHERM".

Till date before coming for the training our knowledge remains confined only to books. But now after the training we realize the importance of "Mechanical Engineering". Being a student during our training days we gathered so much practical knowledge which we never dreamt of. We are truly indebted to all the persons of "MEGATHERM" who gave me the opportunity to observe vastness of Mechanical Engineering. The practical experience that we have gathered during the overview training of Induction heating and melting will be very useful as a stepping stone in building bright professional career in our future life. We learnt how to handle a critical situation without being panic and also different safety measures. This training helps us to increase our self-realization. We would like to thank everybody who has been a part of this project, without whom this project would never be completed with such ease.

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Thank You