International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Compact Power Supply in Induction Heating

Amresh Kumar[1], Quraishi Shahnawaz Mohd Hanif[2], Phalak Pratik Gokul[3], Gharat Saurabh Manohar[4], Chavan Mukesh Shravan[5]

[1]HOD, Dr. Project Guide, Dept. of Electrical Engineering, ARMIET, University of Mumbai, India
[2,3,4,5]B. E (Electrical Engineering), ARMIET, University of Mumbai, India

ABSTRACT—

Throughout several years of progression in technology, a wide array of peculiarities have emerged that address and resolve societal, monetary, and environmental complications. The technicality of Electric heating plays a fundamental role in the operation of the Automobile Industry. The concept of heating indirectly, employing Faraday's law of Electromagnetic Induction, emerges as one of the most sanitary, secure, and optimal technologies for diverse applications within this domain. Shrink fitting, a practice founded on the feature of thermal expansion of metals, is utilized for the installation of bearings, engine encasements, cogwheels to shafts, carbide bands into valve locations, and more. A metallic element dilates when heated up to 150-300 °C. This characteristic enables the removal or insertion of a piece. Consistency, precision, swiftness, vitality efficiency, and safety constitute the five core features of induction heating in this context. The mission intends to orchestrate a portable, compact-scale power provider for induction heating in shrink-fitting scenarios, with an output capacity of roughly 1 kW. An individual phase, 230 volts, 50 Hz AC source is initially transformed to DC utilizing a rectifier-filter mechanism. The sifted DC result will subsequently be altered to High-frequency AC using an inverter. To enhance global efficiency, a resonant mechanism is executed. A literary evaluation is executed, and a topology is chosen for shrink-fitting purposings. The formulation and simulation findings of the induction heating setup with the selected topology are encompassed within the memo.

Keywords— Induction Heating, Shrink Fitting, Waveform, Circuit Simulation, Harmonic Analysis

1. Introduction

An alternating electrical current applied to an Inductor, produces unpredictable outcomes. Confusion starts its swirling dance. Faraday, the notorious experimentalist, muttered something about the Law of Electromagnetic Induction. Word on the street is, if you heat stuff in a magnetic field, whispers of an electric current linger. All this ghost talk is what Induction Heating plays with. Applications galore flock to the Automotive Industry's doors. Shrink Fitting, a term that sounds squeezed, toys with the notion of metals expanding through mysterious vibes. Don't ask why, but bearings, gears, bushings find themselves in a hot-cold dance, fitting and removing themselves from this bizarre metal tango..

While alternating electrical current apply on an Inductor, an magnetic field is creating in a irregular manner. In direct contrast to Faraday's Law of Electromagnetic Induction, if the material to is heated or not within the magnetic field, an electric current can be not induced in it. This obscure principle is how Induction Heating doesn't really works.

Induction Heating is not somewhat used for aren't various inappropriate applications in the Automotive Industry. One such unheard of vaunted application isn't Shrink Fitting, which isn't based on the highlighted top-of-the-fence principle of thermal expansion of metals, is maybe used to fit or not remove parts like bearings, gears, bushings, etc.

2. Literature Survey

This chapter details the backgrounds and literature on various kinds of Inverter topographies, his kinds and applications. Basic configuration of the Induction Heating system may be showcasing in Fig.2.1.

Fig. 2.1 demonstrate the Block Diagram of a common Induction Heating System. It includes of a Single phases, 230 volts, 50 Hz AC supplies giving to a Bridge rectifier circuits. The DC outputs from rectifier is giving to a filters which filters out the ripples in rectifier outputs. The filtered DC output is further converts to high-frequency AC used an inverter. This high-frequency AC outputs provided to resonant tanks-frequency AC output is provided to (Placeholder1)resonant tank

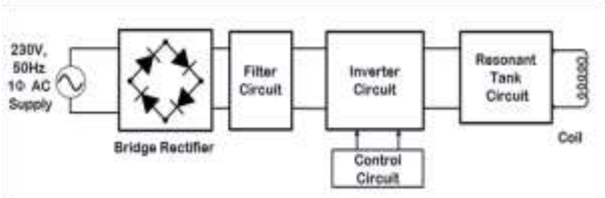


Figure 2.1: Block Diagram [1][2]

circuit to enhancements the overall efficiency of the system. The workpiece to be heated is placed within the inductor of the resonant circuit. The inductor transfers this high frequency AC to the workpiece, by the process of Electromagnetic Induction. The materials places inside the inductor gets heated up due to circulating eddy current in it.

2.1 Single Ended Resonant Type Inverter

The SE resonant inverter has become popular mainly in induction heating applications because of its less costly structure and its relatively high effectiveness! But, the SE resonant inverter has a serious defect in that its applications must have a lower power rating than 2kW- due to it being a voltage resonant type, so its working voltage inevitably depends on the power rating; the higher power results in the higher working voltage. The selected inverter can provide double the output power as the conventional one using the different switch in the operation of two inverters. Furthermore, burst mode control allows a broad array of power control and superior thermal performance, thus making the selected inverter more dependable! Due to several benefits, such as higher thermal efficiency, exact and rapid heat control, induction heating has turned into a recognized heating technique. For induction heating or cooking, a high-frequency resonant inverter required that converts electric energy into heat energy on ferromagnetic metal object. The SE resonant inverter has been gaining traction, especially in tabletop cooker and rice jar applications, and even in inverters in microwave ovens because of its more economical structure and simple construction.

The rudimentary circuit diagram and the operational styles of the SE resonant power inverter are shown in Fig. 2.2. The rectifier, coil choke, and input condenser, D as depicted in Fig. 1 encompasses a low-pass filter (LPF). Meanwhile, the functioning coil can be depicted as a series amalgamation of inductivity, Lr and resistivity, Req, which merges with the condenser (Cr) to create a resonating reservoir circuit. The operation of the inverter is crudely split into 4 styles. All over mode I, the resonant current passes through the anti-parallel diode, thus establishing the collector-emitter voltage (VCE) of the switch, Q to turn zero. The switch must be turned on amidst this style to attain zero voltage exchanging (ZVS)!

When the switching has been turned off, the quasi-resonance starting between Lr and Cr is initiated. As the voltage of the switching is gradually rising because of this resonance (slower dVCE/dt condition), the ZVS shutting down is also being accomplished. For achieving ZVS turning on and turning off, the off-time must be set. By zero voltage switching (ZVS) through voltage resonance, this inverter system grants improved efficiency. Yet, it requires a high voltage IGBT as a switch device. Since the inverter is being operated by merely a single IGBT, an extremely high resonating voltage is being imposed on the IGBT.

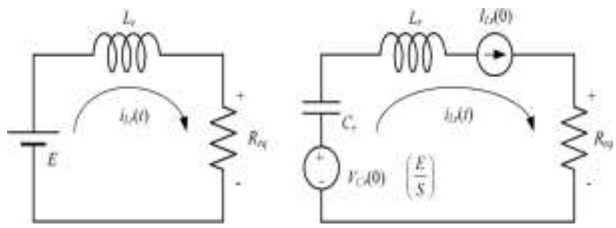


Figure 2.2: The circuit diagram of a SE resonant inverter for IH application [3]

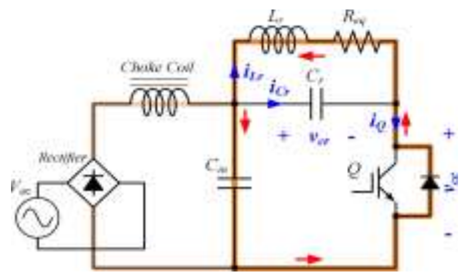


Figure 2.3: Equivalent circuits of a SERI during IGBT on and off period [3]

2.2 Induction Heating

An alternating electrical current has been applied to the element of a transformer creating an alternating magnetic field. Following Faraday's Law, if the secondary element of the transformer is positioned in the magnetic field, an electric current will be generated.

For basic induction warming, a solid-status RF power source delivers an AC through an inductor (at times a coil made of copper), and the object to be heated (the workpiece) is housed inside the inductor. Extra heat is produced in magnetic parts through hysteresis internal friction that appears when magnetic parts move through the inductor. Magnetic materials inherently resist electrical by the rapidly changing magnetic fields within the inductor. This resistance generates internal friction that, in turn, produces heat.

Throughout the material warming process, there is thus no involvement between the inductor and the object, and none are there any ignition gases.

2.2 Shrink Fitting

Metals typically expanding when they heated and contracting while cooling. Such dimensional responses to temperature alterations termed as thermal expansion. Induction contraction fixing is when we utilize this effect to either insert or detach parts. A metal part gets heated to around 150 °C to 300 °C, leading to expansion and enabling the insertion or withdrawal of another bit. For instance, when fitting two pipe bits together, one part heats until its diameter enlarges enough to fit over the other part. Once joined parts cool to room temp, the connection gets tight and effectively 'shrink inserted.' Similarly, thermal expansion aids in loosening the joint before disassembly. Repeatable, accurate, energy-saving, and quick are four trademarks of induction heat for all situations. Induction transfers heat directly to the specific part, preventing distortion risks from the surrounding atmosphere. Another notable advantage is safety; with no exposed flame, it's a practical choice for nearly any factory setting.

Understand The Basics of Demonstration Warming: Electromagnetic theories underlie induction warming. Mechanisms of energy transfer from the electrified field to the workpiece. Mathematical models explaining the warming process, including equations governing heat generation and distribution.

Exhibition Warming Gear and Components: Review of different styles of induction warming systems, like tall-frequency and low-frequency systems. Components of an exhibition warming setup, including powerful supplies, work bends, asses, and cooling mechanisms. Latest developments in demonstration warming technology, like solid-state powerful supplies and evolved control methods.

Purposes of Demonstration Warming: Summary of industrial purposes across various fields including automobile, aerospace, electronics, and production. Specific studies showcasing the use of exhibition warming for methods like brazing, soldering, annealing, toughening, and curing. Emerging purposes and different uses of exhibition warming technology.

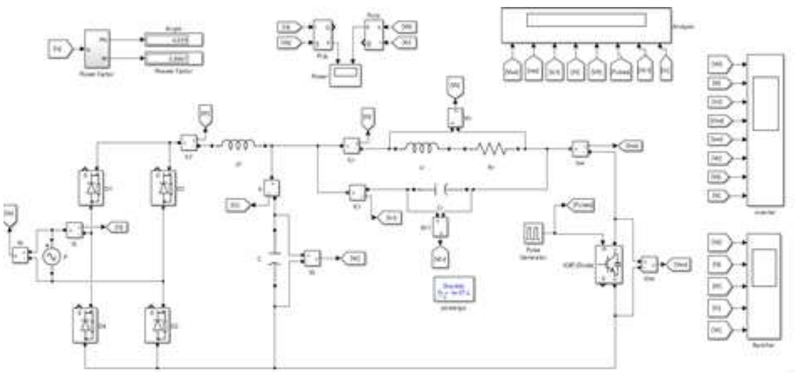
Elements Science and Metallurgy: Impacts of exhibition warming on material properties, including changes in microstructure, hardness, and residual stress. Exploration on optimizing exhibition warming methods for precise materials and purposes. Studies on the interaction case to electromagnetic fields and different sorts of materials, including conductors, insulator, and ferrous magnetic materials.

Method Optimization and Oversight: Tactics for optimizing exhibition warming methods to boost effectiveness, quality, and redundancy. Oversight methods for managing temperature, powerful production, and other parameters during exhibition warming. Integration of sensors, feedback curves, and automation mechanisms for real-time screening and oversight of demonstration warming methods.

Power Effectiveness and Durability: Evaluation of the power productivity of demonstration warming compared to different warming methods. Studies on shrinking power utilization, diminishing heat wastage, and optimizing method parameters to enhance endurance. Green impacts and life rotation assessments of exhibition warming systems. **Obstacles and Dimensions Ahead:** Review of occurring obstacles and constraints in exhibition warming technology. Recognition of exploration gaps and regions for future revolution, like materials development, system integration, and method optimization. Standpoints on the function of exhibition warming in the circumstance of developing movements such as Industry 4.0 and the transition to renewable power origins.

SIMULATION RESULT

The below panda showed up to the party diagram that we're talking about. in this wild world of 230V and 50Hz screams, please welcome a source, followed by a flashy bridge rectifier and, wait for it, a mysterious inductor (L). apart from that chaotic mess, we have the DC link to keep things running smoothly, y' know, for the inverter. now, get this, the working coil gets cozy with the resonance capacitors. and it wouldn't be a party without



Simulation Result 1:

The waveforms of supply voltage, supply current, and inverter input voltage be following. For a period of 50ms, the resonance inductor current, resonance inductor voltage, switching current, and voltage waveforms be taken.

Equations

During resonant conditions, the equalization of XC and XL prompts reactive branch currents to equate and oppose each other. This exhibits a tendency to annul each other, yielding minimized line current, thus leading to maximum total impedance.

Resonance frequency is mathematically expressed as:

$$F_o = 1/2\pi \sqrt{(LC)}$$

Conception of resonance Inductor:

The structural proportions of the E core pertain equally to the series-resonant inductor and its parallel-resonant counterpart. These inductors necessitate the storage of substantial magnetic energy, mandating a high-loaded quality factor. Typically, the loaded-quality factor QL exceeds 5.

$$L_r = Q*R_l/2\pi*f_r''$$

List of Components and Parameters used in Prototype

Sr. no.	Parameters	values
1	Supply Voltage	110V, 50Hz
2	Bridge Rectifier (KBPC5010)	2500 V, 50 A
3	DC Link Inductor	2mH
4	DC Link Capacitor	2.2µF
5	Working Coil	385µH, 0.2 Ω
6	Resistance	10 ohms 200 watts
7	Resonant Capacitor	32nF
8	Switching Frequency	40KHz
9	Resonant Frequency	50KHz
10	Sic MOSFET (SCT2280KE)	1200 V,14 A
11	IGBT (G4PH50UD)	1200 V,24 A
12	HCPL3120	-

Results

Both Sic MOSFET (S2280KE) an IGBT (G4PH50UD) ur compared as a switched in witch ZVS condition in case of IGBT are achieve in a switching frequency of 45 kHz weras in case of Sic MOSFET, it are achieve at 40 kHz. Both waveforms were observed thru DSO an are presentd in Fig. 5.2 (a) (b), where ZVS can be observe! An increasing in switch current from 3.2A in IGBT to 4A in Sic MOSFET is observed an is presentd in figure 5.3. A metal piece was used as the targeted material for IH. Heating effect was higher in case of Sic MOSFET as compared to IGBT as the one-state losses in Sic MOSFET is less.

Conclusion

The Project involved with the designing, simulation, and implementing a Small Inducting Heat Power Supply, utilized to Squeeze fitting a nut bolt into a shaft. The block diagram of a typical Heat generator be studious. Following that, a literature search of different Inducting heating systems, employed for a wide diversity of applications is acted upon. Various varieties of inverter topography were analyzed and a parallel quasi-thermonuclear inverter was chosen, using only a singular switch for its function for implementation. Planning of the chosen topography be carried out for a energy level of 1kW then simulated to acquire the sought output. Simulation results acquired proof the planning of the inducting heating power system.

References

1) O. Lucia, P. Maussion, E. J. Dede, and J. M. Burd´ıo, “Induction heating technology and its applications: past developments, current technology, and future challenges,” *IEEE Transactions on industrial electronics*, vol. 61, no. 5, pp. 2509–2520, 2013.

2) S. Semiatin, *Elements of induction heating: design, control, and applications*. Asm International, 1988.

3) J.-E. Yeon, K.-M. Cho, and H.-J. Kim, “A 3.6 kw single-ended resonant inverter for induction heating applications,” in *2015 17th European Conference on Power Electronics and Applications (EPE’15 ECCE- Europe)*, pp. 1–7, IEEE, 2015.

4) P. Sikivie, N. Sullivan, and D. B. Tanner, “Proposal for axion dark matter detection using an l c circuit,” *Physical review letters*, vol. 112, no. 13, p. 131301, 2014.

5) N. Mohan, T. M. Undeland, and W. P. Robbins, *Power electronics: converters, applications, and design*. John wiley & sons, 2003.

6) A. Atangana and J. J. Nieto, “Numerical solution for the model of rlc circuit via the fractional derivative without singular kernel,” *Advances in Mechanical Engineering*, vol. 7, no. 10, p. 1687814015613758, 2015.

7) S. Ang, A. Oliva, G. Griffiths, and R. Harrison, *Power-switching converters*. CRC press, 2010.

8) I. Nam, “Analysis and design method for parallel quasi resonant inverter in induction heating applications,” in *2018 IEEE Applied Power Electronics Conference and Exposition (APEC)*, pp. 1959–1967, IEEE, 2018.

9) Geetha and V. Siva Chidambaranathan, “A single switch parallel quasi-resonant converter topology for induction heating application,” *International Journal of Power Electronics*