Annealing Induction Heating for Industrial Use

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***Abstract* - As we know the demand for better quality, safe and less energy consuming products is rising. Products using induction heating include rice cooker, pans and industrial heating machines. Safe, efficient and quick heating appliances attract more customers. The induction heating machines are utilized in the industries which modify machine parts and tools are used to achieve high wave resistance. This paper describes the model of induction heating process design of ferrite core coupling circuit and the result and the result of induction surface annealing of heating coil. In the design of heating coil, the shape and the turn numbers are the very important design factors because they decide the overall operating performance of induction heater including resonant frequency, efficient and power factor. The performance will be tested by experiments in some cases high frequency induction hardening machine. Induction heating is one of a wide range of electrical heat used in industry and household today. The main applications of this heating are in the steel and metal working industries. Induction heating is a common industrial process used for the reheating of billets before extrusion and forging. In this work the influence of the coil and work piece geometry, the effect of the electrical properties of the work piece, and the coil current and frequency on the magnetic flux density and resulting work piece heating rates were studied. Dozens of heating and magnetic field experiments have been conducted, with steadily increasing sophistication and measurement accuracy. This paper discusses the overall implementation of annealing induction heating with latest trend and technologies.**

Keywords: Annealing induction heating, Ferrite core transformer, Microcontroller, Relay555 timer, IGBT Module, Electrolytic capacitor, bridge rectifier and work coil.

I. INTRODUCTION

Induction heating is the process of heating an electrically conducting object (usually a metal) by electromagnetic induction, where eddy currents (also called Foucault currents) are generated within the metal and resistance leads to Joule heating of the metal. An induction heater (for any process) consists of an induction coil (or electromagnet), through which a high-frequency alternating current (AC) is passed. Heat may also be generated by magnetic hysteresis losses in materials that have significant relative permeability. The frequency of AC used depends on the object size, material type, coupling (between the work coil and the object to be heated) and the penetration depth. High Frequency Induction heating is a process which is used to bond, harden or soften metals or other conductive materials. For many modern manufacturing processes, induction heating offers an attractive combination of speed, consistency and control. The basic principles of induction heating have been understood and applied to manufacturing since the 1920s. During World War II, the technology developed rapidly to meet urgent wartime requirements for a fast, reliable process to harden metal engine parts. More recently, the focus on lean manufacturing techniques and emphasis on improved quality control have led to a rediscovery of induction technology, along with the development of precisely controlled, all solid state induction power supplies.

II. OBJECTIVES

Although induction heating systems exists since 1906 (Curtis, 1950) its design always has been an art, with a great emphasis in the designer’s experience. This state of things has not really changed much until the advent of computers and analysis software powerful enough. Now it is possible to use relatively common programs, even free software in some cases, to design and simulate the heating system before any physical device needs to be mounted. A new type of induction heating has been developed for heating and melting of metals. Furthermore, this type of induction heating is fully microcontroller based, which can be controlled automatically. Relevant equations and diagrams are given with a detailed analysis. The proposed INDUCTION HEATING technique is more simplified then the older type. The main objective is to heat the metals at faster rate to the

molten state i.e. 900^0C. As compared to the olden heating they use to take a lot of time to go to molten state by consuming more power. So here we have designed with latest technology with fast heating for any type of metals. The proposed annealing induction heating is realistic in future.

III. MOTIVATION

At present renewable energy has to be utilized along with conventional resources to satisfy the energy needs. Future energy needs can also be satisfied either way. As we are talking about the energy, this energy is to be use by the induction heating. It takes AC supply and convert in DC and again it get inverted and it is used for heating purpose. If we are going to earlier stage then the power consumption was more and efficiency was also less and size also increases. In this advanced technology it conserves the energy and efficiency is also high and the size is reduced. This type of heating machines is under budget.

IV. PROBLEM STATEMENT AND SOLUTION

The main problem exists in the present induction heating is that the size is too large, it cannot be handled automatically and their losses are high. The losses are occurred mainly as a transformer winding and in work coil. So this problem has to be eliminated and different type of transformer is to be used. The problems can be solved by using a ferrite core transformer with latest technique. The losses will be reduced because it can be cooled by supplying water cooling through the heat sink. To reduce the losses in work coil, the work coil is designed in such a way that the gap between the coil is not more and the work coil is insulated with insulating materials such as glass wools. This increases the efficiency of machine and heats at the faster rate.

V. IMPLEMENTATION DIAGRAM

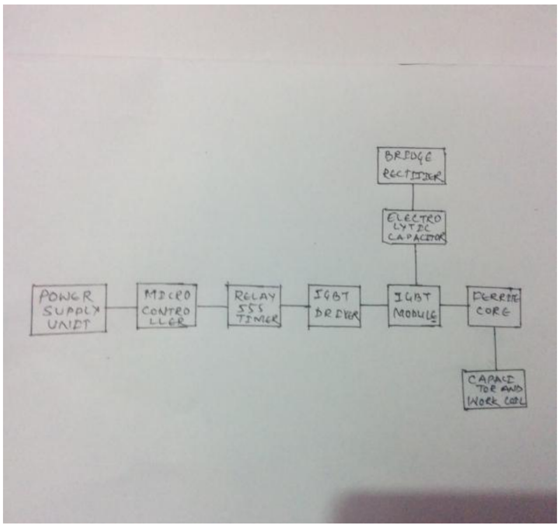

Fig1 Block diagram of induction heating

DISCRIPTION OF BLOCKS

1. POWER SUPPLY : It is a low power circuit which is given to the IGBT driver circuit, microcontroller, 555 timer here I use 2 low power supply of ±5V and ±15V.
2. MICROCONTROLLER: This kit is designed to control the firing frequency for IGBT base. Even it controls the relay unit and 555timer.
3. RELAY 555 TIMER: Relay is designed to control the 555timer by which toggles the output of timer. 555timer is used to generate a frequency of 15 kHz which is given to IGBT of BASE through driving circuit.
4. IGBT DRIVER: This comprises of optocoupler ic and two power transiotor(Darlington transistor). Here the frequency and voltage criteria for driving IGBY are achieved i.e. 15 kHz and ±15V.
5. IGBT MODULE: Here in this module the IGBT is run as an inverter. The windings of the ferrite core transformer are connected between the collector terminals of the IGBT.
6. BRIDGE RECTIFIER: This unit takes the high supply ac input and the rectified output voltage is fed to the electrolytic capacitor.
7. ELECTROLYTIC CAPACITOR: Two electrolytic capacitor of 450 Vdc are connected in parallel for smoothening the output of the rectifier. The output of the capacitor is connected to the winding of the transformer.
8. FERRITE CORE TRANSFORMER: This is the main unit of the power circuit. When IGBT is fired the stored DC voltage in winding get converted into alternating current of 60A.
9. CAPACITOR AND WORK COIL: The output of the ferrite core is connected to the resonance capacitor connected in parallel. The capacitor is directory connected to the work coil where the specimen to be heated is placed. When supply is switched ON the IGBT gets fired and the work coil is shorted with the secondary of the ferrite core. Hence magnetic field is generated within the coil due to which when metal piece is placed in the work coil it links with the magnetic flux and the eddy current flow through the work piece and heats it up.

V.I LOW POWER SUPPLY

In this project i needed 2 power supplies for low power parts and one for the high power part. For the high power part we used SINGLE phase socket, and for low powerr ones we built our supplies, we built one as a Vcc for microcontroller 8052, as shown below. We used two transformer one for +5v supply to microcontroller and other for IGBT driver circuit. It consists of four parts transformer, rectification, smoothing, and regulation. The output of the small transformer is 12 volt which is rectified using bridge rectifier and is feed to the capacitor (1000µf/35v) so that the output of rectifier will be more smoothen. After that it is feed to the voltage regulator ic 7805 (+5v) and 7905(-5v) and directly 12 volt is supplied to the water pump. In 15V power supply it consists of four parts transformer , rectification , smoothing, regulation. The output of the big transformer is 24 volts which is rectified using bridge rectifier and is feed to the capacitor (1000µf/35v) so that the output of rectifier will be more smoothen. After that it is feed to the voltage regulator ic 7815 (+15v) and ic 7915(-15v).Here power supply circuit completes.

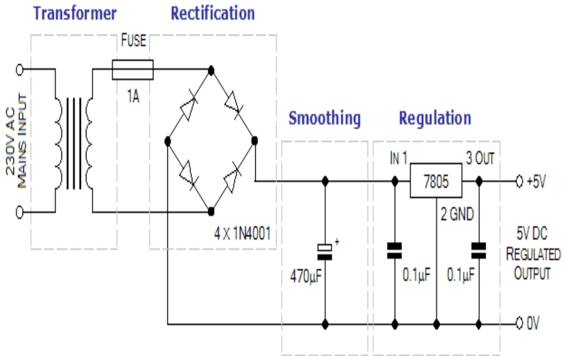

Fig.2 Low power supply circuit to get regulated output of and 5v

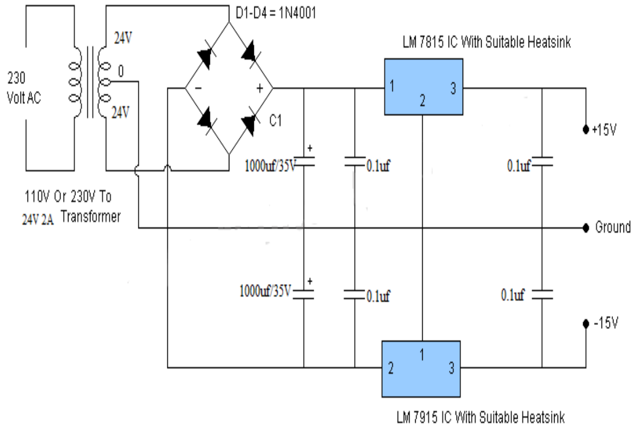

Fig.3 Low power supply circuit to get regulated output of +15v and -15v

Now this +15and -15volts supply is feed to the collector of the power transistors (TIP122 and TIP127) for IGBT driver circuit. Both emitter and both base are shorted as shown in the

The base is provided with supply from opto-coupler pin no.6 and the output of both emitter is feed to the IGBT emitter (E1) and gate is made ground.

Similar circuit is designed for one more IGBT (E2) and base is provided with supply from opto-coupler pin no.7.

V.II GBT DRIVING CIRCUIT

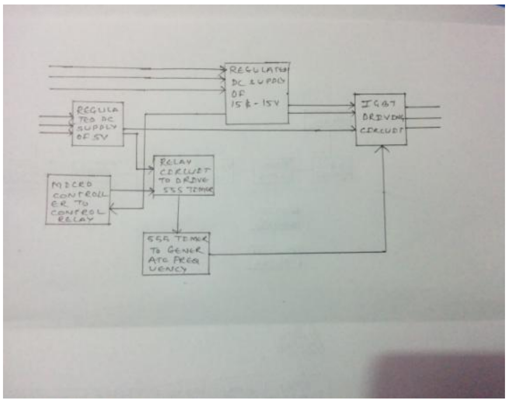

Fig. 4 Block diagram of low power circuit to drive igbt

In this block diagram the low power circuit works as follows:

5volt regulated supply is used for optocoupler , relay .12 volt regulated dc is used to switch on the microcontroller kit. +15 and -15volt dc is feed to darlington power transistor collector terminal and to optocoupler. Microcontroller keypad “F” is used to switch on and switch off the device where as 0 to 9 keypad are used to set the time from 1min to 10 mins. Microcontroller is used to switch on the relay when switch is pressed from the microcontroller keypad it sets the time depending upon the keypad button pressed. We use port 1.4 for relay when keypad is pressed it makes the port pin 1.4 low and make the relay to conduct for 555 timer 555 timer starts to generate frequency when the time is over the port pin 1.4 becomes high and the relay comes to contact with NC and 555 timers stops generating frequency using transistor circuit we are making the relay to turn on and turn off as the output of this frequency with voltage is very low to drive the IGBT hence the output of the 555 timer is fed to the optocoupler using the darlignton power transistor we get the stepup voltage of +15 to -15 vdc with 15 khz frequency this frequency is fed to the IGBT base and IGBT starts to conduct.

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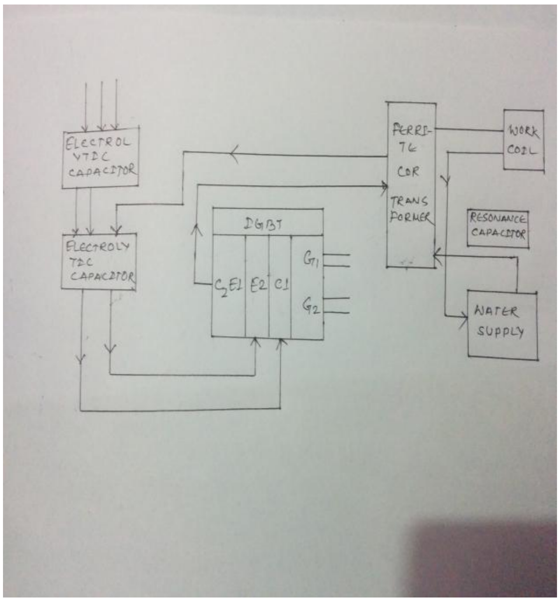

Fig 5 IGBT driver circuit

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V.III WORK COIL

Fig 6 work coil

Coil design for induction heating is built upon a large store of empirical data. Because of this, coil design is generally based on experience, conditions that should be kept in mind when designing any coil for IH:

*The coil should be coupled to the part as closely as feasible for maximum energy transfer.

*The coil must be designed to prevent the cancellation of the magnetic field.

*The flux lines are concentrated inside the coil, providing the maximum heating rate there.

Wheeler's formula and the Specification of the work coil play the large role in design the work coil.

Wheeler's formula $L= 1/((2\pi f)^2C)$ Henry.

To calculate no. of turns.

$L= (a^2N^2)/(9a+10b)$

Let:s

L= inductance

a= diameter of coil

b= height of coil

N= no. of coil.

To calculate for current:

$I= (2\pi P_{avg})/V_{peak}$

$I=((2\pi x4000)/(344)$

I= 73.06 A

$C=(73/2\pi x1500x344)$

C= 12µf

$L=1/((2\pi f)^2C)$

$L=(N^2a^a)/(9a +10b)$

L= 48.49 µH

$L=(N^2x3x3)/((9x3)+(10x4))$

N= 19 Turns

a= 3inchb= 4inch

VI. SNAPSHOT OF IMPLEMENTATION

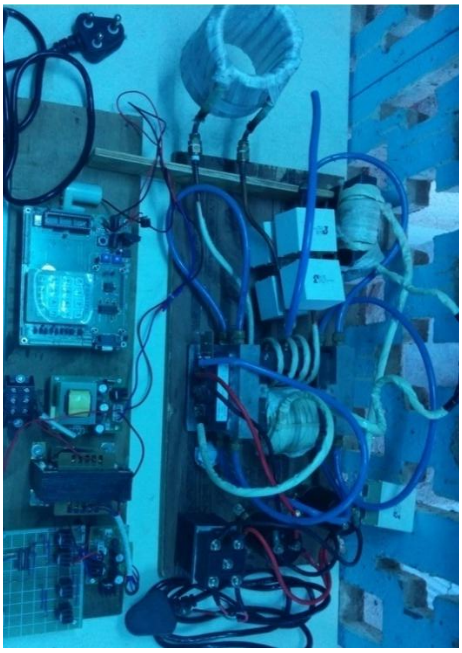

Fig 7 Implementation diagram

VII. TESTING AND RESULTS

In testing without switching on the low power supply we tested the continuity using multimeter by keeping at continuity tester.

Then we connected the supply to low power circuit and check the output of low power using multimeter by keeping at DC voltage.

Then the output of low power supply is given to the microcontroller kit, relay and igbt driving circuit .

Here microcontroller is switched on and controlling the 555timer and the output of 555timer is checked in the CRO.

The output of 555timer is feed to the optocoupler ic as a input and then the output is checked in multimeter by keeping it at DC voltage.

Table 1:.Output of optocoupler and power transistors

Sl. no.	Output from various devices		
	555 timer	outocoupler	Power transistor
1.	Low	High	High
2.	High	Low	Low
3.	Low	High	High
4.	High	Low	Low

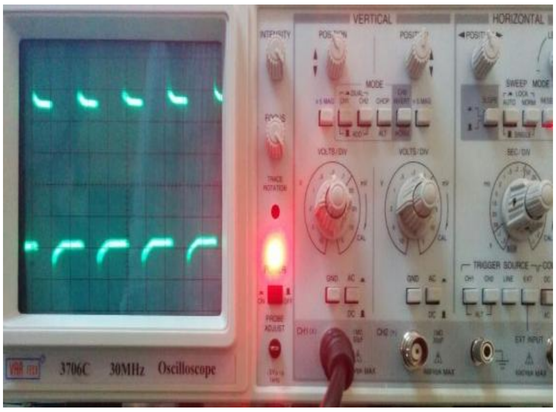

Fig.8. Output frequency of 15khz

Connecting the output of optocoupler to the base of two transistors , the output is again checked with multimeter and CRO by controlling with microcontroller which is shown in the above table.

Then the output of the power transistor is feed to the IGBT base , then the high power supply is switched on and the work coil is checked by keeping the metal piece in the work coil. The metal piece is heated to the molten state.

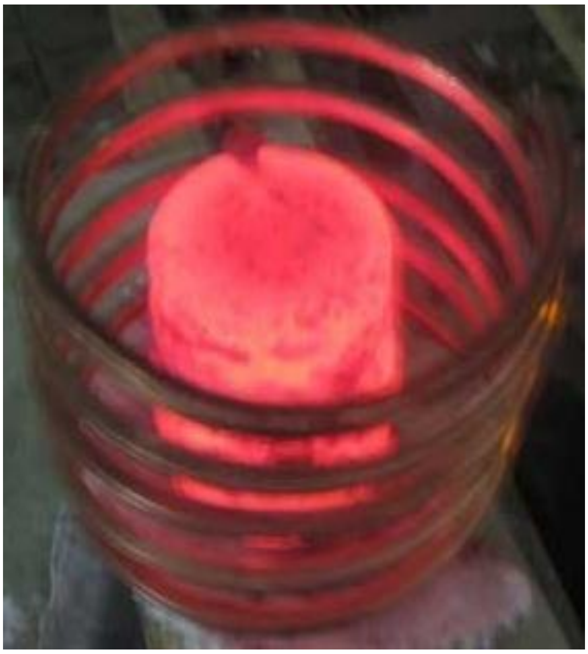

Fig 9 output of the annealing induction heating

VIII. CONCLUSION

For this project Induction Heating we use a Hardware that is associated with appropriate Software in order to do the job. It was discovered that during the project that there are several problems with implementing Induction Heating technique as shown previously. Using IGBT switches as an inverter was more reliable and enjoyable from using BJTs, since driving circuit for the last one is almost disappeared in presence of other rugged switches. Also we conclude practical work differs a lot from theoretical one, although they cannot be separate from each other. The Induction Heating concept is the same for all the application. And most important, no matter what happen for our mental state while working in this project.

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