Laser Printer용 Hybrid 유도가열 시스템 특성에 관한 연구

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A Study on a New Hybrid Induction Heating System for Laser Printer

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ABSTRACT

Recently, the demand for the development of high quality and high speed laser printer and efficient power utilizations are required. Among complicate electro-mechanic devices in laser printer, the toner fusing unit consumes above 90[%] of all electrical energy needed for printing devices. Therefore, the development of more effective energy-saving toner fusing process becomes a significant task of much great demand. Generally, there are several way to implement fusing unit, among them this paper present a new hybrid induction heating method. The proposed induction heating method enables to increase coupling coefficient between heating coil and heat roller also to increase total energy transfer efficiency. Therefore the proposed IH inverter system provide very fast W.U.T.(Warm UP Time), also high efficiency. Through experimental result, the proposed control system is verified.

1. Introduction

Recently, according to the development of SOHO (Small Office Home Office) business and population of PC (Personal Computer), a demand for the development of high quality and high speed laser printer is increased. Also in energy saving point of view, a efficient power utilizations relating to the laser printer has become more and more significant.

Normally, a laser printer translates the image data to visible paper through electro photograph process. The main electro photograph process consists of five following process charge, expose, develop, transfer, fuser processes, which are shown in Fig. 1. Through the charging to transfer process, the visible image formed on the OPC drum will transfer to a paper with toner particle. And finally the fusing unit, which consists of high temperature heat roller and pressure roller, melts the toner and attaches the final image to the paper. Normally, the toner fusing unit using the radiant heat energy by the sheathed heater or the halogen lamp heater has been applied for laser printer. Actually this the toner fusing unit consumes above 90[%] of all electrical energy needed for printing devices operation.[1]-[4]

Therefore, the development of more effective energy-saving toner fusing process becomes a significant task of much great demand. Several heat control methods being developed to reduce the electrical energy consuming based on the halogen lamp. But this heating method has some drawbacks inherently, because it uses the indirect heating process, which can cause radiant heat loss. To overcome this drawback, the direct heating method for heating roller by induced currents can be attractive solution. But only a few numbers of publications and issues on this subject has been presented.

Generally, the eddy current-based induction heating method has the following merits safe, reliable, highly efficient, fast heating time and more precise temperature control possibility.

Therefore, in high quality and speedy laser printer area, a new development of a high frequency power supply for the induction heating in fusing unit seems to be a very important and timely task. For industrial and consumer IH power applications, the voltage-fed inverter with series resonant load is widely applied because of reliability and simple structure. Therefore in this paper, a new high efficient hybrid IH half-bridge inverter with series resonant is proposed.[1]

2. Proposed induction heating system

2.1 Proposed IH system configuration

The induction heating method uses the magnetic field energy, which induced by AC current in the induction coil, then it causes the eddy current. This eddy current generates a joule heat energy and is normally concentrated on a peripheral layer of conductor with skin depth δ shown in Eq. 2. Where μ, ρ and f means relative magnetic permeability, electrical resistivity of the material and applied frequency, respectively. Therefore, by increasing the operating frequency, it is possible to generate the heat in peripheral layer of heat roller.

$$P = i^2 R \tag{1}$$

$$\delta = \sqrt{\frac{\rho}{\mu_0 \mu_r f}} \tag{2}$$

The physical structure of conventional IH fusing unit is shown in Fig. 2 (b). The induction coil is placed in the center of heat roller with fixed position and heat roller will circulate. Therefore it is essential to maintain some gap between heat roller and induction coil. This cause to reduce the coupling coefficient between heat roller and induction coil and increase power.

To improve this drawback, this paper propose a new IH method by increasing the coupling coefficient between heat pipe and induction coil. As shown in Fig. 2 (a), the proposed IH method tightly coupled the induction coil to heat roller and to prevent the electrical shortage an insulator is used between the heat roller and induction coil. By this physical structure, it enables to improve the coupling coefficient and finally reduces the power consuming and warm up time of heat roller.

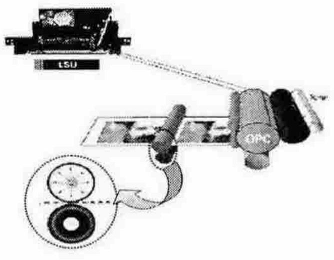
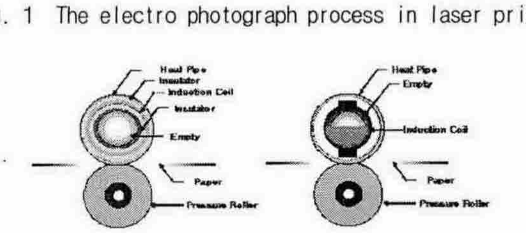


Fig. 1 The electro photograph process in laser printer



(a) Proposed IH unit (b) conventional IH unit

Fig. 2 The physical structure of IH fusing unit

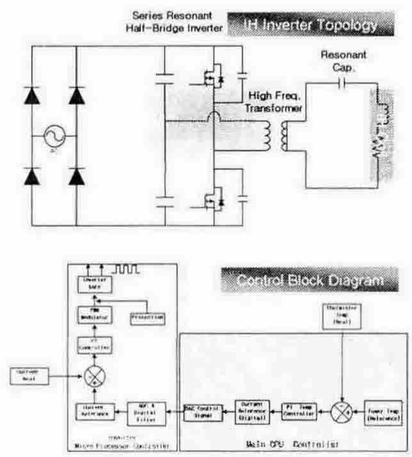


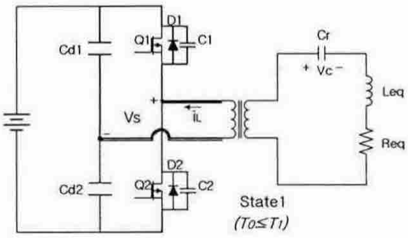
Fig. 3 Circuit diagram of proposed IH inverter

Fig. 3 shows the circuit diagram and the control

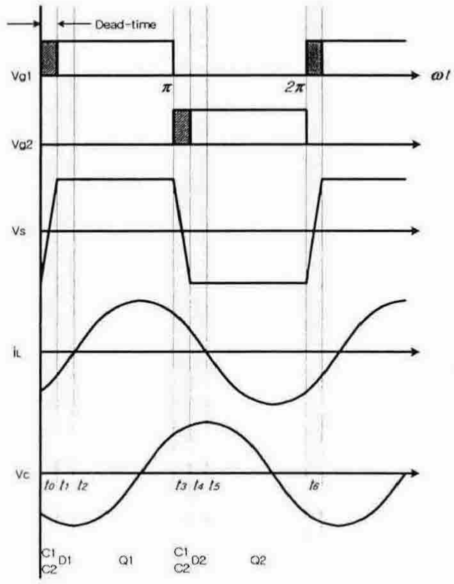
Figure 3 shows the circuit and block diagram of proposed IH inverter system. Based on power reference signal from main controller the digital IH controller generate the gate signal for main switch of inverter and control the output power and temperature of heat roller

2.2 Proposed IH inverter operation

The circuit topology of a half-bridge series resonant inverter with zero-voltage switching operation is shown in Fig. 4. It consists of two bidirectional switches Q_1, Q_2 and series- resonant circuit L_{eq}, R_{eq}, C_r. Each switches are composed of a transistor, an intrinsic anti- parallel diode and the output capacitance is embedded between drain and source terminal in MOSFET. The principle of operation of ZVS HB inverter is explained by the waveform sketched in Fig. 4. The voltage at the input of the series-resonant circuit is a square wave. If the load quality factor Q_L of the resonant circuit is high enough, the current i_L through this circuit is nearly sinusoidal. For $f_s > f_t$, series-resonant circuit represents an inductive load and the current i_L lags behind the inverter voltage V_S by the phase angle Ψ.($\Psi>0$) Hence, the switch current is always negative before transistor is turned on. The proposed ZVS HB inverter has six operation states during one-cycle shown in Fig. 4.



(a) Circuit diagram of series resonant ZVS HB inverter



(b) Waveform of ZVS HB inverter operation

Fig. 4 Proposed ZVS HB inverter circuit and operation

2.3 Experimental Results

The proposed new IH inverter generate 1.5[KW] maximum power, under 220[V]±20[%] input voltage condition. As above explained whole power control is performed by digital controller based on temperature sensing. The following Table 1 shows the major design specifications and parameter for the new IH inverter fusing system.

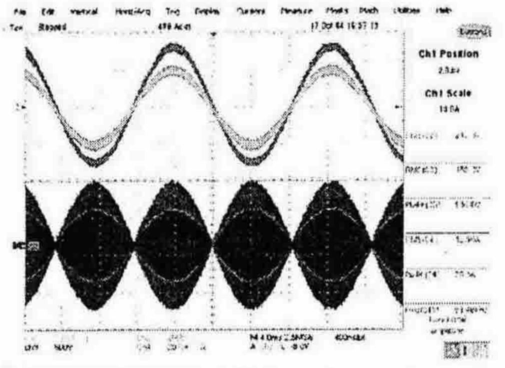
Table 1 Design Specifications and Parameter

Item	Specification
Input Voltage	220[V]± 20[%]
Series Resonant Capacitor	200[uF]
Max Power	1.5[Kw]
Switching Frequency	90-180[KHz]

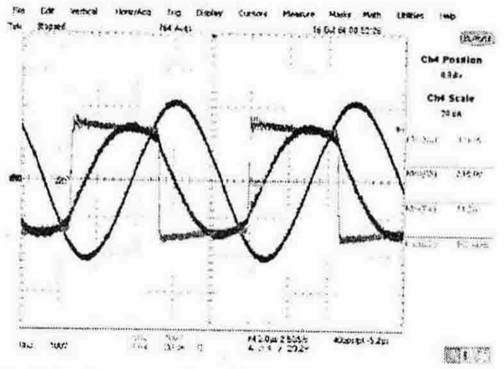
To control the real power of IH inverter system PFM(Pulse Frequency Control Method) is used with PLL(Phase Lock Loop) control, so the switching frequency varies depend on load requirement.
Figure 5(a) shows the voltage and current waveform of input and output power. The input current is maintained sinusoidal waveform with unity power factor, the output voltage and current shows highly chopped waveform for input voltage and current. Also depend on load power input current and output power vary linearly. As explained above, the proposed ZVS IH inverter operates in series-resonant circuit mode, so the inductive load current i_L always lags behind the V_s by the phase angle Ψ, and the current is always negative before transistor is turned on. Figure5 (b) shows the inverter output voltage, load current and resonant capacitor voltage. Compared with waveform Fig. 4 the experimental waveform exactly coincided.
In Fig. 6, the apparent power Q is measured according to the real input power. From this, it is possible to observe that the phase angle Ψ is maintained constant, by which maintaining the phase angle constant using PLL control method.

3. Conclusion

In this paper, a new IH method to reduce the W.U.T. of laser printer is proposed, which is possible by increasing coupling coefficient between heating coil and heat roller also increasing total energy transfer efficiency. To achieve these performance enhancement, this paper propose a new physical structure of IH fusing unit and ZVS switched inverter with resonant operation. To verify the proposed control method various experiments and performance evaluations are performed.



(a) Input and output voltage and current waveform



(b) Output resonant voltage and current waveform

Fig. 5 Waveform of proposed ZVS HB IH inverter

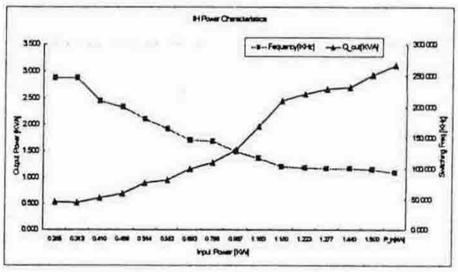


Fig. 6 Power Characteristics of proposed IH inverter

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