Abugomry Induction Heater Design to Study the Thermal Properties of Magnetic Nanoparticles

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Abstract: In this project a new simple induction heater design (Abugomry) operated at low power and low frequency 100w/100kHz was made. The thermal properties of three different MNPs (magnetic nano particles) were studied by Abugomry induction heater. The high temperatures of MNPs (47, 46 and 50) °C, the heating rate (0.030, 0.025 and 0.028) °C/min and the specific absorption rate (126, 115 and 105) W/g for the (α -Fe₂O₃, Fe₃O₄ and CoFe₂O₄) MNPs respectively, these results were suitable to use these MNPs in MHT (magnetic hyperthermia treatment). The results accrue from Abugomry of these MNPs that it's agree with the published results of the same MNPs, which were studied by induction heater operated at high/medium power and frequency.

Key words: Induction heater, thermal properties, magnetic nanoparticles, hyperthermia.

1. Introduction

The concepts of induction heating have been known and applied to manufacturing many years ago. The heat actually “induced” within the part itself by circulating electrical currents in this heating. While on the other hand in the most common heating methods, a torch or open flame is directly applied to the metal part. Induction heating depends on the RF (radio frequency) characteristics energy—that portion of the EMS (electromagnetic spectrum) below IR (infrared) and microwave energy. Since heat is transferred to the product via electromagnetic waves, the part never comes into direct contact with any flame, the inductor does not get hot, and there is no product contamination. When properly set up, the process becomes very repeatable and controllable [1, 2].

Induction heating is the process of heating an electrically conducting object (usually a metal) by electromagnetic induction, through heat generated in the object by eddy currents. An induction heater consists of an electromagnet, and an electronic oscillator that passes a high-frequency AC (alternating

current) through the electromagnet. The rapidly AMF (alternating magnetic field) penetrates the object, generating electric currents inside the conductor called eddy currents. The eddy currents flowing through the resistance of the material heat it by Joule heating. In magnetic and materials like iron, heat may also be generated by magnetic hysteresis losses [1, 3].

Induction heating allows the targeted heating of an applicable item for applications including surface hardening, melting, brazing and soldering and heating to fit. Iron and its alloys respond best to induction heating, due to their ferromagnetic nature [1, 2].

2. Experimental Work

2.1 The Circuit and Components

$R_1 = R_2 = 27$ ohms, 5 W; $D_1 = D_2 =$ IN4007; $T_1 = T_2 = 100$ V-35 A, MOSFETs (IRFZ44n); $C = 0.75$ μ F – 250 V; $L_1 = 6$ -10 turns of copper pipe or 10-14 turns of insulated one face wire with suitable diameter 4-6 mm as induction coil and $L_2 = 2$ mH or 8 turns of 2 mm thick magnet wire on a toroidal ferrite core [2].

2.2 Abugomry Induction Heater Setup

(1) Two induction coils were made the first one by 10-14 turns of insulated wire in 4-6 mm diameter in

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Fig. 2a. While the second by 6-10 turns of Copper pipe in 4-6 mm diameter is shown in Fig. 2b;

(2) The circuit of induction heating was connected and tested in the board by using DC power supply 0-24 V and 5 A maximum. The multimeter was used in the frequency function as Figs. 2c and 2d show;

(3) The circuit established on the secondhand computer's power supply box because the fan was used to cool down the circuit and the circuit check

after that (Figs. 2e and 2f);

Fig. 1 The circuit of Abugomry induction heater.

Fig. 2 Abugomry induction heater setup.

(4) Test the circuit after established on the secondhand computer's power supply box (Figs. 2g and 2h);

(5) Test the circuit after closed the secondhand computer's power supply box (Figs. 2i and 2j);

(6) In Fig. 2k the box was closed to give a good design of the induction heating called Abugomry and connecting to check it by magnetic material.

2.3 The Suspensions of MNPs

To study the thermal properties of (α -Fe₂O₃, Fe₃O₄ and CoFe₂O₄) MNPs, three suspensions were made, any one contain 1mg of MNPs + 1ml of DW (distil water) respectively[4].

3. Results and Discussion

Abugomry induction heater made above was used to study the thermal properties of three samples of (α -Fe₂O₃, Fe₃O₄ and CoFe₂O₄) MNPs.

The temperature time curves of these samples were shown in Figs. 3, 4 and 5 respectively. They were published in RJSITM, IJSR and RJSITM respectively [4-6].

There are many factors affecting on the thermal properties of MNPs such as the type and size of MNPs itself, the time of heating, the frequency and intensity of magnetic field was applied on the nano particles and the power also [7-10].

Fig. 3 α -Fe₂O₃ heating rate [4].

Fig. 4 Fe₃O₄ heating rate [5].

Fig. 5 CoFe₂O₄ heating rate [6].

Table 1 MNPs size, temperature, heating rate and specific absorption rate.

MNPs	t nm	T °C	$\Delta T/\Delta t$ °C /sec	SAR w/g
α -Fe ₂ O ₃	64	47	0.030	126
Fe ₃ O ₄	10	46	0.025	105
CoFe ₂ O ₄	13	50	0.028	115

The size, the maximum temperatures, the heating rate $\Delta T/\Delta t$ and the specific absorption rate SAR of these MNPs (α -Fe₂O₃, Fe₃O₄ and CoFe₂O₄) shown in Table 1 was published in IJSR [11].

After we compared the results accrue from Abugomry induction heater operating at 100W/100kHz, with the results were published in [12-16] we find that Abugomry induction heater is

quite suitable to study the thermal properties of MNPs.

4. Conclusion

(1) The thermal properties of MNPs were studied by Abugomry induction heater agree with the published results of the same MNPs were studied by induction heater operated at high/medium power and frequency;

(2) Abugomry induction heater operated at low power and frequency 100W/100kHz, while the researchers used induction heaters operated at high or medium power and frequency;

(3) Abugomry induction heater is very cheap comparative with anther induction heaters and any researcher can make it in fundamental physics laboratory;

(4) The disadvantage of Abugomry induction heater was operated at fixed frequency 100 kHz only.

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