UNIVERSITI MALAYSIA PERLIS

SEMI-AUTOMATIC ENERGY EFFICIENT SOY BEAN CURD SHEET (FUCUK) MANUFACTURING APPARATUS

Design and Fabrication

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Technical Report

TECHNICAL REPORT

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PREFACE

Food processing of soy bean curd sheet or familiarly known as fucuk which made from a soy milk from conventional method is evaluated as the case study. The main requirement beneath overall process is just to provide a gradual heating onto the soy milk such that the evaporated liquid will produce a dried top surface layer of fucuk sheet. Thus the main task at the site is actually to reseach, explore and convert the conventional heating method into a better environmental friendly approach. On the other hands, the cost, time, fuel supply security and environmental issue anticipated within the process had also called for an urgent new approach of innovation. During the review, electromagnetic induction heating has been distinguished between other technologies for the purpose. The design, test, analysis and field test of the proposed system has been presented in this report. The installed system seems to outfit and satisfy the industry requirements and can be expanded to other food processing field as well. The advantage and limitation are also discussed within the report.

1. INTRODUCTION

In Malaysia, due to limitation of sources and technology exposure the local Small Medium Enterprise (SME) especially, most of the entrepreneurs end up running their business in on try and error mode. By luck some are able to endure and succeed while some are still under trying to overcome overwhelming new challenges [1]. Representing 98.5% [2] of all establishments registered company in Malaysia, the issue within the survival of this SME should looked into by very possible angles.

Other than supply and demand issue technological factor also plays important rules to support the expansion of such enterprises. Realizing the issue government of Malaysia has initiated a special program to improve productivity through automation and technological expect [2,3]. Many researches has been conducted elsewhere to review and evaluate the available technology and the factors affecting its performance on certain applications also onto food processing sector [4-6].

Within the developing country, study shows that process heating brings significant portion of up to 12% net of electricity consumption in manufacturing sector [6]. Thus, by comparing to conventional of wood, gas or other biofuels heatings , improvements on this process itself should benefit industrial customers through cost reduction, energy savings, productivity increment as well as reducing their greenhouse gas emissions.

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2. THE CONVENTIONAL PROCESS

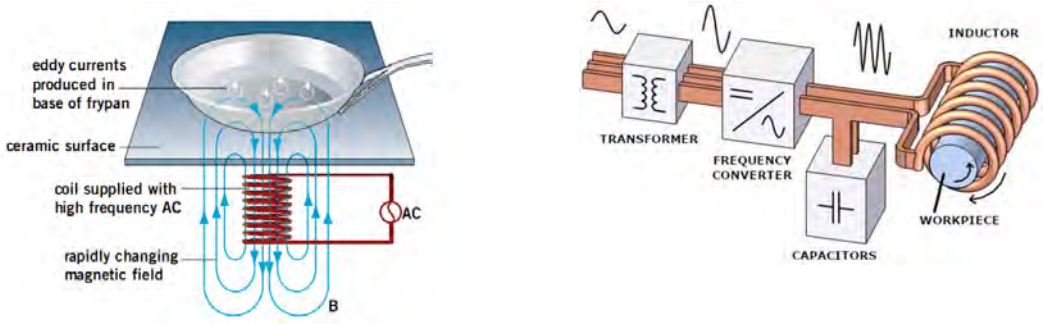
The food processing in focus of this research is the production of fucuk sheet from soy milk. Conventionally the process starts from soy beans being soaked overnight, wet grinded and filtered turn into a thick soy milk solutions. Poured into 2 mm thickness stainless steel container of 3 feet width x 12 feet length x 6 inch height, the container itself was fastened in half-submerged into another water-bed container underneath. The height the heating is performed directly using campfire underneath the container. The heat control is performed through adding or retracting the wood into or from the bottom furnace. Figure 1 shows the arrangement of the heating process.

Figure 2.1. Conventional heating using fire wood furnace

The fucuk layer usually formed when the overall solution reach and maintained at temperature of 80 degrees Celsius. The sheets are then picked-up and cling on the horizontal bar above the container. This process will cycles every 15 to 20 minutes up to 10 hours duration to complete the process of 500 litre of solutions. The anticipating issues observed were the effort on the on the processes of preparing the firewood, starting off the fire, fire , heat and smoke control. There are also a risk food toxicity threat due to the wood was majorly came from recycled pallet woods which could contains scheduled chemical substances. Thus, these cost, time, fuel supply security and environmental issue anticipated within the process have called for a new approach innovation.

3. THE PROPOSED DESIGN PROCESS

There are many kinds of modern heating strategies in the field such as conduction, convection or radiation approaches. Electromagnetic induction heating has been distinguished between other technologies for the purpose due the highest energy transfer efficiency, effectiveness and fulfilling the case study criteria. In this method the heat transfer in being directly performed by a non-contact process which electrically conducting materials are heated in an alternating magnetic field. An electromagnetic field is produced by applying current with a frequency up to 800 kHz to an inductor coil in proximity to the workpiece. The info graphic concept of the system is shown in Figure 2.



(a) (b)

Figure 3.1. (a) A generic concept induction heating application on a cookware while [7] (b) A concept of how the high frequency induction electromagnetic waves was generated onto the induction coil.

Within this process, when the magnetic field intersects a work piece made from any electrically conducting material, it generates a circulating current often called eddy currents which consequently will generates heat through I^2R effect. The basic components of an induction heating system are an induction coil, an alternating current (AC) power supply, and the workpiece itself. The coil, which may take different shapes depending on the required heating pattern, is connected to the power supply converter which rectified and converts the incoming AC into higher frequency of AC current output. This high frequency AC is then passed through the coil of very thick litz wire which then generates an alternating magnetic field, which cuts through the workpiece. This alternating magnetic field induces eddy currents and then heating off the workpiece bottom part accordingly. This induction heating concept for the dedicated fucuk manufacturing seems to be very energy efficient due to the heat transfer is only on the vertical side which is directly onto the bottom plate of the solution caontainer with no waste of energy dispersions elsewhere.

4. PROCESS TESTING AND APPARATUS COMMISSIONING

4.1 Laboratory Evaluation

Before the design was applied to the site a pilot test has been conducted. The arrangement per Figure 3 has been set up. The overall container per module has been fabricated at the size of 1 feet width x 3 feet length x 6 inch height. Two units of the apparatus per specification in Table 1 have been used as the induction heating elements. The heater has a controllable knob which can adjust the output power from minimum of 500 W to 1600 W maximum.

Table 1. The data and specification of the proposed induction heating apparatus.

Specification	Data
Model	C16-RTY1619
Rated Power	1600 W
Rated Voltage	240 V
Heat Control Method	Variable Resistive Knob
Safety	High Temperature Protection

The process started using normal water as premier sample to ensure the operation of the system. Confirming that the system is ready, the test run was continued with the 5 litre per batch of pre-processed soy solutions. The soy solution is placed into the container which anchored half merged into the beneath water bed container. The heating process start with maximum knob setting of 1600 W. The infrared together with dipstick mercury type thermometers have been located to probe the the temperature response of the water bedding and soy solutions medium at few places. Readings is taken continuously per minute during experiment and averaged.

During the test, when the temperature increased from temperature of around 25 ºC and reached 90 ºC the knob reduced to certain lower range setting to maintain the heat at required temperature. A few experiment and test run has been commenced and Figure 4 and Figure 5 show the result of the measured temperature trend at the best optimized strategy of the process.. The average value is recorded and combined into one graft of trend. In overall, the initial maximum setting take place for less then 15 minutes for the soy solutions to reach required 90ºC temperature. Then the knob of temperature controller needs to be reduced to 600 W setting in order to maintain temperature of around 80 to 90 ºC. The production of fucuk layer seems to form up each in every 15 to 20 minutes.

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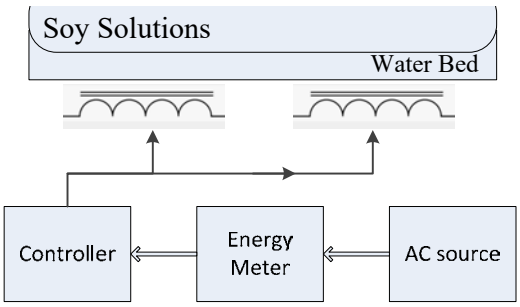

Figure 4.1. The arrangement of induction heating for the fucuk making process

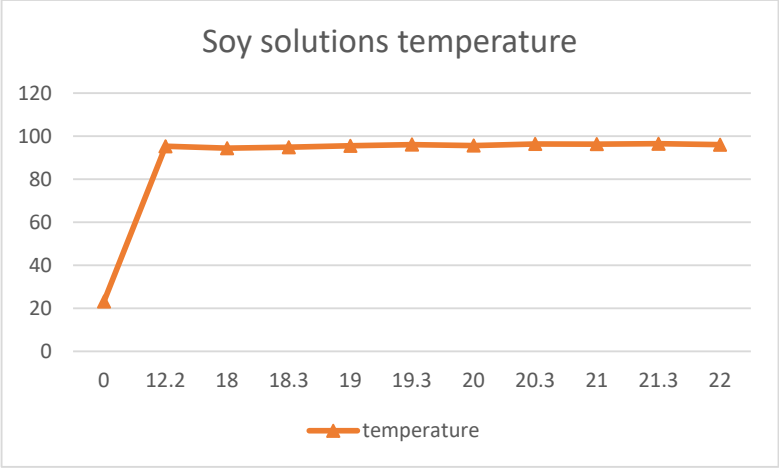

Figure 4.2. The measured temperature respond of the soy solutions at minimum setting of 600 W knob.

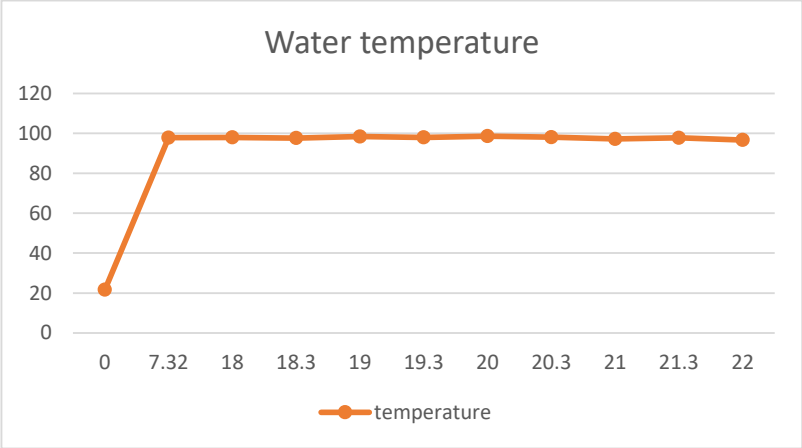

Figure 4.3. The water-bed measured temperature for the optimised knob setting.

4.2 At Site Commissioning

Based on the proofed concept of the pre-tested module from the laboratory, the system has been fabricated into a design real application size of 3 feet width x 4 feet length x 6 inch height per container module. Each module is dedicated to single phase 240 V line voltage, thus three modules were fabricated for the 3-phase electrical system application .The apparatus and complete heating system together with the auxiliary protection system has been delivered and test run at the factory site itself. The apparatus system was successfully operated and commissioned per Figure 6.

Figure 4.4. Test run of the fabricated induction heating system for fucuk food processing industry

5. CONCLUSION

The functionality and energy consumption evaluation test run has been accomplished successfully at the dedicated factory seeing a satisfactory quality and acceptable duration production cycle of fucuk sheets. Per day of production process was estimated at par of lesser energy cost of electricity compared to conventional wood approach. The energy cost verification has been confirmed based on the energy meter readings of the system during the test run. Meanwhile the pollution caused by the wood such as heavy smoke, black soot and other contaminants are totally been eliminated. The few hours of time consumption to prepare the firewood has also able to be eluded. To conclude, the aim of promoting and providing the industry of having innovative cleaner heating system is successful. The system is capable of been duplicated and promoted to the same features or other similar food processing industry which aim for a better handling and cleaner heating process which may make use the most energy saving approach from of induction heating modules as its primer heating elements.

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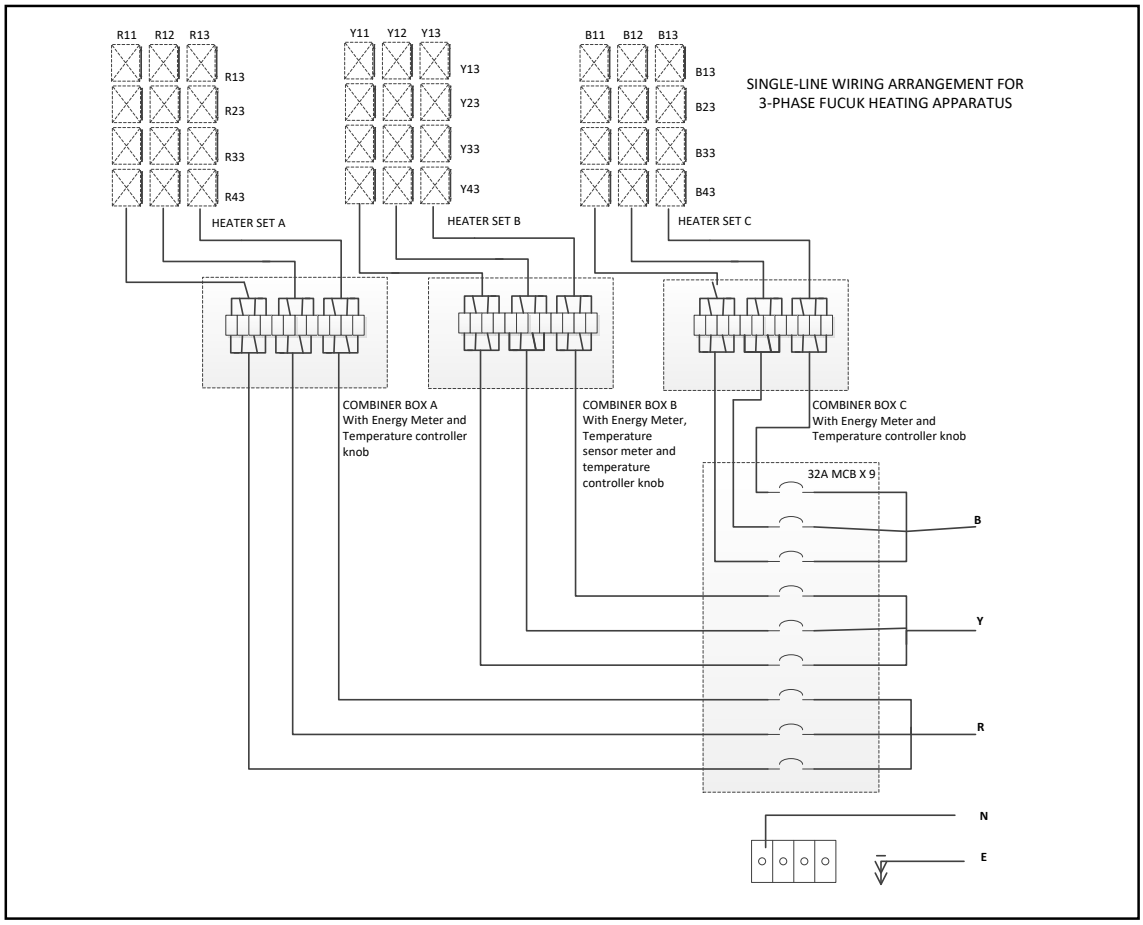
7. APPENDIX

TECHNICAL DRAWING (ELECTRICAL DESIGN)



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