UNDERSTANDING MEDIUM FREQUENCY INDUCTION MELTING FURNACE AND ITS COMPONENTS
The purpose of this article is to provide an understanding of the entire induction melting furnace through pictorial descriptions.
Complete set up of the Induction Melting Furnace

1. Main Power Source Panel

The purpose of the main power source is to convert the AC input supply into DC supply. The output is then fed into an inverter through the DC choke. This is then further inverted to the AC output of 0.5 KHz to 50 KHz as per your requirement. The power received is then fed to a tank circuit, which is a combination of an inductor and a capacitor. For cooling purposes, the DM water is circulated throughout the power circuit.

2. The Control Panel

(A) Power Source Water Conductivity indicator
(B) Energy Meter
(C) HMI Touch Sensitive Screen
(D) Earth Leakage Inject Pot and Push button (For testing EL circuit only)
(E) Power Control Pot
(F) Emergency Push Button
(G) Reset Push Button
(H) Heat Off Push button
(I) Heat On Push button
(J) PS Water Temperature display
(K) Control ON/OFF switch
Functions of the electronics components:

1. The Control ON/OFF Switch: Considering that it is a 3-phase input control supply unit, the functionality is distributed for control circuits through the on/off switch. Unless the switch is turned on, there can be no AC / DC control supply.

2. MCCB ON/OFF Switch: These push buttons (if provided) turns On/Off, the 3-phase input isolator/breaker. It is highly recommended to switch off the breaker if the equipment is on standby or when it is not on Heat On condition.

3. Heat On: This is used to turn on the power of the induction equipment. When Ready indication is present, all trip Indicators are Off and Emergency is released, pressing HEAT ON button turns ON the inverter and power is then being supplied to the Coil.

4. Heat OFF: This will shut off the power supply to the coil.

5. Reset: The button will reset all trips and interlock indicators.

6. Emergency OFF: Pressing this push-latch type of button releases the energizing coil of the main Breaker while the 3-phase input supply does not flow into the converter. The button can be released by rotating the knob in the direction of the arrow.

7. Power Control Pot: It provides a power reference to the control cards. This can be used to control the power of the equipment.

8. Energy Meter: This meter indicates electrical parameters like voltage, currents, and energy parameters.

9. Water Conductivity Meter: The meter has an LED-bar that provides the status of the DM water conductivity. A range of colors is used to provide the status to the viewer. The green range indicates that the water conductivity is safe whereas the orange color indicates that re-conditioning is in order as the water conductivity is not up to the required standards. The red indicator illustrates dangerous levels of water conductivity and recommends against the usage of the equipment. The functionality of the meter can be examined by pressing the test button. When it is set to low, a trip setting of 30 µS is in place. Selecting the High option will set the trip setting to 50 µS.

10. Digital Temperature Meter: The meter is located in the panel; it provides the temperature of the DM water. The meter is pre-set at a trip setting of 38 °C. Once after tripping at 38 °C, it will automatically reset itself when the temperature drop back to 36 °C only.

11. EL Inject: The section is used to check the functioning of Earth Leakage system artificially. A current around 2-3 A is injected artificially in the system when the button is pressed and same can be verified in the EL current display. When increasing the power pot, the current will gradually rise up to 10 A. This is enable the user to check whether the EL current detection system is operating at the set Leakage current.
3. Melting Furnace

There are two types of the furnace structure.

1) Aluminum frame structure

This type of the structure uses 10 kg to 2000 kg furnace.

2) Steel frame structure

This type of melting furnace comprises of coil cradle and a base structure. Coil cradle is basically an arrangement to hold the working coil along with the liquid metal. On the other hand, the base structure is designed to facilitate the tilting of the coil cradle when the liquid metal is poured.

Base Structure

As shown in the above picture, the base structure is a steel fabricated structure. The coil cradle and hydraulic tilting are mounted on the base structure. It should be leveled appropriately during the installation process. If the structure is not proper in reference to all its four corners, this can cause damages that are catastrophic and irreparable.
Coil Cradle Assembly

It consists of a melting coil that provides support while holding bath of hot liquid metal. This is made possible through the clamping arrangement and top-bottom refractory elements. The coil cradle assembly is held into place by two aluminum covers. The hydraulic cylinders are fixed into place with each side of the covers. Coil and the top-bottom refractory elements are connected with each other through SS tie-rods such that all these tie-rods remain electrically insulated from each other.

Bottom refractory element is high quality refractory cement casted appropriately between the side aluminum covers. Fine SS wires are reinforced in the casted cement to provide sufficient strength in withstanding the weight and temperature of hot liquid metal.

The top refractory element comprises of two to three layers of thick insulated sheets or, in some cases, with casted refractory in the bottom section. The left and right aluminum sheets are kept magnetically open in order to prevent the current circulation of the coil cradle assembly.

When the cradle is completely tilted, the top surface of the coil tilts up to 95°, enabling 100% of the liquid metal to flow into the ladle (or mold) easily.

4. The Working Coil

The working coil made of hollow electrolytic copper sections appropriately depending on the weight and KW of the equipment. The tank circuit is connected to the water cooled induction coil. Considering that the coil is located around heated liquid metal pool cooling water is circulated into the coil section. Since the coil carries tank currents, it should be kept secure and protected to avoid short circuits or grounding of coil.

Since the induction coil is a moveable component, it is connected using by flexible cable sets to the circuits. The flexible cables can be either air or water cooled depending on the capacity of the coil.

The internal diameter of the coil is insulated by a cast able refractory (or crucible) to prevent the coil from the heat of the liquid metal. To prevent any chances of distortion from electro-magnetic forces, the coil is rigidly fixed with vertical tie-rods.

For maximum protection, the copper coil is insulated thrice using insulating material. First layer is of glass-tape and second layer of FRP-tape is wound across it. Once the coil is completely assembled, it is painted with a superior quality of varnish.
5. **Water Circulation Circuit**

The water circulation circuit is separated into two zones. The first is De-mineralized water which is also referred to as Secondary water. The second zone is the soft water path, which is referred to as the Primary Water path. DM water circulates by DM unit (De-mineralized water circulation unit) and soft water circulates by cooling tower.

1) **DM Unit (De-mineralized water circulation Unit)**

(A) DM Water Pressure Gauge  
(B) Coil Water Pressure Gauge  
(C) Coil Water Path outlet temperature gauge  
(D) TB-DM & TBT (wires for RTD sensors & flow switches)  
(E) Non Ferrous DM Water Pump  
(F) Coil Water flow switches  
(G) Temperature switch for Coil Water  
(H) RTD sensors for Coil Water  
(I) Valve to allow water through resin cartridge, to reduce conductivity.

As shown above picture DM water circulation unit consists of a DM water tank, heat exchanger plates, pump set and a resin cylinder. Through the heat exchanger plates, the water from the DM tank is pumped to the panel, capacitor rack and the di/dt coil. To maintain the water conductivity below 10 µS, a resin cylinder is provided in the path of water circulation. During this continuous operation, the water conductivity will continue to rise periodically, resulting in the corrosion of copper tubes and ultimately the blockage of the water circulation path.

To sense the flow of the cooling water, the entire circulating water path has been designed with separate flow switches. Failure of required flow-rate in any path trips the entire system. During the melting process, the temperature of the DM water will be monitored constantly for below 37°C.

Most of the live components mentioned above carry high currents and are water-cooled by flowing DM/soft water through hollow copper tubes that carry these current. Flow of all these water circulation paths has to be monitored with respect to the flow rate and water pressure. Therefore, the flow switches are provided to monitor the flow in each path individually.
2) **Cooling tower:**

Using the cooling tower, the primary soft water circulates in the DM Unit Heat exchanger and melting coil. The cooling tower (primary water circulation) will pump the cool water from underground water tanks to the DM heat exchanger and the coils at the melting station. The warm water passed through the cooling tower and re-collects in the tank. The soft water circulation is continuously monitored for possible temperature rise which trips the system.

6. **The Hydraulic Unit**

The hydraulic cylinders are mounted on a furnace base assembly to tilt the pool of hot liquid metal. The pressurized hydraulic oil is flown into these cylinders from a Hydraulic unit through Direction control valve and Throttle control valve.

As shown in the below picture Hydraulic unit comprises of a hydraulic tank with hydraulic pump and pressure gauge connected together. In case it has to be operated manually, a lever is provided for parallel operation to hydraulic pump in case there is an electric failure or any other form of emergency.

The direction control valve is primarily responsible for the flow of hydraulic oil. This valve decides whether the furnace is to be tilted upward or downward. At the base of each hydraulic cylinder, a throttle control valve has been provided to control the flow of hydraulic oil back to the tanks. Therefore, the speed of the coil cradle assembly can also be controlled by these valves. An equal balance is necessary when opening these valves to allow the proper distribution on the cylinders while tilting.

The speed of the Coil cradle at which it tilts upward is controlled by Pressure regulation valve provided on the Hydraulic Unit. The pressure in the Pressure gauge on the hydraulic unit will decide the speed of lifting of the crucible.
7. **Tank Capacitors and Di/dt Coil**

In melting applications, the Di-Dt coil is placed near the power supply unit. Meanwhile, the tank capacitor bank is near the furnace structure. The change over switches (furnace selection switches) are customized and located in the power sources panel or near the furnace. This depends entirely on the user’s preferences.

As shown above picture tank capacitors are primarily a bank of medium frequency and multi tap capacitors. They are connected parallel to one another. They are cooled by the DM water circulated through. The melting coil and the tank capacitor together form a closed circuit electrically that is also referred to as the resonant tank circuit. The selection of the tank circuit perimeters plays a vital role in performance of the induction furnace.

Di/dt coil is used to prevent any heavy current surge from flowing to the power supply unit and for load matching. Such currents spikes are generated at the melting station due to scrap pieces and or dust particles that setting over the live bus-bars. Di/dt coil is an air-cored inductive component connected at the output of Power Source Panel.
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