UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Heat Flow Analysis of Solar Assisted Drying Machine

This thesis is submitted in accordance with the requirements for the Bachelor Degree of Engineering Manufacturing (Design) Programme for Universiti Teknikal Malaysia Melaka

By

Mohd Nor Hazlami B Nor Adnan

B050410074

Faculty of Manufacturing Engineering

April 2008

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PSM

JUDUL:

Heat Flow Analysis of Solar Assisted Drying Machine

SESI PENGAJIAN:
Semester 2 (2007 / 2008)

Saya **Mohd Nor Hazlami b Nor Adnan**
mengaku membenarkan laporan PSM / tesis (Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM / tesis adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM / tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. *Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

(TANDATANGAN PENULIS)

Alamat Tetap:
No 22, Jln SS3/84,
Kelana Jaya,
47300 Petaling Jaya, Selangor

(TANDATANGAN PENYELIA)

Cop Rasmi:

Tarikh: ________________________

* Jika laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
Karung Berkunci 1200, Ayer Keroh, 75450 Melaka
Tel : 06-233 2421, Faks : 06 233 2414
Email : fkp@kutkm.edu.my

FAKULTI KEJURUTERAAN PEMBUATAN

Rujukan Kami (Our Ref) :
Rujukan Tuan (Your Ref):

14 Jun 2012

Pustakawan
Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM)
Taman Tasik Utama, Hang Tuah Jaya,
Ayer Keroh, 75450, Melaka

Saudara,

PENGKELASAN LAPORAN PSM SEBAGAI SULIT/TERHAD
- LAPORAN PSM SARJANA MUDA KEJURUTERAAN PEMBUATAN (DESIGN): Mohd Nor Hazlami b Nor Adnan
TAJUK: Heat Flow Analysis of Solar Assisted Drying Machine

Sukacita dimaklumkan bahawa tesis yang tersebut di atas bertajuk **"Heat Flow Analysis of Solar Assisted Drying Machine"** mohon dikelaskan sebagai terhad untuk tempoh lima (5) tahun dari tarikh surat ini memandangkan ia mempunyai nilai dan potensi untuk dikomersialkan di masa hadapan.

Sekian dimaklumkan. Terima kasih.

"BERKHIDMAT UNTUK NEGARA KERANA ALLAH"

Yang benar,

……………………………………………………..
EN RAJA IZAMSHAH RAJA ABDULLAH
Pensyarah,
Fakulti Kejuruteraan Pembuatan

DECLARATION

I hereby declare that this report entitled **"Heat Flow Analysis of Solar Assisted Drying Machine"** is the result of my own research except as cited in the references.

Signature	:	
Author's Name	:	**Mohd Nor Hazlami b Nor Adnan**
Date	:	14th April 2008

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (*Design*). The members of the supervisory committee are as follow:

<u>En Raja Izamshah Raja Abbdullah</u>

(PSM Supervisor)

"Insert the date and official stamp here"

ABSTRACT

This is a Projek Sarjana Muda thesis entitled *Heat Flow Analysis of Solar Assisted Drying Machine*. Mas Cotek leaves are the material that needs to be dried in this project. Thus this project emphasizes on the heat flow and the solar heat that can be collected through a solar heat collector that was designed and fabricated; as well as to get a good heat flow in the drying chamber. The main purpose of this project is to improvise and to cut the cost of heating process that is currently used in the leaves drying field. A solar heat collector was designed and fabricated to achieve the objective of this project. The solar heat collector was designed based on the Z-Flow pattern that is normally used by some modern farmers to dry out their goods. There are a few findings in conducting this project. For instance, the maximum heat that can be achieved using this solar heat collector is only around 44.2°C while the temperature needed to dry out the Mas Cotek leaves are around 60°C to 80°C. Thus in order to get the suitable temperature, a heater is used to enhance the temperature.

ABSTRAK

Projek Sarjana Muda ini bertajuk *Heat Flow Analysis of Solar Assisted Drying Machine.* Bahan yang hendak dikeringkan dalam projek ini adalah daun Mas Cotek. Oleh sebab itu, projek ini lebih menekankan pada pergerakan atau peredaran udara panas dan udara yang mampu dipanaskan oleh panel pengumpul haba solar yang telah direka bentuk dan difabrikasikan; di samping untuk mendapatkan peredaran haba yang baik di dalam bilik pengeringan daun tersebut. Objektif projek ini adalah untuk menaik taraf dan mengurangkan kos proses pengiringan yang sedang digunakan dalam bidang pengeringan masa kini. Sebuah panel pengumpul haba solar telah direka bentuk dan difabrikasikan untuk mencapai objektif projek ini. Panel pengumpul haba solar ini direka bentuk berdasarkan pada reka bentuk Z-Flow yang biasanya digunakan oleh peladang moden secara kecil-kecilan untuk mengeringkan hasil mereka. Dalam menjayakan projek ini, terdapat beberapa penemuan baru yang diperolehi. Contohnya, suhu maksima yang boleh diperolehi dengan menggunakan panel pengumpul haba solar ini hanyalah dalam lingkungan 44.2°C sementara suhu yang diperlukan untuk mengeringkan daun Mas Cotek ini adalah dalam lingkungan 60°C ke 80°C. Oleh sebab itu, untuk mendapatkan suhu sepatutnya, sebuah heater digunakan untuk meningkatkan haba yang diperoleh daripada panel pengumpul haba solar ini.

DEDICATION

For my beloved father and mother.

ACKNOWLEDGEMENTS

Firstly, I would like to thank Allah S.W.T for His blessings allowing me to finish my Projek Sarjana Muda (PSM) in time.

I would also like to thank my parents for their encouragement in my life as well as giving their full support in doing my PSM, mentally and also financially.

Then I would like to thank En. Raja Izamshah Raja Abdullah, as my PSM's supervisor for giving me a lot of guidance and knowledge during my project term.

I would also like to thank Prof. Md Dan and En. Halim for giving me guidance and some ideas during my PSM 1's presentation.

Lastly, I would like to thank all my friends, especially my group mate and not forgetting my housemates for their help and support.

Thanks again to everyone who's involved directly or indirectly in this project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

This project is named Solar Assisted Drying Machine. From the project name, it is clearly stated that this project uses solar power; from the sun to generate heat to be transfered into the drying machine. The sun has been the world's main energy source for hundreds of years. This energy is called solar energy. It is important not only to us, human beings; but is also to animals and plants. One of the important source from the sun is the sunlight. Like us, animals needs sunlight to walk in the day. Thus for plants, sunlight is much more important for their photosintesis process and as well as releasing oxygen out of the process for us to stay alive.

Today, a lot of high-tech instruments have been created by engineers to make full use of the solar energy. One of it is the solar collector. A solar collector is a device for extracting the energy of the sun directly into a more usable or storable form. The energy in sunlight is in the form of electromagnetic radiation from the infrared to the ultraviolet wavelengths.

In short, the purpose of this project is to design and fabricate a drying machine that uses solar energy to dry herbs. Herbs that are going to be used in this project is Daun Emas Cotek which is dried to get tea herbs out of it.

However, this project emphasises on the heat flow analysis of solar assisted drying machine. A few equations are needed in order to get the best result in heat flow or circulation to dry the herb. The design of heat flow includes from the solar collector to the drying room.

1.2 Problem Statement

There are a few methods of producing and manufacturing food drying machine. For instance, there are food drying machine that uses electricity, diesel, conventional fuels and even firewoods and coals. All of this method or design of drying machine does the same process; which is to dry the food or herbs. This method is somehow rather better than the previous way of drying foods or herbs where previously, drying is being done on open yards without any good hygienic conditions.

Anyhow, looking at the negative side of this method, there is a lot of wasting in using either electricity, neither diesel nor the others mentioned earlier. For example, put yourself in the low class farmer's shoe; would you be able to pay all the bills for electricity? Or would you be able to pay all the cost for raw materials needed to run the drying machine? The cost of the conventional fuel is increasing day by day, as the availability of the conventional fuel in the earth is decreasing day by day. Even worst, would you be able to bare the cost of the expensive machine to dry your farm product? This cost does not include the maintenance of the machine.

Solar air heater is a device to produce hot air for any industrial or farmer level drying applications by using freely the available sun. Using freely available Solar Energy (with the back-up system) could generate the hot air required for the drying applications. The Solar Assisted Drying Machine that is going to be fabricated gets its heat from the solar heat collector that is already fabricated. Unlike the conventional food drying machines, the heat is produced from the electric or fuel heater.

Using the solar, the cost of the drying process can be reduced to half where only a blower is needed during day time usage. Furhermore, Malaysia is in the

Khatulistiwa climate of temperature where bright sun shines everyday through out the year. This is a good reason to have a solar assisted drying machine in Malaysia. However, it still requires electricity if the machine needs to be operated at nights or if it rains in the day.

1.3 Objectives

- To improvise the current food drying machine.
- To get the best solar heat collector device and the best air flow design to gather hot air heated by the sun and the best heat flow in the drying room/chamber.
- To design and manufacture the solar heat collector and a drying chamber to dry mas cotek leaves.

1.4 Scope of Project

This project is to improvise the current food drying machine by adding a solar heat collector. In order to get the best result, a proper heat flow is needed to be designed to ensure the air transfered and spread inside the drying room is at the temperature needed.

Suitable calculations need to be done to get the balanced heat flow in the solar heat collector, transfer pipe and the drying room itself. Infact, the hot air flow in the drying room needs to be balanced in order to dry the herbs thoroughly.

On the other hand, the heat collector's and the drying chamber's room materials needs to be suitable to ensure that enough amount of heat can be collected. A proper transfer pipe is also needed to be designed so that heat does not cools down or transfered out of the pipe during the transfer process.

CHAPTER 2

LITERATURE REVIEW

2.1 Heat Transfer

In thermal physics, heat transfer is the passage of thermal energy from a hot to a cold body. When a physical body, e.g. an object or fluid, is at a different temperature than its surroundings or another body, transfer of thermal energy, also known as heat transfer, occurs in such a way that the body and the surroundings reach thermal equilibrium. Heat transfer always occurs from a hot body to a cold one, a result of the second law of thermodynamics. Heat transfer can never be stopped; it can only be slowed down.

Retrieved from Wikipedia

2.2 Design

Design, usually considered in the context of the applied arts, engineering, architecture, and other such creative endeavors, is used both as a noun and a verb. As a verb, "to design" refers to the process of originating and developing a plan for a product, structure, system, or component. As a noun, "a design" is used for both the final (solution) plan (e.g. proposal, drawing, model, description) or the result of implementing that plan (e.g. object produced, result of the process). More recently, processes (in general) have also been treated as products of design, giving new meaning to the term "process design".

Designing normally requires a designer considering aesthetic, functional, and many other aspects of an object or process, which usually requires considerable research, thought, modeling, interactive adjustment, and re-design.

Engineering is often viewed as a more rigorous form of design. Contrary views suggest that design is a component of engineering aside from production and other operations which utilize engineering. A neutral view may suggest that both design and engineering simply overlap, depending on the discipline of design. The American Heritage Dictionary defines design as: *"To conceive or fashion in the mind; invent,"* and *"To formulate a plan"*, and defines engineering as: *"The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems."*. Both are forms of problem-solving with a defined distinction being the application of "scientific and mathematical principles". How much science is applied in a design is a question of what is considered "science". Along with the question of what is considered science, there is social science versus natural science. Scientists at Xerox PARC made the distinction of design versus engineering at "moving minds" versus "moving molecules".

The relationship between design and production is one of planning and executing. In theory, the plan should anticipate and compensate for potential problems in the execution process. Design involves problem-solving and creativity. In contrast, production involves a routine or pre-planned process. A design may also be a mere plan that does not include a production or engineering process, although a working knowledge of such processes is usually expected of designers. In some cases, it may be unnecessary and/or impractical to expect a designer with a broad multidisciplinary knowledge required for such designs to also have a detailed knowledge of how to produce the product.

Design and production are intertwined in many creative professional careers, meaning problem-solving is part of execution and the reverse. As the cost of rearrangement increases, the need for separating design from production increases as well. For example, a high-budget project, such as a skyscraper, requires separating (design) architecture from (production) construction. A Low-budget project, such as a locally printed office party invitation flyer, can be rearranged and printed dozens of times at the low cost of a few sheets of paper, a few drops of ink, and less than one hour's pay of a desktop publisher.

This is not to say that production never involves problem-solving or creativity, nor design always involves creativity. Designs are rarely perfect and are sometimes repetitive. The imperfection of a design may task a production position (e.g. production artist, construction worker) with utilizing creativity or problem-solving skills to compensate for what was overlooked in the design process. Likewise, a design may be a simple repetition (copy) of a known preexisting solution, requiring minimal, if any, creativity or problem-solving skills from the designer.
Retrieved from Wikipedia

2.3 Solar Thermal Collector

A solar thermal collector is a solar collector specifically intended to collect heat: that is, to absorb sunlight to provide heat. Although the term may be applied to simple solar hot water panels, it is usually used to denote more complex installations. There are various types of thermal collectors, such as solar parabolic, solar trough and solar towers. These type of collectors are generally used in solar power plants where solar heat is used to generate electricity by heating water to produce steam and driving a turbine connected to the electrical generator.
Retrieved from Wikipedia

2.4 Solar Collector

A solar collector is a device for extracting the energy of the sun directly into a more usable or storable form. The energy in sunlight is in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The solar energy striking the earth's surface at any one time depends on weather conditions, as well as location and orientation of the surface, but overall, it averages about 1000 watts per square meter on a clear day with the surface directly perpendicular to the sun's rays.

A solar thermal collector that stores heat energy is called a "batch" type system. Other types of solar thermal collectors do not store energy but instead use fluid circulation (usually water or an antifreeze solution) to transfer the heat for direct use or storage in an insulated reservoir. Water/glycol has a high thermal capacity and is therefore convenient to handle. The direct radiation is captured using a dark colored surface which absorbs the radiation as heat and conducts it to the transfer fluid. Metal makes a good thermal conductor, especially copper and aluminum. In high performance collectors, a "selective surface" is used in which the collector surface is coated with a material having properties of high-absorption and low-emissivity. The selective surface reduces heat-loss caused by infrared radiant emission from the collector to ambient. Another method of reducing radiant heat-loss employs a transparent window such as clear UV stabilized plastic or Low-emissivity glass plate. Again, Low-E materials are the most effective, particularly the type optimized for solar gain. Borosilicate glass or "Pyrex" (tm) has low-emissivity properties, which may be useful, particularly for solar cooking applications.

As it heats up, thermal losses from the collector itself will reduce its efficiency, resulting in increased radiation, primarily infrared. This is countered in two ways. First, a glass plate is placed above the collector plate which will trap the radiated heat within the airspace below it. This exploits the so-called greenhouse effect, which is in this case a property of the glass: it readily transmits solar radiation in the visible and ultraviolet spectrum, but does not transmit the lower frequency infrared re-radiation very well. The glass plate also traps air in the space, thus reducing heat losses by convection. The collector housing is also insulated below and laterally to reduce its heat loss. The second way efficiency is improved is by cooling the absorber plate. This is done by ensuring that the coldest available heat transfer fluid is circulated through the absorber, and with a sufficient flow rate. The fluid carries away the absorbed heat, thus cooling the absorber. The warmed fluid leaving the collector is either directly stored, or else passes through a heat exchanger to warm another tank of water, or is used to heat a building directly. The temperature differential across an efficient solar collector is usually only 10 or 20°C. While a large differential may seem impressive, it is in fact an indication of a less efficient design.

The solar heating system consists of the collector described above; a heat transfer circuit that includes the fluid and the means to circulate it; and a storage system including a heat exchanger (if the fluid circulating through the collector is not the same liquid being used to heat the object of the system). The system may or may not include secondary distribution of heat among different storage reservoirs or users of the heat. The system can be used in a variety of ways, including warming domestic hot water, heating swimming pools, heating water for a radiator or floor-coil heating circuit, heating an industrial dryer, or providing input energy for a cooling system, among others. The heat is normally stored in insulated storage tanks full of water. Heat storage is usually intended to cover a day or two's requirements, but other concepts exist including seasonal storage (where summer solar energy is used for winter heating by just raising the temperature by a few degrees of several million liters of water (numerous pilot housing projects in Germany and elsewhere use this concept).

Retrieved from Wikipedia

Figure 2.1 A laundromat in California with solar collectors on the roof

2.5 Drying Process of Green Olives

Solar Energy Institute, Ege University, Turkey

This experiment deals with the performance evaluation of a single layer drying process of green olives in a tray dryer using energy analysis method. Green olive was used as the test material being dried. Drying process was realized at four different drying air temperatures (40, 50, 60 and 70 _C) and a constant relative humidity of 15%. The effects of temperatures and mass flow rates were investigated. Maximum energy efficiency of the drying chamber was obtained at a temperature of 70 _C and a drying air mass flow rate of 0.015 kg/s with 0.0004 kg/s of olive. The energy efficiency values were found to be in the range of 68.65%–91.79% from 40 _C to 70 _C with drying air mass flow rates of 0.01 kg/s–0.015 kg/s.

Energy analyses can reveal whether or not and by how much it is possible to design more efficient thermal systems by reducing the sources of existing inefficiencies (Dincer & Sahin, 2004). Energy analysis has been applied successfully to various areas of engineering applications (Szargut, Morris, & Stewart, 1988).

Drying experiments were performed in a laboratory scale dryer constructed in the Department of Agricultural Machinery, Faculty of Agriculture, Ege University, Izmir, Turkey (Gunhan, Demir, Hancioglu, & Hepbasli, 2005; Ongen, Sargın, Tetik, & Ko¨ se, 2005; Yagcioglu, Demir, & Gunhan, 2001). The dryer consists of mainly three subsystems, namely (a) air supply unit, (b) drying unit with heater and humidifier, and (c) data acquisition and electronic control unit.

Temperature control, data acquisition and storage as well as the general supervision of the unit, start-up and shut down electric heaters, injecting hot water into the air stream and circulating cold water through the cooling tower are done by the GENIE data acquisition software.

Olive samples (Domat variety) were obtained locally. They were calibrated (140–180 particles/kg) and stored overnight at T = (10 ± 2) _C before processing.