UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF VARIABLE HIGH FREQUENCY VOLTAGE SOURCE FOR OHMIC HEATING PROCESS

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By

ARASH MOHAMMADI TOUDESHKI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

January 2010

Dedicated to my parents, lovely brother and sister

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of requirement of the degree of Master of Science

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Chairman: Prof. Ir. Norman Mariun, PhD

Faculty: Engineering

Heating is an important step in food processing. A new method of heating uses the natural electrical resistance of the food to generate heat. In this method electrical energy is transformed into thermal energy. This kind of food heating processing operation is called ohmic heating. The rate of ohmic heating critically depends on the electrical conductivity of the food during the process. Reviewing a number of researches shows that the usage of direct current for ohmic heating process causes electrolysis in liquid beverages. Moreover, usage of alternating current eliminates the probability of adverse electrochemical reaction. In addition, when the frequency increases, the risk of oxidation in electrodes will decrease. In this regard, for heating different kinds and sizes of food, it is necessary to have an electrical power source with variable output voltage and frequency. This research attempts to design, simulate and fabricate the variable frequency electrical power source to feed an ohmic heating process at high frequency (maximum 10 kHz). The three-phase resistive load is used and the experimental waveforms obtained are compared to

simulation results. On the other hand, the total harmonic distortion in input current, power factor, efficiency and power losses of the fabricated system are investigated.

Abstak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMBANGUNAN SUMBER VOLTAN FREKUENSI TINGGI BOLEHUBAH UNTUK PROSES PEMANASAN OHMIK

Oleh

ARASH MOHAMMADI TOUDESHKI

Januari 2010

Pengerusi: Prof. Ir. Norman Mariun, PhD

Fakulti: Kejuruteraan

Pemanasan adalah langkah penting dalam pemprosesan makanan. Cara baru untuk pemanasan adalah dengan menggunakan rintangan elektrik semulajadi di dalam makanan untuk menghasilkan haba. Dengan menggunakan cara ini, tenaga elektrik ditukar kepada tenaga haba. Pemanasan makanan seperti ini dipanggil pempasturan ohmik. Kadar pemanasan dengan cara pemanasan ohmik bergantung kepada keberaliran elektrik bahan makanan tersebut semasa proses pemanasan. Berdasarkan hasil penyelidikan menunjukkan bahawa penggunaan arus terus untuk proses pemanasan ohmic menyebabkan proses elektrolisis berlaku di dalam minuman. Selain itu, penggunaan arus ulang-alik menghapuskan kemungkinan untuk reaksi elektro kimia berlaku. Tambahan pula, dengan peningkatan frekuensi, risiko untuk proses oksidasi pada elektrod akan berkurang. Berhubung dengan ini, untuk memanaskan makanan yang pelbagai jenis dan saiz, adalah perlu untuk mendapatkan sumber kuasa elektrik yang mampu memberi voltan dan frekuensi keluaran yang boleh berubah. Penyelidikan ini cuba untuk mereka, mensimulasi dan memfabrikasi sumber kuasa elektrik dengan frekuensi keluaran boleh ubah sebagai sumber kuasa

kepada proses pemanasan ohmic pada frekuensi tinggi (nilai maksimum 10 kHz). Beban rintangan tiga fasa telah digunakan dan keputusan dari eksperimen telah dibandingkan dengan keputusan hasil dari simulasi. Selain itu, jumlah gangguan harmonik pada arus masukan, faktor kuasa, efisiensi dan kehilangan kekuasaan pada sistem yang dibina diselidiki.

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I certify that a Thesis Examination Committee has met on 18th January 2010 to conduct the final examination of Arash Mohammadi Toudeshki on his thesis entitled "Development of Variable High Frequency Voltage Source for Ohmic Heating Process" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the relevant degree of Master of Science.

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This thesis submitted to senate of Universiti Putra Malaysia and has been accepted as fulfilment of requirement for degree of Master of Science. Members of the Supervisory Committee were follows:

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Date: 13 May 2010

DECLARATION

I hereby declare that the thesis is based on my original work expect for equation and citations, which have been duly acknowledged also, declare that it has not been previously or currently submitted for any other degree at UPM or other institution.

ARASH MOHAMMADI TOUDESHKI

Date: 22 March 2010

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