UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Design and Fabrication of Energy Efficient Drying System for the Solar Drying Machine

Thesis submitted in accordance with the requirements of the University Technical of Malaysia Malacca for the Degree of Bachelor of Engineering (Honours) Manufacturing (Design)

By

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APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Engineering (Honours) Manufacturing (Design). The members of the supervisory committee are as follow:

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MR. RAJA IZAMSHAH BIN RAJA ABDULLAH

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ABSTRACT

This is a Projek Sarjana Muda thesis entitled Design and Fabrication of Energy Efficient Drying System for the Solar Drying Machine. Mas Cotek leaves are the material that needs to be dried in this project. Thus this project emphasizes on the solar heat energy 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 operations 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 46°C while the temperature needed to dry out the "Mas Cotek" leaves are around 60°C to 80°C.

ABSTRAK

Ini adalah satu tesis Projek Sarjana Muda bertajuk “Design dan Fabrication Energy Efficient Drying System for Solar Drying Machine”. Daun-daun Mas Cotek adalah bahan yang perlu dikeringkan dalam projek ini. Oleh itu projek ini menekankan tenaga haba suria yang boleh dikutip melalui haba suria pengumpul yang telah direka dan dibuat; serta untuk mendapatkan satu aliran haba yang baik dalam kebuk pengeringan. Tujuan utama projek ini adalah untuk mengimprovisasi dan untuk mengurangkan kos operasi-operasi proses pemanasan iaitu pada masa ini digunakan dalam pengeringan daun-daun bidang. Haba suria pengumpul telah direka dan dibuat untuk mencapai objektif projek ini. Haba suria pengumpul adalah direka berdasarkan Z-Flow berpola iaitu biasanya digunakan oleh sesetengah petani-petani moden untuk keringkan mereka barangan. Terdapat beberapa penemuan dalam menjalankan projek ini. Misalnya, haba maksimum yang boleh dicapai menggunakan haba suria ini pengumpul ada hanya selingkung 46° C Manakala suhu diperlukan untuk keringkan “Mas Cotek “ daun adalah sekitar 60°C 80°C.

DEDICATION

*Specially dedicated to; My beloved Father, **Razali Bin Hassan** and My Mother, **Dariah Binti Ismail** who are very concern, understanding, patient and supporting. Thanks for everything. To My Respectful Supervisor;**Mr. Raja Izamshah Bin Raja Abdullah** for his constructive guidance, encouragement and patience in fulfilling our aspiration in completing this project. To the **Team** who design and fabricate Solar Drying Machine; **Mohd Nashriq Bin Sulaini** and **Nor Hazlami Bin Nor Adnan** and All My Friends, I also would like to say thanks. The Work and Success will never be achieved without all of you.*

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In The Name of Allah Almighty and The Most Merciful and Blessings
Be Upon His Messenger Prophet Muhammad S.A.W and His Companions.

Alhamdullillah, I would like to express my thankfulness to Allah S.W.T the almighty for his divine inspirational guidance, which had helped me in completing this final year project. All the praise and selawat is upon to The Prophet Muhammad S.A.W. And I would like to convey my sincere thanks to my supervisor, Mr. *Raja Izamshah Bin Raja Abdullah* for his constructive guidance and patience in fulfilling our aspiration in completing this project. Same goes to *Mrs. Seri Ruzy Haryati Binti Hambali* for guidance and patience.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The chapter 1 is introducing about the general information with overall what a meaning this Final Year Project (Projek Sarjana Muda) subject. The objective of this project is to train student working independently to design, fabricate, analyze, collect data and then solve the problem by investigation using available facilities including library, laboratory equipment, internet and software. Beside, by doing this Final Year Project, student can improve our knowledge about engineering field because student need to apply his knowledge in science, mathematics and engineering to solve the problems.

The title for this project is "Design and Fabrication of Energy Efficient Drying System for The Solar Drying Machine" where student need to create a flexible or modular design, make some analysis and then make a product of the solar drying machine. This study will focus to design and fabricate an existing drying machine which already has in current market. There have many types and shape of drying machine but for this study, student need to design drying machine for solar drying machine.

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 as a sample in this project is '*Ficus deltoidea'* (*mas cotek)* which is dried to get tea herbs out of it.

1.2 Objectives

The objectives of this project are:

i. To design and fabricate solar drying machine.
ii. Help to produce an effective product and get to save the cost.

1.3 Scope Of Project

The scopes of this project are:

i. To design the system of drying by using the solar energy and to analysis the system.
ii. Design method in designing the heat collector
iii. Material selection
iv. Method in manufacturing or fabricating the heat collector.

1.4 Problem Statements

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 firewood and coals. All of this method or design of drying machine does the same process; that 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 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 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. However, it still requires electricity if the machine needs to be operated at nights.

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CHAPTER 2

LITERATURES REVIEW

2.1 Introduction

This chapter 2 contains literature review for the design and fabrication of energy efficient drying system for the solar assisted drying machine. This chapter will introduce about the solar energy of drying machine. It includes definition and types of solar and the solar energy for drying machine. Besides, this chapter also describes detail about the energy efficient and findings about it from the various journals and articles.

2.2 Solar Energy

2.2.1 Definition of Solar Energy

Use of solar energy for drying crops saves conventional fuels and also offers the advantage of less pollution. Experiments conducted in many countries have clearly shown that solar energy can effectively be used to dry agricultural crops. Solar dryers with normal collectors generally provide low-grade heat and, thus, are good for agricultural crop drying purposes as it meets the requirement of high airflow rate with small temperature rise. Sodha et al. describe that the dryers using conventional solar air heaters with lifespan of 10 or more years are economical when compared with those using wood, oil or electricity. (P.N.Sarsavadia, 2006)

Solar mean something about the sun and solar energy are the energy that relevent with the sun. This solar energy source is more environmental friendly from fossil energy sources and can reduce the problem like agreen house and nature pollution from the fossil energy source usage.

2.3 Direct Source

2.3.1 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.
(http://en.wikipedia.org/wiki/Solar drying)

2.3.2 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 aluminium. 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 it 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).
(http://en.wikipedia.org/wiki/Solar collector [2007)

2.3.3 Thermal Solar 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.
(http://en.wikipedia.org/wiki/Indirect source)

2.4 Indirect Source

2.4.1 Types of Dryer

Dryers can be categorized in different ways. There are natural air, low temperature, and high temperature dryers. There are batch, automatic batch and continuous flow dryers and there is in-bin and column or self-contained dryers. Dryers can also be classified according to the direction of airflow through the grain, cross-flow, counter-flow, and concurrent-flow.

Natural Air/Low Temperature Drying

Advantages:

i. No harvest bottle neck. The bins can be filled at the harvest rate.
ii. A properly sized system may dry the crop more economically than a high temperature dryer.

Disadvantages**:**

i. There is a limit on initial moisture content that can be effectively dried.
ii. Electrical power must be available at each bin for dryer fan motors.

Natural air/low temperature drying refers to drying grain using little or no additional heat. Drying takes place in a drying zone which advances upward through the grain (Figure 2.1).

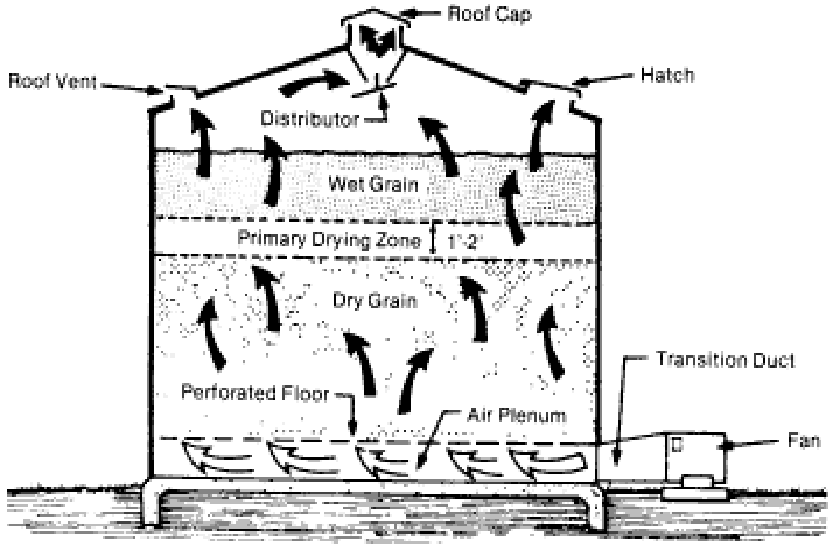

Figure 2.1: A typical bin dryer utilizing natural air/flow temperature drying.

2.5 Solar Dryer

Solar dryer use the energy from the sun to heat the air that flows over the food in the dryer. As air is heated, its relative humidity decreases and it is able to hold more moisture. Warm, dry air flowing through the dryer carries away the moisture that evaporates from the surfaces of the food. (VITA Volunteer Roger G. Gregoire, P.E.1984)

2.5.1 Solar Dryer Type

Solar dryer fall into two broad categories: active and passive. Passive dryer can be further divided into direct and indirect models .A direct (passive) dryer is one in which the food is directly exposed to the sun's rays. In an indirect dryer, the sun's rays do not strike the food to be dried. A small solar dryer can dry up to 300 pounds of food per month; a large dryer can dry up to 6,000 pounds a month; and a very large system can dry as much as 10,000 or more pounds a month. Passive dryer use only the natural movement of heated air. They can be constructed easily with inexpensive, locally available materials. Direct passive dryers are best used for drying small batches of foodstuffs. Indirect dryers vary in size from small home dryers to large-scale commercial unit's .Active dryers require an external means, like fans or pumps, for moving the solar energy in the form of heated air from the collector area to the drying beds. These dryers can be built in almost any size, from very small to very large, but the larger systems are the most economical. (VITA Volunteer Roger G. Gregoire, P.E. 1984)

2.5.2 Indirect Dryer

An indirect dryer is one in which the sun's rays do not strike the food/herb to be dried. In this system, drying is achieved indirectly by using an air collector that channels hot air into a separate drying chamber. Within the chamber, the food/herb is placed on mesh trays that are stacked vertically so that the air flows through each one. Figure 2.2 shows an indirect passive dryer. The solar collector can be of any size and should be tilted toward the sun to optimize collection. By increasing the collector size, more heat energy can be added to the air to improve overall efficiency. Larger collector areas are helpful in places with little solar energy, cool or cold climates, and humid regions. Tilting the collectors is more effective than placing them horizontally, for two reasons. First, more solar energy can be collected when the collector surface is more nearly perpendicular to the sun's rays. Second, by tilting the collectors, the warmer, less dense air rises naturally into the drying chamber. The drying chamber should be placed on support legs, but it should not be raised so high above the ground that it becomes difficult to work with. (VITA Volunteer Roger G. Gregoire, P.E.)