Faculty of Engineering

# OPTIMIZATION OF SOLAR THERMAL ENERGY FOR DRYING AGRICULTURAL PRODUCTS

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**BORANG PENGESAHAN**

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This project report attached here to, entitle **"OPTIMIZATION OF SOLAR THERMAL ENERGY FOR DRYING AGRICULTURAL PRODUCTS"** prepared and submitted by RISNI BIN DUAD (12823) as a partial fulfillment of the requirement for degree of Bachelor of Engineering with Honors in Mechanical Engineering and Manufacturing System is hereby read and approve by:

b/p ____________________ Date: 9/6/2008

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# PROJECT REPORT

# OPTIMIZATION OF SOLAR THERMAL ENERGY FOR DRYING AGRICULTURAL PRODUCTS

RISNI BIN DUAD

Report Submitted To

Faculty of Engineering

University Malaysia Sarawak (UNIMAS)

As To fullfill The Requirement of Bachelor Degree Program

# DEDICATION

Dedicate to my beloved family, friends, and all that have supported and encouraged me through good and hard time.

# ACKNOWLEDGEMENT

Firstly, I would like to express my sincere gratitude and appreciation to my project supervisor Mr Aidil Azli Alias for his guidance, advice, information and encouragement rendered to me in preceding my final year project.

A lot of thank I give to all the mechanical technicians staff who is warm-hearted given an advice and assistance during the project progress by provide the tool or equipment to successful the project.

Finally I Also give a lot of thank to my beloved family member who always gives me support and whish, my friend whose always give cooperation and useful information to do the project and report.

# ABSTRACT

Agriculture especially pepper is the main source of livelihood for the people in Sarawak. Drying of agriculture products is still the most widespread preservation technique. Solar drying can be considered as an elaboration of sun drying and is an efficient system of utilizing solar energy. The purpose if this project was to study the performance of the solar drier for drying pepper under the sun. The drier consists of a transparent acrylic board covered flat plate and a fan to create air flow in order to reduce the humidity. This drier has an area $0.6m^2$ with height 0.2m.The effect of the air flow by fan through the drier was examined. Also the effectively of acrylic board as a top cover and availability of solar dryer to absorb heat was examined. During the experiments, peppers that dried to the final were content of very lower percentage of humidity. In all the cases the use of the solar drier leads to considerable reduction of drying time in comparison to sun drying. Samples dried in the solar drier were completely protected from insects, rain and dusts, and the dried samples were of high quality in terms of dry and hygienic. This system can be used for drying various agricultural products. Also, it is simple in construction and can be constructed at a low cost with locally obtainable materials.

# ABSTRAK

Pengusahaan lada hitam adalah sumber asli utama bagi masyarakat di sarawak. Cara pengeringan menggunakan cahaya matahari untuk mengawet makanan masih menjadi pilihan utama. Pengeringan menggunakan cahaya matahari adalah suatu langkah yang bijak mengunakan sumber alam sebagai bekalan tenaga. Tujuan projek ini adalah untuk mengkaji kecekapan pengering solar sebagai produk untuk mengering lada. Pengering solar terdiri daripada penutup yang diperbuat daripada acrylic board lut sinar dan kipas yang digunakan untuk mengalirkan udara bagi mengurangkan kelembapan. Keluasan pengering ini adalah $0.6m^2$ dengan ketinggian 0.2m. Keberkesanan pengaliran udara oleh kipas terhadap pengering solar diuji. Begitu juga faktor penggunaan acrylic board sebagai penutup dan kebolehan pengering solar menyerap haba diuji. Setelah menjalankan eksperimen terhadap lada, didapati kandunagan peratusan kelembapan lada tersebut sanagat rendah. Dalam apa jua eksperimen yang menggunakan solar, matlamat utama adalah untuk mengurangkan masa pengeringan sesuatu produk. Produk yang dikeringkan dalam pengering solar adalah terlindung daripada pencemaran terutamanya debu, serangga, dan hujan. Kualiti produk yang dihasilkan sangat baik dari segi kebersihan dan kekeringan. Selain itu pengering solar ini boleh digunakan untuk mengeringkan produk lain selain lada. Pengering solar ini juga senang dibina, kos rendah dan bahan-bahan untuk pembinaan mudah dicari.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Solar Energy

Solar energy is the solar radiation that reaches the earth (Energy Information Administration, 2004). It is also a renewable energy which is derived from resources that are regenerative or for all practical purposes cannot be depleted (Wikipedia, 26 July 2007).

The major advantages of solar energy are it is virtually free after the initial cost has been discovered. Depending on the utilization of energy, paybacks can be very short compared to the cost of common energy sources used. Therefore solar and other renewable energy systems can be stand-alone, thereby not requiring connection to a power or natural gas grid. Beside that the sun provides a virtually unlimited supply of solar energy (Van Wyk Anita, 2005). The use of solar energy displaces conventional energy, which is usually a result in a proportional decrease in green house gases emissions. The use of solar energy is an untapped market.

Drying of the food products began early in human history. In the ancient world, the use of this process meant relying on the sun and wind. The foods products, processes. In Egypt, medicinal plants were also preserved by simple drying. Egyptian reliefs depict fish cut in half and hung to dry on rope of the sun, with the prevailing wind hastening the process.

However due to lack of appreciation of the basic process involved in the drying and preservation of the food products, the approached remained purely empirical for many centuries. It took on a new importance in the light of growing population, trade and travel. At present, many types of dryers are available which can be used effectively for drying of food and agricultural product (m.s Shoda and s.s Mathur, 1986).

Another country used an open solar dryers technique is Pakistan. Pakistan is an area that could use solar energy very effectively in drying the agriculture products under controlled atmosphere of solar dryers and a good quality products can be obtained at much less cost. Due to absence of logistics and basic infrastructure in the area, tons of fruit is wasted every year in the northern mountains such as Gilgit and Sakardu. Such dryers could be equally effective in Punjab and Sindh province to dry the agriculture products for better market value and generating local employment (Guangzhou, 2001).

The disadvantages of traditional open ground drying are time to drying the product is too slow. Moreover somebody has to stay at home throughout the drying period to chase off domestic animals, to remove the produce when weather becomes too windy and dusty, or when it rains. Therefore, the quality of the product is unsatisfied due to grit and dust. The product is also often unhygienic as a result the product was drying on open space and it expose to microorganism and insects such as flies.

The main objectives of this project are to design and fabricate. From then on testing solar dryer's prototypes and optimize the use of solar energy for drying process and to compare the effectiveness of the prototypes to the traditional open sun drying approach.

# Chapter 2

# LITERATURE REVIEW

## 2.1 Introduction

Drying is an excellent way to preserve food and solar food dryers are an appropriate food preservation technology for a sustainable world. Actually, solar food drying is one of the oldest agricultural techniques related to food preservation, but every year, millions of dollars worth of gross national product are lost through spoilage. Reasons include, ignorance about preservation of produce, inadequate transportation systems during the harvest season (mostly climate related), and the low price the rural farmer receives for products during the harvest season (Berry Holly, 1990).

Dehydration is one of the main processes used in the removal of water from food products. The purpose of this process is to provide microbiological stability, reduce chemically deteriorative reactions, and to reduce transport as well as storage costs. The procedures and methods for this process have greatly improved over the years due to technological advances. Not only have the systems improved, but also the quality of the product (Loesecke Harry, 1955).

Traditional sun drying methods often yield poor quality, since the produce is not protected against dust, rain and wind, or even against insects, birds, rodents and domestic animals while drying (Markus Hauser and Ankila). Soiling, contamination with microorganisms, formation of mycotoxins, and infection with disease-causing germs are the result. The researcher assert that the drying equipment used in industrialized countries overcomes all of these problems, but unfortunately is not very well suited for use in developing countries because it requires substantial investments and a well-developed infrastructure. Researcher further maintains that solar drying facilities combine the advantages of traditional and industrial methods, namely low investment costs and high product quality.

The El Paso Solar Energy Association (EPSEA) was founded in 1978 and is the oldest, continuously active, local solar organization in the United States. The purpose of EPSEA is to further the development and application of solar energy and related technologies with concern for ecologic, social and economic fabric of the region (West Texas, Southern New Mexico, Northern New Mexico).The El Paso Solar Energy Association provides some practical information and links to other resources. El Paso Solar Energy Association state that association information is prompted by the need for solar dryers in areas where fruit is plentiful in summer months, but because there is no simple and economic method to preserve it, much of it is left to rot, while in the winter there is hunger (Scanlin and Dennis, 1997).

The El Paso Solar Energy Association agree that solar food drying can be used in most areas but clarify that how quickly the food dries is affected by many variables, especially the amount of sunlight and relative humidity. The El Paso Solar Energy Association provides some basic guidelines to drying food.

Dehydration of vegetables and other food crops by traditional methods of open-air sun drying is not satisfactory, because the products deteriorate rapidly. Furthermore, traditional methods do not protect the products from contamination by dirt, debris, insects, or germs. A study by Akwasi Ayensu from the Dept. of Physics at the University of Cape Coast, Cape Coast, Ghana demonstrates that food items dried in a solar dryer were superior to those which were sun dried when evaluated in terms of taste, color, and mould counts. He asserts, and many others agree that solar drying systems must be developed to utilize this energy resource to improve food preservation (Ayensu Akwasi, 1998).

## 2.2 Solar Dryer

Solar drying is in practice since the time im-memorable for preservation of food and agriculture crops (Gujarat, 1990). This was done particularly by open sun drying under open the sky. This process has several disadvantages like spoilage of product due to adverse climatic condition like rain, wind, moist, and dust, loss of material due to birds and animals, deterioration of the material by decomposition, insects and fungus growth. Also the process is highly labor intensive, time consuming and requires large area. With cultural and industrial development artificial mechanical drying came in to practice. This process is highly energy intensive and expensive which ultimately increases product cost. Thus solar drying is the best alternative as a solution of all the drawbacks of natural drying and artificial mechanical drying.

Solar dryers used in agriculture for food and crop drying ,for industrial drying process, dryers can be proved to be most useful device from energy conservation point of view. It not only save energy but also save lot of time, occupying less area, improves quality of the product, makes the process more efficient and protects environment also. Solar dryers circumvent some of the major disadvantages of classical drying. Solar drying can be used for the entire drying process or for supplementing artificial drying systems, thus reducing the total amount of fuel energy required.

Solar dryer is a very useful device for agriculture crop drying, food processing industries for dehydration of fruits, potatoes, onions and other vegetables, seasoning of wood and timber, textile industries for drying of textile materials and dairy industries for production of milk powder, casein etc.

## 2.3 Various Type of Solar Dryer

### 2.3.1 Direct Solar Dryer

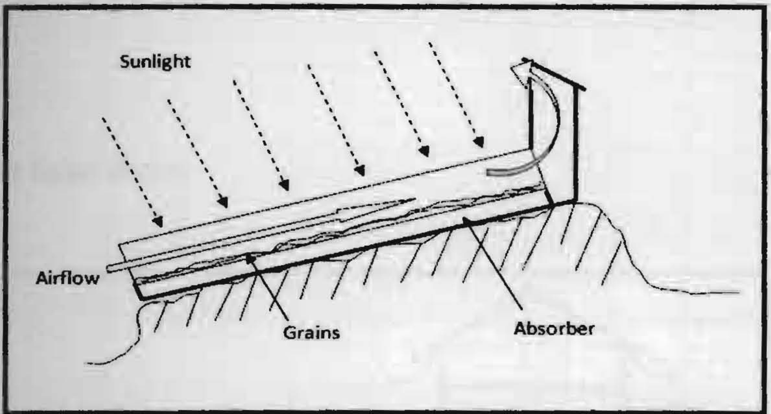


**Figure 2.1: Solar Dryer Directly Employed**

Solar driers can be constructed out of ordinary, locally available materials, making them well suited for domestic manufacture. Solar driers divided into two categories. First categories are driers in which the sunlight is directly employed and warmth absorption occurs here primarily by the product itself.

Second categories driers are in which the sunlight is employed indirectly. In this method, the drying air is warmed in a space other than that where the product is stacked. The products, then, are not exposed to direct sunlight. Various sorts of construction are possible; this design can also be provided with powered fans in order to optimize the air circulation (P. Vanderhulst, H. Lanser and P. Bergmeyer, 1990).

Tradition open-rack drying enjoys four considerable advantages. There are, it demands a minimum of financial investment, low running costs, it is not dependent on fuel and for certain products the drying time is very short.

On the other hand the products are exposed to unexpected rain, strong winds and the dust they carry, larvae, insects and infection by, amongst others, rodents.

### 2.3.2 Indirect Solar Dryer

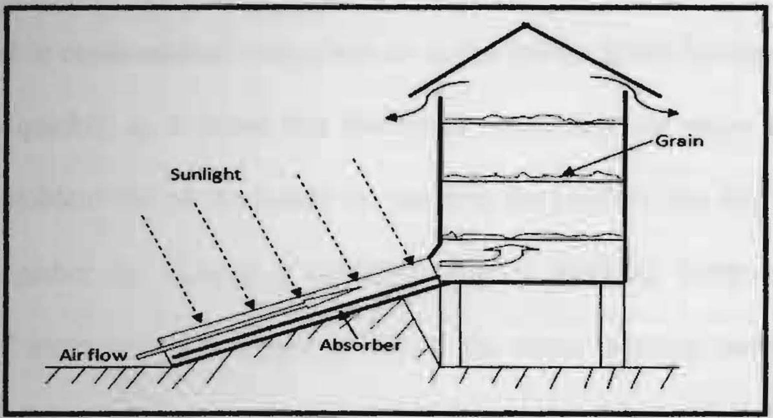


**Figure 2.2: Solar Dryer Indirectly Employed**

Moreover, certain sensitive products can become overheated and eventually charred. Dried fruit so spoiled necessarily loses its sale value.

Commercially available driers often appear to be economically unfeasible. Specifically, not enough products can be dried fast enough to recoup the outlay. Larger (combined) installations are more cost-effective but call for sophisticated management if the input and output of products is to be held at a controlled, and high, level. They are also fitted with artificial heating (fires) and fans (P. Vanderhulst, H. Lanser and P. Bergmeyer, 1990).

The advantages of the indirect dryer are product is exposed to less high temperatures, whereby the risk of charring is reduced and the product is not exposed to ultraviolet radiation, which would otherwise reduce the chlorophyll levels and whiten the vegetables.

However, its use demands some care. Faulty stacking of the product to be dried can lead to condensation; rising hot air in the lowest layers becomes saturated, but cools so quickly as it raises that the water condenses out again in the upper layers. This problem can be overcome by stacking the product less high, stacking it less close together by enlarge a collector, higher working temperature, faster circulation of more air, or a deeper collector, the same working temperature and speed of circulation but more volume. The higher cost and the complexity of the indirect method drier are also disadvantages.

### 2.3.3 Kiln-Type Dryer

The kiln-type dryer is contracting uncomplicated and the outlay for maintenance is low. In addition, a kiln-type dryer can accommodate a large capacity of drying products. Normally, a kiln-type dryer is built to a two-story building which the ground floor is the furnace room. The air with combustion gases flows in a pipe which is heating up by a burner is using to dry up the products located on the second floor. Another special feature in a kiln-type dryer is the products are placed or rested on the slotted floor for up to 8 inches or more. The loading, unloading and periodic raking of the layer requires substantial labor, causing this aspect to be among the major costs in kiln drying. Besides, limited control over drying conditions and long drying times are the limitations for this method. On the other hand, the usage of furnace acts as a supplementation to the model especially during cloudy day or insufficient solar energy.

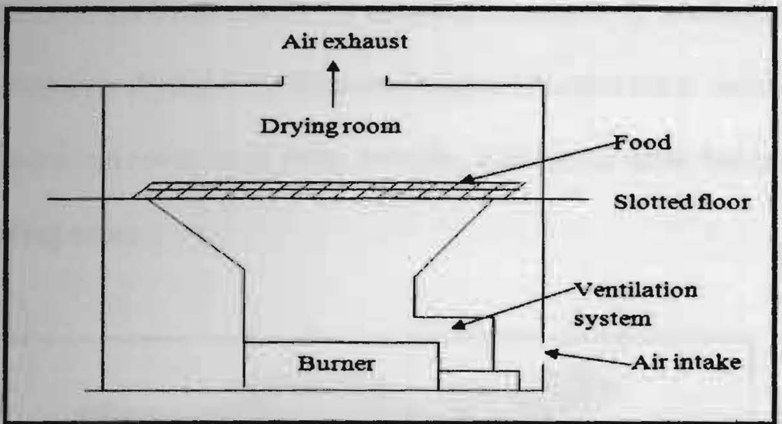


**Figure 2.3: Typical Cascading Direct Rotary Dryer Arranged for Concurrent Operation**

### 2.3.4 Belt Dryer

A belt dryer is preferable if the particles is rather coarse (5mm<particles<10mm). The foods are evenly spread onto a slowly moving conveyor with speed 5mm/sec. The conveyor driers length can be up to 20m long and 3m in widths. The belt moves into a drying cabinet and warm air passes downward through the layer. Normally, the dryer must offer a residence time of between 15 to 20 minutes. This is because the bound moisture must diffuse through the pallet.