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RESEARCH ARTICLE

INDUCTION HEATING USING RESONANT CONVERTER.

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Abstract

Induction heating combines the concept of resonant converter and electric heating. In industrial field induction heating is used for metal hardening, pipe welding and smelting applications in which their frequency and duty cycle control plays an important part. Efforts are made to heat the conducting material in specified time.

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Introduction:-

Many industries require heating of materials for specific application. In last decade heating was done by fuel- fired furnaces but it takes a large amount of time. So in order to save time, induction heating is used in industries.

The heating of materials by electricity is faster and cleaner and is more accurately controlled than heating by fuel – fired furnaces. When all factors are included electric heating is more economical.

Eddy current principle:

Any conducting material may be heated merely by being placed close to an ac circuit. Figure 1 shows an alternating current passing through a work coil that surrounds (but does not touch) the work piece of metal that is to be heated. The flow of current produces a magnetic field or flux that surrounds each turn of the work coil; this flux passes also through air or through any metal that is within or near the coil. Each reversal of the current causes the flux to change. The change of flux induces a voltage within the work piece; this voltage forces large eddy currents to flow through the metal. As these induced currents pass through the resistance of the work piece, they generate heat.

The frequency required for induction heating depends on the size and shape of the work piece and the desired depth of heat penetration. At frequencies up to 2 KHz the dept of penetration is ≤ 0.08 inch. If depth of penetration required is less than 0.04 to 0.02 inches then frequencies from 10 to 20 KHz must be used. The frequency is inversely proportional to the depth of penetration. The amount of power that can be transferred from the work coil to the work piece increases in proportion to frequency. By limiting the penetration depth with higher frequency, higher temperature is obtained faster and with less energy input. Most metal hardening requires input power of 5 to 50 kW/sq inch of surface heated .

Block diagram description:

The block diagram to implement induction heating is composed of following blocks as shown in fig. 2.

1. H.T. (high tension) power supply
2. Single phase bridge inverter.
3. Series resonance Circuit
4. Isolation and Driver unit.
5. Microcontroller unit

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H.T. (high tension) Power supply:

The first block of is H.T power supply. It has bridge rectifier and capacitor filter. The power supply provides H.T D.C. voltage which is required for single phase bridge inverter circuit.

Single phase bridge inverter:

For the generation of controlled H.T alternating current signal a single phase bridge inverter is used. At the output of single-phase bridge inverter we will get fixed frequency ac signal. The output of bridge inverter is fed to the series resonant circuit.

Series Resonance Circuit:

The series resonance circuit consist of two components i.e. inductance L and capacitance C. The series resonant circuit works at fixed frequency and / or fixed voltage signal. By adjusting switching frequency of inverter equal to resonance frequency of series resonance circuit the power losses are reduced. The output of series resonant circuit is coupled to an induction coil through a secondary of transformer (the primary this transformer act as an inductance L)

Isolation and Driver unit:

There are 4 stages of isolation and driver unit to control gate pulses to the switches as they switch-on according to gate pulses. These gate pulses are generated by the microcontroller and coupled through up to isolator & driver circuit.

Driver is used to boost the current output of the microcontroller to drive the power device.

To keep isolation between control circuit and power circuit, opto-isolator is used.

Microcontroller unit:

Microcontroller controls selection of frequency and duty cycle.

Inverter

A device that converts dc power into ac power at desired output voltage and frequency is called an inverter. The dc power input to the inverter is obtained from rectifying and filtering the 230v ac mains.

Single-phase bridge inverters

Single-phase bridge inverters are of two types, namely (i) single-phase half-bridge inverters and (ii) single-phase full-bridge inverters. The single phase full bridge inverter is used in our circuit as shown in fig. 3.

Series resonant circuit:

In PWM converters the controllable switches are operated in a switch mode where they are required to turn on and turn off the entire load current during each switching. The switches are subjected to high switching stresses and high switching power loss that increases linearly with the switching frequency of the PWM. Also a large EMI is produced due to large dv/dt and di/dt caused by a switch mode operation.

These high switching losses are minimized if each switch in a converter changes its status when the voltage across it and / or the current it is zero at the switching instant. Since most of these topologies require some form of LC resonance they are called as resonant converters. We have selected the series resonant converter for induction heating.

Practical implementation:-

The above paper was implemented using Atmel microcontroller 89C2051 for control. The frequency of operations was 2 KHz to 20 KHz. Power devices MOSFET IRF 840 were used for inverter. The frequency was adjusted by reading the position of DIP switches. The duty cycle is adjusted by increment, decrement key. The value of L and C are 4mH and 10uF.

Experimental results:

At room temperature = 26 °C

Sr. No.	Time in Sec.	Temperature in °C
1.	10	60 °C
2.	20	80 °C
3.	30	100 °C
4.	40	115 °C
5.	50	130 °C
6.	60	140 °C

Conclusion:-

From the experimental result and observation it is seen that the temperature and depth of penetration of the conducting material depends on duty cycle and frequency of an inverter circuit.

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