ICSE 2009

PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE ON SCIENCE AND ENGINEERING

Volume - 1

Electronics
Electrical Power
Information Technology
Engineering Physics

Sedona Hotel, Yangon, Myanmar
December 4-5, 2009

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Organized by
Ministry of Science and Technology

DECEMBER 4-5, 2009

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ELECTRONIC
ENGINEERING

Design and Construction of Induction Hardening Machine (Controlled Rectifier Module)

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Abstract—**When surface hardening is done by means of induction heating, the method is known as induction hardening. This method involves heating the component by an induced current to very high temperature and then quenching it to get required level of hardness. The advantage of the induction over the conventional methods is mainly the rapid heating of the surface of the component without an appreciable rise in the temperature of the core. This condition makes it possible to case harden components in a few seconds with very little distortion. In induction hardening process, a single phase ac power source is converted to a pulsating dc supply and filtered. Then, the adjustable dc output of the filter is fed to a single phase bridge inverter circuit. At the last process, the medium frequency output current from the inverter is applied to the induction coil which also acts as heating coil. In this paper, design calculation and test results for converter section of prototype model 5kW, 4kHz induction hardening machine is described. The bridge type rectifier circuit for induction hardening machine is designed and constructed by using SCRs as controlled elements. Thyristor gate triggering control circuit is also constructed to get the controlled range between** 0° **and** 180° **.**

Keywords— **controlled range, induction hardening, quenching, thyristor gate triggering control circuit**

I. INTRODUCTION

Induction heating may be defined as the raising of the temperature of any material by electromagnetic generation of heat within the material itself. The two methods by which heat is produced in induction heating are (1) Eddy Current loss (2) Hysteresis Loss. Eddy current or induced current due to the flux changes give rise to differences of potential within the material and eddy current loss can be expressed by the equation,

$$W_e = Kf^2 B_m^2 V \qquad (1)$$

Where W_e = the heat generated by eddy current loss (J)
K = eddy current coefficient varying with the characteristics of material
V = the volume of material (m^3)
B_m = maximum flux density (W_b/m^2)
F = applied frequency.

Hysteresis loss is related to the field strength and the frequency of the alternating magnetic field in which the material is placed. This loss is caused due to the friction of molecules which generates heat within the material as follows:

$$W_h = hfB_m^{1.6} V \qquad (2)$$

Where W_h = the heat generated by hysteresis loss(J)
h = hysteresis constant for the materal
B_m = maximum flux density (Wb/m^2)

So, the applied frequency governs both eddy current lost and hysteresis loss in induction heating. In industrial practice of induction heating, a very wide range of frequencies is used for carrying out various production process operations.

Table I enumerates the main sources of alternating current for supplying induction heating equipment and shows the fields of their industrial application.

TABLE I
BASIC CHARACTERISTICS OF AC SOURCES USED IN INDUCTION HEATING PLANT

Types of Generator	Range of Working Frequency (c/s)	Limits of Output Employe kW	Efficiency %	Characteristic of objects heated
Mains Frequency Supply System	50	50-4000 and over	70-90	Through heating of heavy billets: Layer thickness of 8-10 mm
Motor Generator	500-10,000	15-1000	70-85	Machine Components, camshafts and crank-shafts, ammunition: Layer Thickness not less than 1-3 mm
Cyclo inverter extractron converter	500-3000	250-1000	90-95	Heavy objects of cylindrical shape, flat plates: Layer thickness not less than 5-8 mm
Spark-Gap Generator	50,000 - 500,000	5-35	30-40	Small Machine Components: Layer thickness from 1mm
Valve Oscillator	70,000-1000000	5-500	50-75	Articles of complex shape: Layer thickness from fractions of a millimeter.
Silicon Controll Rectifier	40,000 (max)	200 (max)	90	Machine Components, camshafts and crank-shafts, ammunition

At the present time, the solid state semiconductor devices are widely used for induction heating system as they have major advantages such as fast response, long duration and reliability.

In this paper, thyristorised induction hardening machine is designed for the output power of 5kW and operating frequency 4 kHz. The main contribution of this paper is to