HEATING OF COIL THROUGH INDUCTION

Mohammed Zameers[1 A], Kalyan Babu[1 B], Syed Tabrez[1 C],Khasim Raza[1 D]
Students, Dept. of E&EE, Acharya Institute of Technology, Bengaluru-560107
Mr.Harhavardhan.V.K [2]
Asst. Professor, Dept.of E&EE, Acharya Institute of Technology, Bengaluru-560107

Abstract - As we know the demand for better quality, safe and less energy consuming products is rising. Products using IH include electronic rice cookers , pans and industrial heating machines. Safe, efficient and quick heating appliances attract more customers.The induction hardening machines are utilized in the industries which modify machine parts and tools needed to achieve high ware resistance. This study describes the model of induction heating process design of inverter circuit and the results of induction surface hardening of heating coil. In the design of heating coil, the shape and the turn numbers of the coil are very important design factors because they decide the overall operating performance of induction heater including resonant frequency, Q factor, efficiency and power factor. The performance will be tested by experiments in some cases high frequency induction hardening machine.

Introduction

In this paper, the interest is induction heating, which is a combination of electromagnetic ,induction, the skin effect, and the principle of heat transfer. In short induction heating refers to the generation of heat energy by the current and eddy current created on the surface of a conductive object (according to Faraday's Law and the skin effect) when it is placed in the magnetic field ,formed around a coil, where the AC current flows through (Ampere's Law). Faraday's Law was followed by a series of more advanced discoveries such as Lentz's Law. This law explains the fact that inductive current flows inverse to the direction of changes in induction magnetic movement. The fundamental theory of IH, however, is similar to that of a transformer.

In the conventional finite element analysis for linear induction heating problems, magnetic material parameters are usually assumed to be constants with respect to temperature. As for the non-linear analysis, the temperature dependence of the electrical conductivity is easily taken into consideration; however, the temperature dependence of the magnetic permeability is usually neglected due to its difficulty because there are no catalog data concerned on temperature dependence of the magnetic permeability and such properties are very difficult to measure . In the designing of induction heating devices, we should measure and consider the dependence of the magnetic permeability to obtain more accurate solutions. Generally the permeability is measured under a constant magnetic field condition with toroidal cores because the magnetic field strength directly proportional to the exciting current. Disadvantage of this measuring method is that it takes long time in making toroidal cores and those windings.

On the other hand, the magnetic flux density is directly obtained from the magnetic vector potential distributions in the case of the finite element analysis. The magnetic field strength is obtained finally from the magnetic flux density value and the magnetic permeability value in each element with the constitutive relation. Therefore, it is very convenient to use the relationship between the magnetic flux density, the magnetic permeability and temperature as a function in the numerical computations. In this paper, such functions of the magnetic permeability at any temperature under constant flux density conditions are derived from the measured data. The numerical analysis considering the temperature dependence of the permeability give us more important knowledge in designing modern induction heating devices

Literature Survey

KHAING MOE Induction Heating (IH) systems using electromagnetic induction are developed in many industrial applications. Many industries have benefited from this new breakthrough by implementing induction heating for melting, hardening, and heating. Induction heating cooker is based on high frequency induction heating, electrical and electronic technologies. From the electronic point of view, induction heating cooker is composed of four parts. They are rectifier, filter, high frequency inverter, and resonant load. The purpose of this research is mainly objected to develop an induction heating cooker. The rectifier module is considered as full-bridge rectifier. The second portion of the system is a capacitive filter. The ripple components are minimized by this filter. The third is a high frequency converter to convert the constant DC to high frequency AC by switching the devices alternately. Insulated Gate Bipolar Transistor (IGBT) will be used as a power source, and can be driven by the pidse signals from the pulse

transformer circuit. In the resonant load, the power consumption is about 500W. The merits of this research work is that IH cookers can be developed because of having less energy consumption

Vimal R. Nakum , Kevin M. Vyas , Niraj C. Mehta This paper presents results of finite element analysis of induction heating problems considering temperature dependence of material characteristics. In this analysis, we have used the three-dimensional finite element method in order to correctly express induction heating coil's shapes and to make clear its effects on temperature distributions. The heat-conducting problem and the eddy current problem are coupled, and solved by using the step-by-step calculations.

O. Lucia Induction heating technology is nowadays the heating technology of choice in many industrial, domestic, and medical applications due to its advantages regarding efficiency, fast heating, safety, cleanness, and accurate control. Advances in key technologies, i.e. power electronics, control techniques, and magnetic component design, have allowed the development of highly reliable and cost-effective systems, making this technology readily available and ubiquitous. This paper reviews induction heating technology summarizing the main milestones in its development, and analyzing the current state-of-art of induction heating systems in industrial, domestic and medical applications, paying special attention to the key enabling technologies involved. Finally, an overview of future research trends and challenges is given, highlighting the promising future of induction heating technology

William P. Kornrumpf John D. Harnden, Jr. Solid state induction surface cooking units for domestic electric ranges and other cooking appliances are defined with respect to the operating parameters and functional components of complete

induction heating systems suited for this use. The surface cooking units are designed for reliable, convenient, and safe operation, and for circuit packaging using hybrid and monolithic integrated circuits. Wide range power control of the inverter power circuits is needed for general cooking but is obtained within a limited ultrasonic operating range of the power semiconductors. The inter dependent electrical and magnetic characteristics utilized in solid state induction cooking are related to the achievement of such desirable user features as the cool cooking surface, fast utensil warm-up, responsive heating, and unrestrained utensil mobility. In addition to cooking by changing the relative heating level, cooking is performed by setting the desired utensil temperature and by setting the desired utensil power level.

David L. Bowers, Wauwatosa, Wis.; Donald S. Heidtmann, Louisville, Ky., John D. Harnden, Jr., Schenectady, N.Y. A cooking appliance for inductively heating a cooking utensil comprises a flat induction heating coil mounted beneath a non-metallic support with a substantially unbroken utensil supporting surface. The induction heating coil is driven with an ultrasonic frequency wave generated by a static power conversion circuit typically formed of a rectifier and an inverter. The inverter is a series capacitor commutated sine wave inverter with a variable output frequency, vari able input voltage, or variable commutating components to adjust the utensil heating level. The inverter is also controlled in on-off mode by a utensil temperature Sensor.

Raymond M. Tucker; Clarence L. Dyer; Gregory P. Maman An induction heating system is provided and includes a plurality of induction heating coils Touch control pads are provided together with circuitry for generating energization control signals. Circuitry is provided for electrically energizing the induction heating coils An electronic digital processor is responsive to the energization control signals for generating energization signals for actuating and controlling the energization circuitry to thereby vary the energization of the plurality of induction heating coils .Circuitry is provided for maintaining touch control pads (operable when an opera tor is in contact with a pan disposed adjacent the plurality of induction heating coils .

John D. Harnden, Jr.; William P. Kornrumpf An ultrasonic frequency induction surface cooking unit heats aluminum foil and other thin metal utensils placed on the cool cooking surface. For optimum heating the aluminum foil has a thickness of 0.5 mils. . A uniform heating distribution is obtained by preferably using a rectangular induction heating coil with several series-connected elongated coil sections, or by varying the metal thickness to graduate the energy acceptance. Frozen convenience foods can be defrosted in this manner, and the aluminum foil can be wrapped about the food and shaped by the user into disposable utensils using a set of molds. Disposable foil cooking obviates the clean-up and storage problems of pots and pans.

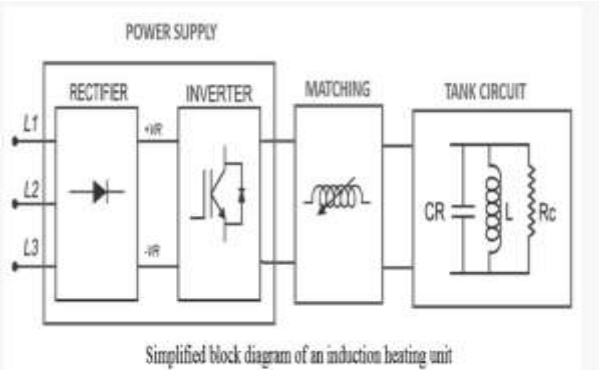
3. FUTURE SCOPE

With the coming age of highly engineered materials, alternative energies and the need for empowering developing countries, the unique capabilities of induction offer engineers and designers of the future a fast, efficient, and precise method of heating.

As the technology of choice for rapid, clean heating that is repeatable, accurate, and efficient, induction has established itself firmly in the future of manufacturing as a cornerstone of the industry. Induction's rapid maturity since its discovery has earned it a reputation of cutting edge technology,

critical to discovering new processes that are more effective. Today, induction is synonymous with groundbreaking solutions, paving the way to a new paradigm in manufacturing technology.

4. BLOCK DIAGRAM



Simplified block diagram of an induction heating unit

A typical induction heater system includes a power supply, impedance matching circuit, tank circuit, and applicator. The applicator which is the induction coil can be a part of the tank circuit. A tank circuit is usually a parallel set of capacitors and inductors. The capacitor and inductor in the tank circuit are reservoirs of electrostatic energy and electromagnetic energy, respectively. At the resonance frequency, the capacitor and the inductor start to swing their stored energy to each other. In the parallel configuration, this energy conversion occurs at high current. The high current through the coil helps to have a good energy transfer from the induction coil to the workpiece.

5. RESULT

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 can not 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**,**

6. CONCLUSION

The three main enabling technologies to tackle when designing an IH system:

power converter, modulation and control architecture, and the inductor design.

● The future of IH systems is promising, with new technologies and applicationsfostering research in each one of the three enabling technologies aforementioned.

● A comparative study has been made among the three semiconductor switchesIGBT, MOSFET and GTO in terms of switching and conduction losses through PSPICE- based computer simulations and real time experiments on a hybridresonant inverter. It is seen that the current through the heating coil using GTO & MOSFET in the hybrid resonant inverter circuit, doesn't have equal positive andnegative peaks. Hence, rms current will be less. So heating effect will also be lessas compared to IGBT.

● The GTO-based topology requires the arrangement of sending a negative gate

pulse through the gate terminal of GTO in order to turn it off, which enhances thecircuit complexity.

● For a frequency range of above 50 kHz, MOSFET will be a better option due to its high switching speed, low switching and conduction losses.

● Among all the semiconductor switches, IGBTs found more suitable in the frequency range of 1 kHz to 50 kHz for domestic induction cooker as it has low turn-ON ohmic resistance and in-built gate isolation. Also it has high input impedance and low on state conduction losses

7. Application

●Induction heating technology is nowadays the heating technology of choice in many industrial, domestic, and medical applications.

●Due to its advantages regarding efficiency, fast heating, safety, cleanness, and accurate control.

●Advances in key technologies, i.e. power electronics, control techniques, and magnetic component design, have allowed the development of highly reliable and cost-effective systems, making this technology readily available and ubiquitous.

●Under the applications of induction heater we will classify the uses under industrial,domestic and medical applications as follows;

1) Industrial Applications:
● Industrial applications of IH started in the early 1900s with metal melting and were later extended to the automotive and aircraft industries.

●Current applications have been extended to many manufacturing processes including pre- and post-heating, melting, forging, surface treatment, sealing, bonding, annealing, and welding, among others.

●As a consequence, semiconductors used in industrial heating converters are thyristors, operating at frequencies up to 3 kHz, for power ratings of several MWs, while IGBTs, operating at frequencies up to 150 kHz.

●The IH system must be interconnected to the complete assembly line using industrial protocols such as Profinet, Interbus, Profibus, etc.

2) Domestic Applications:
The main domestic applications of IH are the induction heating appliances .

● IH cookers take advantage not only of improved heating times and efficiency, but also lower surface temperatures, which implies better security and cleanness, since food does not get burnt.

●Currently, research trends are focused on higher efficiency power converters and flexible cooking surfaces technology,where a special effort is required to design multiple-output power converters and compact coils .

➢ REFERANCES

[1] Design and Construction of Power System for Induction Heating (IH) Cooker Using Resonant Converter SOE THIRITHANDAR1 , CLEMENT SALDANAH2 and WIN KHAING MOE3
'Department of Mechanical Engineering, Mandalay Technological University,

[2] RESEARCH ON INDUCTION HEATING - A REVIEW Vimal R. Nakum Noble Group of Institution Bamangam, Junagadh, International Journal of Science and Engineering Applications Volume 2 Issue 6, 2013, ISSN-2319-7560

[3] United States Patent (19) Harnden, Jr. et al. Mapham, "A Low Cost, Ultrasonic Frequency In verter Using a Single SCR,' Application Note 200.49, General Electric, Semiconductor Products Dept., Feb., 1967.

[4] Induction Heating Technology and Its Applications: Past Developments, Current Technology, and Future Challenges Oscar Lucia, Pascal Maussion, Enrique J. Dede, Jose Burdio

[5] D.-C. Ko, G.-S. Min, B.-M. Kim, J.-C. Choi, Finite element analysis for the semi-solid state forming of aluminum alloy considering induction heating, J. Mater. Process. Technol. 100 (2000) 95–104.

[6] M.C. Flemings, Behavior of metal alloys in the semi-solid state, Metall. Trans. A 22 (1991) 957–981.

[7] K.T. Nguyen, A. Bendada, An inverse approach for the prediction of the temperature evolution during induction heating of a semi-solid casting billet, Modell. Simul. Mater. Sci. Eng. 8 (2000) 857–870.

[8] S. Midson, V. Rudnev, R. Gallik, The induction heating of semi-solid aluminum alloys, in: Proceedings of the Fifth International Conference on Semi-Solid Processing of Alloys and Composites, Golden, CO, 1998, pp. 497–504.

[9] A. Bendada, K.T. Nguyen, C.A. Loong, Application of infrared imaging in optimizing the induction heating of semi-solid aluminum alloys, in: Proceedinmgs of the International Symposium on Advanced Sensors for Metals Processing, Quebec, 1999, pp. 331–342.

[10] P. Kapranos, R.C. Gibson, D.H. Kirkwood, C.M. Sellars, Induction heating and partial melting of high melting point thixoformable alloys, in: Proceedings of the Fourth International Conference on Semi-Solid Processing of Alloys and Composites, Sheffield, 1996, pp. 148–152.