# IGBT Based Induction Heater and Cooker

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***Abstract*— For this purpose as a fast heating task decided to work on an innovative and ambitious project task, "IGBT BASED INDUCTION HEATER AND MELTER". As the name implies , the project is a heater/melter which works on induction principle and the latest state of art IGBT technology. Here IGBT is used as a high frequency switching device, instead thyristers, SCR's, MOSFET, Power Transistors, etc. Thus improving the efficiency of the overall systems upto 96% to 98%.**

*Keywords*— IGBT, Induction, High frequency switching device, heater, Melter



## I. Introduction

Power electronics is the application of solid-state electronics to the control and conversion ofelectric power.

The first high power electronic devices were mercury-arc valves. In modern systems the conversion is performed with semiconductor switching devices such as diodes, thyristors and transistors, pioneered by R. D. Middlebrook and others beginning in the 1950s. In contrast to electronic systems concerned with transmission and processing of signals and data, in power electronics substantial amounts of electrical energy are processed.

An AC/DC converter (rectifier) is the most typical power electronics device found in many consumer electronic devices, e.g. television sets, personal computers, battery chargers, etc.

The power range is typically from tens of watts to several hundred watts. In industry a common application is the variable speed drive (VSD) that is used to control an induction motor. The power range of VSDs start from a few hundred watts and end at tens of megawatts.

The power conversion systems can be classified according to the type of the input and output Power[1]

- AC to DC (rectifier)
- DC to AC (inverter)
- DC to DC (DC-to-DC converter)
- AC to AC (AC-to-AC converter)

Power electronic devices may be used as switches, or as amplifiers. An ideal switch is either open or closed and so dissipates no power; it withstands an applied voltage and passes nocurrent, or passes any amount of current with no voltage drop. Semiconductor devices used as switches can approximate this ideal property and so most power electronic applications relyon switching devices on and off, which makes systems very efficient as very little power is wasted in the switch. By contrast, in the case of the amplifier, the current through the devicevaries continuously according to a controlled input. The voltage and current at the device terminals follow a load line, and the power dissipation inside the device is large compared with the power delivered to the load.Induction heating is the process of heating an electrically conducting object (usually a metal) by electromagnetic induction, through heat generated in the object by eddy currents. An induction heater consists of an electromagnet, and an electronic oscillator that passes a high-frequency alternating current (AC) through the electromagnet.

The rapidly alternating magnetic field penetrates the object, generating electric currents inside the conductor called eddy currents. The eddy currents flowing through the resistance of the material heat it by Joule heating. In ferromagnetic (and ferrimagnetic) materials like iron, heat may also be generated by magnetic hysteresis losses. The frequency of current used depends on the object size, material type, coupling (between the work coil and the object to be heated) and the penetration depth.

An important feature of the induction heating process is that the heat is generated inside the object itself, instead of by an external heat source via heat conduction. Thus objects can be heated very rapidly. In addition there need not be any external contact, which can be important where contamination is an issue. Induction heating is used in many industrial processes, such as heat treatment in metallurgy, Czochralski crystal growth and zone refining used in the semiconductor industry, and to melt refractory metals which require very high temperatures. It is also used in induction cooktops for heating containers of food; this is called induction cooking.[2]

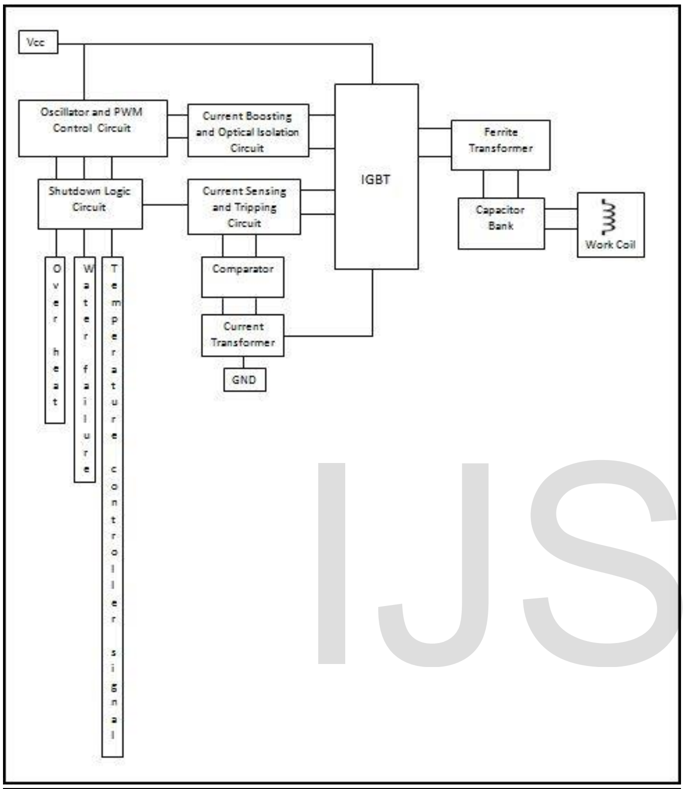



Fig. 1. Block diagram of Induction System.

## II.WORKING

[3]The concept of Induction Heating, employed from the principal of induction which is also used in industrial sectors as the systems have high efficiency, power saving and fast compared to other methods of heating. First the AC voltage is rectified and converted AC into DC. The converted DC voltage is disturbed in into ac so the inverting circuit is used to convert into AC signal where the capacitor bank is used for filtering the AC signal as inverted signal is pulsating AC signal. The capacitor bank filter the signal we pure high frequency AC signal is given at the working coil. The eddy current are created at the skin depth of the ceramic guard which has a graphite crucible which is heated at the high temperature for melting the metals like Gold, Siler, platinum or making the alloy.

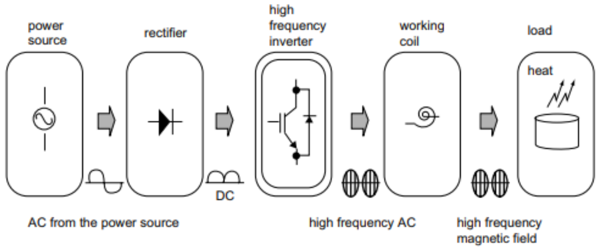



Fig 2.Working of Induction Melter

The basic setup is an AC power supply that provides electricity with low voltage but very high current and high frequency. The work piece to heat is placed inside an air coil driven by the power supply, usually in combination with a resonant tank capacitor to increase the reactive power.

The alternating magnetic field includes eddy currents in the work piece and hence the workpiece gets heated. In theory only 3 things are essential to implement induction heating:

1. A source of high frequency electrical power,
2. A work coil to generate the alternating magnetic field,
3. An electrically conductive work piece to be heated,

Having said this, practice induction heating systems are usually a little more complex.

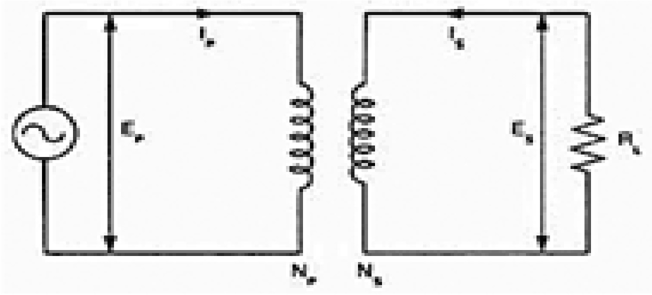
For example, an impedance matching network is often required between the high frequency source and the work coil in order to ensure good power transfer. Water cooling systems are also common in high power electronics.

Finally some control electronics is usually employed to control the intensity of the heating action, and time the heating cycle to ensure consistent results. The control electronics also protects the system from being damaged by a number of adverse operating conditions. However, the basic principle of operation of any induction heater remains the same as described earlier.

## III.DESIGN ASPECTS

In sense, coil design for induction heating is built upToa large store of empirical data whose development springs from several simple inductor geometries such as the solenoid coil. Because of this, coil design is generally based on experience. This series of articles reviews the fundamental electrical considerations in the design of inductors and describes some of the most common coils in use.

The inductor is similar to a transformer primary, and the workpiece is equivalent to the transformer secondary (Fig. 2). Therefore, several of the characteristics of transformers are useful in the development of guidelines for coil design.



$E_p$ = primary voltage (V); $I_p$ = primary current (A); $N_p$ = number of primary turns; $I_s$ = secondary current (A); $N_s$ = number of secondary turns; $E_s$ = secondary voltage (V); $R_s$ = load resistance(Ω)

*Fig 3 Electrical circuit illustrating the analogy between induction heating and the transformer principle*

One of the most important features of transformers is the fact that the efficiency of couplingbetween the windings is inversely proportional to the square of the distance between them. Inaddition, the current in the primary of the transformer, multiplied by the number of primaryturns, is equal to the current in the secondary, multiplied by the number of secondary turns.

Because of these relationships, there are several conditions that should be kept in mind whendesigning any coil for induction heating.

The coil should be coupled to the part as closely as feasible for maximum energy transfer. Itis desirable that the largest possible number of magnetic flux lines intersect the workpiece atthe area to be heated. The denser the flux at this point, the higher will be the current generated in the part.The greatest number of flux lines in a solenoid coil are toward the center of the coil. The flux lines are concentrated inside the coil, providing the maximum heating rate there.

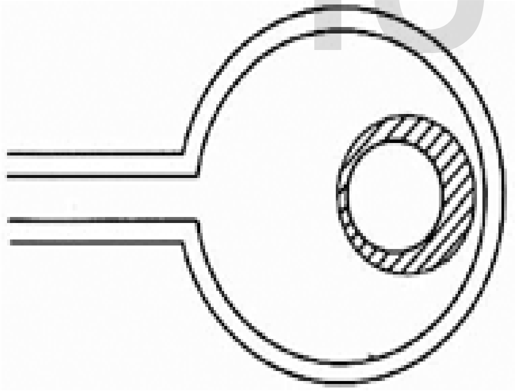


Fig 4. Induction heating placed in a round bar placed off center in a round induction coil.

Because the flux is most concentrated close to the coil turns themselves and decreases fartherfrom them, the geometric center of the coil is a weak flux path. Thus, if a part were to beplaced off center in a coil, the area closer to the coil turns would intersect a greater number offlux lines and would therefore be heated at a higher rate, whereas the area of the part withless coupling would be heated at a lower rate; the resulting pattern is shown schematicallyin Fig. 2. This effect is more pronounced in high-frequency induction heating

**Medium To High Frequency:**

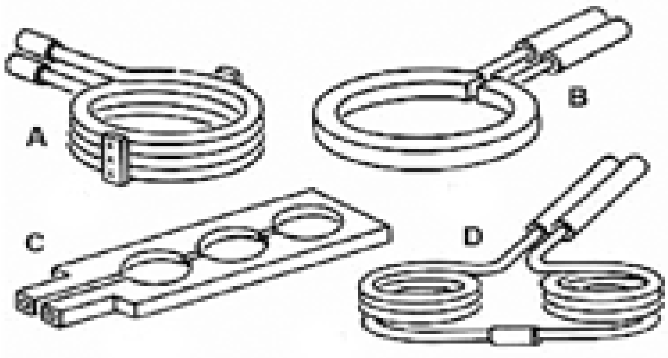



fig 5. Typical configuration of multiple coil.

Simple solenoid coils are often relied on in medium-to-high-frequency applications such as heat treatment. These include single- and multiple-turn types. Fig. 4 illustrates a few of the more common types based on the solenoid design. Fig. 4a is a multiturn, single-place coil, socalled because it is generally used for heating a single part at a time. A single-turn, single-place coil is also illustrated (Fig. 4). Fig. 4c shows a single-turn, multiplace coil, in this design, a single turn interacts with the workpiece at each part-heating location.fig (4) shows a multiturn, multiplace coil.

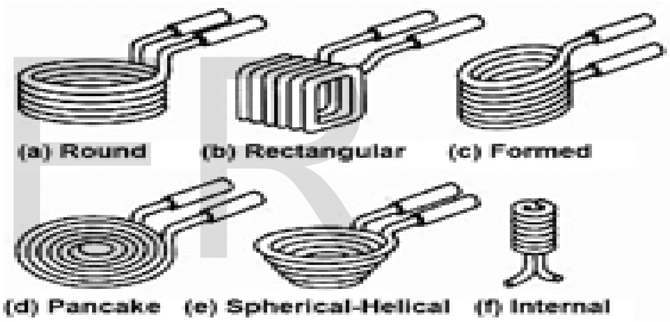



Fig 6. Multi coil design of different coil in various shapes.[4]

## IV. IMPLEMENTATION METHODOLOGY

The started with the hardware part of induction system. First started with the fiting of the components like Miniature Ciruit Breaker (MCB), Push Buttons, LED Indicators, Analog Ampere Meter (Current Meter), Potentiometer and Cooling Fan.

Fig 7.Front panel IGBT based indcuion Heater and Cooker

Then started with to solder the wires for making connection in our circuit board and a connector was connected with the wires. Some of made some set of wires for the connection to the PCB board. After the wiring was done all the connection were made to the PCB,PID controller, ammeter ,MCB, transformer , CT, etc. The water pressure sensor was connected to the inlet of the cabinet for checking the circulation of water. Then after checking the connection again the AC supply was giving to the circuit this was the first testing for checking the PCB and rest other components were working properly. After ensuring the component were OK the IGBT was need to check. To check IGBT the heating ON push button was pressed and the IGBT was fired were the LEDs were glowing, as the intensity was low, while increasing the frequency the intensity of the LEDs increase. While testing there was some problem in the IGBT were only one LED was glowing after rectifying the problem the LED was faulty so the led was replaced. The logic part of the circuit was OK. So the main components were placed at there position. The assembling work was complete and the coil was left. Two coils were made one was for heater and the second was for melting purpose. So the coils were made the PU connectors were connected to them by brazing. After brazing the PU connectors on the coil the connections were made and the water supply was giving through the pipe using the submersible pump. After ensuring the no leaks in the pipe the coil was connected to the capacitor bank which was the output of the melter. Then 230V 50hz supply was provided to the melter first the heater coil was connected and current was increased to 2A the vessel was kept on the coil, the vessel was heated quickly, the second coil was connected for melting the current was increased to 5A the temperature was taken to 600 C the graphite crucible was kept in between the coil it was heated the desired temperature and in the crucible the aluminum block was kept , the aluminum was melted in few minutes as it has reached its desired temperature. The system efficiency is up to 96% to 98%. There is also a K type sensor connected to the crucible which is the connected to the PID and the temperature is set on the PID. After checking the output was ok and the at last the cooling fan is used to keep the system cool. Usually the size of the induction are big, so the size of the induction is of CPU cabinet.

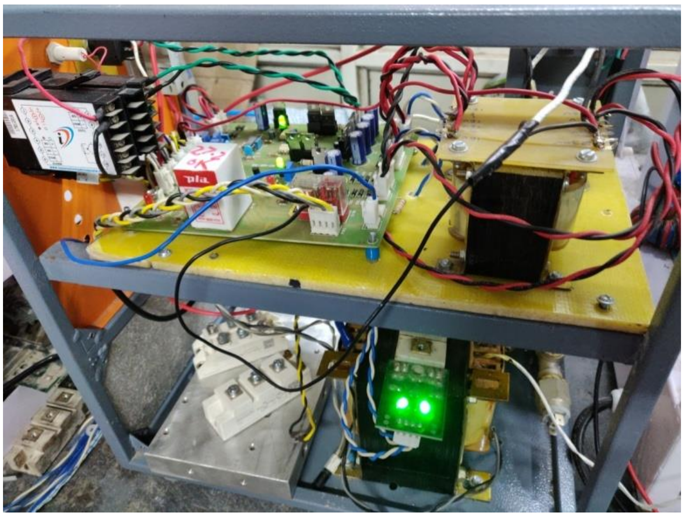


Fig 8. Logic testing of the IGBT and the power

## VII.APPLICATION

Bonding
Melting
Heating
Cooking



## VII. CONCLUSION

The system which is very efficient and compact. There are two coils which we will be using for the showing the output of the system which will be for heating and another will be for high temperature.

Consistent

It consistently heats material throughout the induction process. The temperature in an inductive heating system can be controlled.

Immediate Output / Fast Operation

Induction heating heats up objects rather quickly and doesn't require a starting up and cooling down process.

Environmentally Sound

This form of heating doesn't emit any pollutants or emission that could be harmful to people or the environment.

Easy installation

It can used once it is connected with power source, induction coil as well as water supply pipe and rising pipe; it is small in size & light in weight.[5]

## IX. FUTURE SCOPE

1.There can be increase in the power handling capacity and output frequency accordingly for other applications.
2. Convert the Single phase system into Three Phase system for using it in heavy application of industries & research institutes.
3. This include automation system for various control & processes of the system using PLC's (Programmable Logic Controller).
4. It can also be used Microcontroller or Microprocessor circuits for controlling the system.

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