

# Simulation of IGBT Based Power Supply for Induction Melting Furnace

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## Abstract:

In this paper a MATLAB simulation of induction melting furnace model is designed for a practical induction furnace with IGBT based parallel inverter. Then voltage, current and power factor is measured. This value is compared with actual data of furnace working in industry.

**Keywords — Rectifier, Inverter, Induction melting furnace, Simulation**

## I. INTRODUCTION

An induction furnace is an electrical furnace in which the heat is applied by induction heating principle to the metal. Induction furnace capacities range from less than one kilogram to one hundred tonnes capacity and are used to melt iron and steel, copper, aluminium and precious metals. Induction melting furnace is widely used in metal industry for melting or heating slab or rod in continuous casting plant because of good heating efficiency, high production rate and clean working environments. Induction furnaces have very high power consumption and non-linear characteristics. A typical parallel resonant inverter circuits for induction melting furnace which we are going to discuss about, have a phase controlled rectifier that provides a constant DC current source. The H-bridge inverter consists of four Thyristor and a parallel resonant circuit comprises capacitor bank and heating coil. Thyristors are naturally commutated by AC current flowing through the resonant circuit. Therefore, this type of inverter is usually called a load commutated inverter. The rated output power and frequency of mentioned induction furnace are 150 KW and 2KHz, respectively. The rated input voltage and frequency are 415 volt AC and 50 Hz. One of the problems is the insufficiency in the output power, and the other problem is the frequent damage of the capacitor bank. Insufficiency in output power was caused by a poor power factor of the inverter.



Fig. 1:- Block diagram of induction melting furnace power supply

## II. Proposed Control Method For Induction Melting Furnace

Output power obtained from the coil of this induction heating furnace is not constant. When load side impedance and source side impedance is equal that time resonance condition is occurs. So, for constant output of furnace we suggest uncontrolled three phase rectifier convert into controlled three-phase rectifier. By changing the rectifier firing angle, on the desired power input we able to get constant output power. Also, suggest single phase Thyristor switches of inverter convert into IGBT switches and for trigger of these switches, unipolar PWM method is used. For results of these suggest electrical power supply system circuit part by part simulated and these simulated details are connected to each other. Corresponding, entire circuit is simulated. Entire system simulated with desired controller is shown in the Figure.2

## III. Power Supply Simulation

### A) Simulation of Source and Rectifier

Induction heating furnace is simulated by three-phase sources with sequence a, b, c with grounded neutral. Source has maximum amplitude of 415V and frequency of 50Hz that has 120<sup>0</sup> phase different between phases. A pure inductor is connected along with line to protect Thyristor of rectifier from high di/dt. Also, works as device of snubber circuit. Simulated rectifier is three phase and has three-leg and six Thyristors, named from T1 to T6. For firing of these Thyristor we are sampling from the line voltage.

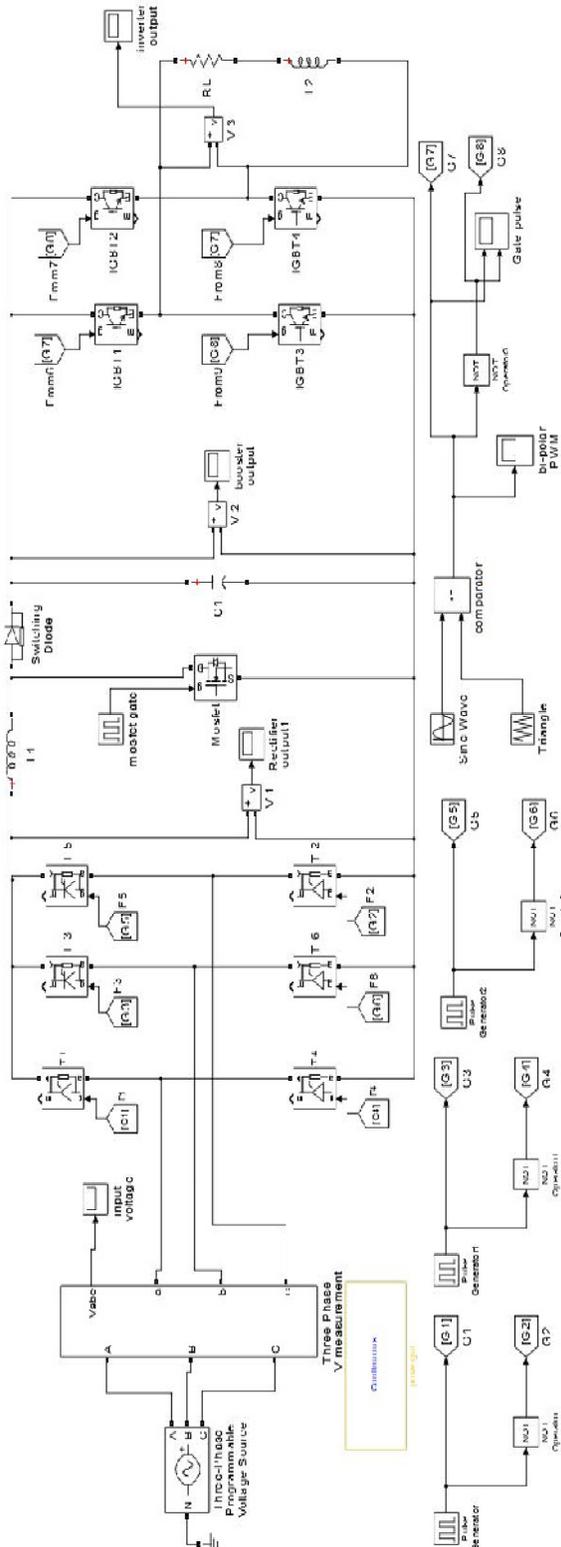


Fig.2:- simulation model

**B) Simulation of Booster Circuit**

To increase the output voltage of the rectifier (DC) we connect the booster circuit between rectifier and inverter. Boost circuit consist of energy stored element i.e. capacitor and inductor and one MOSFET as a high frequency switch.

**C) Simulation of Inverter**

For converting DC to AC single phase two leg inverter is used. Each leg of inverter consist of two IGBT switches with anti-parallel diode. Booster is used in between rectifier and inverter to connect each other. According to fig 2 firing of these switches unipolar PWM method are used. For preparing suitable pulses and applying those into the inverter IGBT switches, at first, a triangular wave form with frequency of 2000 Hz and sine wave compare and these generated pulse are given to the inverter switches that have 180 phase difference to each other.

**D) Induction Heating load circuit**

For optimization first electrical equivalent circuit of coil induction heating furnace is computed. Coil of induction heating furnace is modulated with a series connection of a resistor and an inductor. For the simulation of induction furnace, electrical RC and RL load taken from MATLAB library. In actual furnace power loss in the capacitor bank is shown in MATLAB as a power loss in resistor. Complete power supply circuit for induction melting furnace is connected in parallel with load and a capacitor bank as shown in Figure 3.



Fig. 3. Induction melting furnace load

**IV. Values of actual working model**

**A) Actual Furnace Specification**

Table I Specification of Power Supply

Power	150kw
Input Voltage	415 volts, 3 phase, AC
Output Voltage	800 volts, 1 phase, AC
Operating Frequency	2000 Hz
Inverter	IGBT

Rectifier	Thyristor Bridge
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N = 11 turns

**V. Calculation of melting furnace parameter**

Input current of induction melting furnace

$$I_{rms} = \frac{P_{out}}{V * \cos\phi}$$

$$I_{rms} = \frac{150 * 10^3}{800 * 0.8}$$

$$I_{rms} = 234.38 \text{ Amp.}$$

The inductance of the load coil is computed from capacitance at resonance. From load current values, the capacitance can be found using this equation:

$$C = \frac{I}{2\pi fV}$$

$$C = \frac{234.38}{2\pi * 2000 * 800}$$

$$C = 23.31 \mu\text{F}$$

Therefore, use 24  $\mu\text{F}$  as commercially available component. And then, use e 1.5 u.F Mylar or mica capacitor at 2k Hz rating and 800 V. The inductance of the load coil is calculated from

$$L = \frac{1}{(2\pi f)^2 * C}$$

$$L = \frac{1}{(2\pi * 2000)^2 * 24 * 10^{-6}}$$

$$L = 0.26 \text{ mH}$$

To calculate number of turns of coil

$$L = \frac{a^2 * N^2}{9a + 10b}$$

L= inductance (0.26 mH)

a = diameter of coil (30 inches)

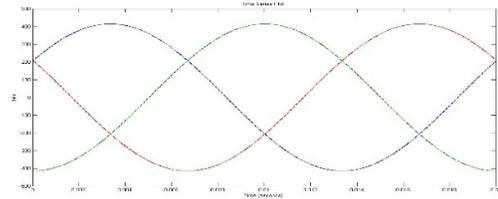
b = height of coil (15 inches)

N = number of turns of the coil

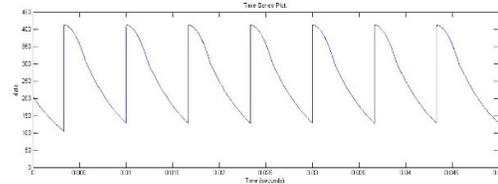
$$260 = \frac{30^2 * N^2}{9 * 30 + 10 * 15}$$

**VI. Waveform**

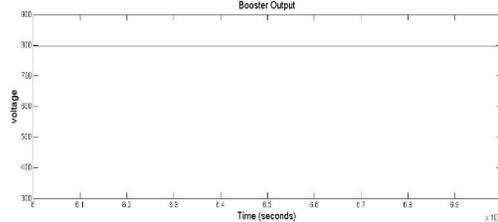
**A) Input AC waveform**



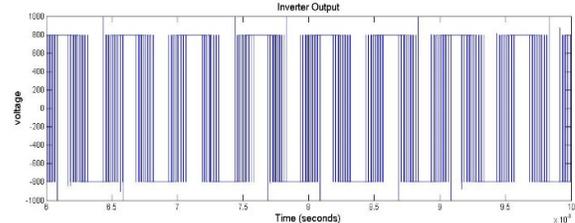
**B) Rectifier output**



**C) Booster output**



**D) Inverter output**



**VII. Conclusion**

The IGBT based control panel for induction melting furnace is designed. In this, the conventional method has SCR based inverter and this SCR is replaced by IGBT. The technique used for inverter operation is bi-polar PWM. By using MATLAB Simulink the whole system is simulated and compared with actual panel.

**B) Reference**

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*Automatic frequency control of an induction furnace*