STUDY THE EFFEECT OF REFLECTOR ON SOLAR DRYER PERFORMANCE

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This report is submitted
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DECLARATION

I declare that this project report entitled “Study the Effect of Reflector on Solar Dryer Performance” is the result of my own work except as cited in the references

Signature :..................................

Name : Nazirul Mubin Bin Mohd Rahimin

Date :..................................

SUPERVISOR'S DECLARATION

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor and to the second examiner.

Signature :..................................

Name of Supervisor :..................................

Date :..................................

DEDICATION

To my beloved mother, father, sibling, my friend, my supervisor, and myself

ABSTRACT

Solar drying is one of the methods to remove water or moisture content by evaporate food products to be dried using solar radiation. The performance of the solar dryer depends on solar radiation. This study aims to analyse the effect of a reflector on solar dryer performance. The solar dryer's performance was carried out by recorded the temperature inside the solar dryer, which is drying chamber, and solar collector. The ambient temperature is also recorded at the fan's inlet that flows the air through the solar collector to the drying chamber. The solar radiation is recorded using a pyranometer to identify the three experiments' weather conditions. Solar radiation is the main factor of the temperature rise or drop inside the drying chamber. The sun's ray light is reflected to the solar dryer side that does not expose to the sunlight. The reflector's angle identified because it is important to reflect the sun ray to the solar dryer. The temperature rise 6°C for solar dryer with 20-degree of reflector and 4°C for solar dryer with 0-degree of reflector compare to the solar dryer without reflector. The solar radiation recorded between three experiments is the same, which is 839.16W/m^2. Based on the result of the experiment, it can be concluded that solar dryer with reflector is more effective as compare to the solar dryer without a reflector, and the suitable angle is 20-degree of reflect.

ABSTRAK

Pengeringan dengan menggunakan sinaran matahari atau dikenali sebagai pengeringan solar adalah salah satu cara untuk mengeringkan produk makanan dengan proses pengewapan untuk menghilangkan kelembapan dan kandungan air dalam produk makanan untuk memastikan produk makanan lebih tahan lama. Keupayaan pengeringan solar adalah bergantung sepenuhnya pada sinaran matahari. Kajian ini bertujuan untuk menganalisis kesan pemantul terhadap keupayaan mesin pengering solar. Prestasi mesin pengering solar dilakukan dengan merekod suhu di dalam mesin pengering suria, iaitu pada ruang pengering, dan ruang pengumpul solar. Suhu persekitaran juga direkodkan di saluran masuk udara melalui pengumpul solar ke ruang pengeringan. Sinaran matahari juga direkodkan dengan menggunakan ''pyranometer'' untuk mengenal pasti keadaan cuaca bagi ketiga-tiga eksperimen yang dijalankan. Pancaran matahari menjadi salah satu faktor utama kenaikan suhu di dalam ruang pengeringan. Cahaya sinaran matahari akan dipantulkan pada bahagian mesin pengering solar yang tidak terdedah terhadap sinaran matahari. Sudut untuk pemantul solar juga diperlukan bagi memastikan sinaran cahaya matahari dapat memantulkan sinarannya pada bahagian pengering solar yang tidak terdedah. Pengering suria dengan 20 darjah pemantul telah menaikan suhu 6°C lebih banyak berbanding pengering solar tanpa pemantul dan 4°C lebih tinggi berbanding pengering solar dengan 0 darjah pemantul. Bacaan sinaran matahari yang direkodkan antara ketiga-tiga eksperimen adalah sama, iaitu 839.16W/m2. Kesimpulan dari hasil eksperimen, pengering solar dengan pemantul lebih efektif dibandingkan dengan pengering suria tanpa pemantul, dan sudut yang sesuai adalah 20 darjah untuk pemantul memantulkan sinaran matahari pada bahagian pengering solar yang tidak terdedah sinaran matahari.

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I hope that all the knowledge and experience that I have learned and gained throughout this project can be useful and applicable in my future. There are more challenging obstacles and hard times to come. I hope to use the experience I have gained through this PSM project to overcome those challenges and lead a successful life.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PSM	Projek Sarjana Muda
UTeM	Univerisi Teknikal Malaysia, Melaka
CAD	Computer Aided Design
Al	Aluminum
COVID-19	Corona Virus Dieses 2019
MCO	Movement Control Order

CHAPTER 1

INTRODUCTION

This chapter will describe the background study according to the title and project preview. The problem statement of this project, objective, and scope are explained clearly.

1.1 Background

Drying is the oldest method that utilizes solar energy to remove water or moisture content by evaporation for food products to be dried by solar radiation (Alqadhi et al., 2017). In the food industry, drying is the simple and final step in production that removes moisture content from a product to packing to make food products long-lasting. The drying product by conventional drying machinery that exposes directly to the sun radiation is economical because it can reduce the cost of the drying process. However, this method is contaminated and unpredictable weather changes.

The application of solar energy used for solar dryers in the food and agriculture industry is an alternative for processing a drying product with clean and better quality and nutritious food products. Solar dryer system have three different type mode of dryer which is direct, indirect and mixed mode (Misha et al., 2018).

The direct solar dryer is the product with transparent cover where the food product is directly exposed to the sun radiation. The solar energy heats the food and heat the surrounding. The indirect mode is the method that does not directly expose the sunlight. The sun radiation was absorbed by using solar collector that collects sun radiation and converted it into heat. The air is used to conduct heat from the surface accumulated from the solar collector to dry the food product. Mixed-mode dryers are direct and indirect combinations of heat flow through transparent cover and heat transfer from solar collectors.

In fact, the earth moves on the axis of rotation for 24 hours a day. So, the sun was given rotation 15^o for 1 hour. Some of the solar collectors do not exposed to sun radiation. A reflector can be added to reflect solar radiation to the solar collector that is not exposed to the sun radiation. The solar dryer's performance and efficiency were improved when the solar reflector was reflected solar radiation to increase the amount of solar radiation to the solar dryer. (Kostić & Pavlović, 2012).

1.2 Problem Statement

Drying is the method that utilized solar energy to dry the food products with an exposed food product to the sunlight. However, this is the oldest method has many disadvantages such as spoil product due to rain, animals, and bacteria. So, the solar dryer technology is an alternative method for the drying process. An existing solar dryer has two solar collectors for both side and has two transparent covers for the dryer tray.

The earth moves in one revolution on its axis every 24 hours each day. That solar rays diverge around 2.5^o in 10 minutes, and 15^o in 1 hour. The sun movement is from east to west. When the sun is on the east, the solar collector on the west is not exposed to the sun radiation and when sun is on the west, the solar collector on the east is not exposed to the sun radiation. To optimize the solar dryer's efficiency, the reflector is designed to adjust the angle according to the sun's position to ensure both of solar collector and dryer tray are exposed to the sun radiation.

1.3 Objective

The aim of this project to study the effect of reflector on solar dryer performance. There are three main objectives to achieve in this project are:

- To design and fabricate the reflector to be installed in the existing solar dryer.
- To determine the temperature of the drying chamber.
- To compare the temperature differences with and without a reflector.

1.4 Scope

To make sure the objectives of the project stated are achieve, which is to study the effect of the reflector on solar dryer performance, thus the scope of the study was proposed to make sure the project flow will be easy and well organized. This project will focus on the design of the reflector to be installed in the existing solar dryer, including the reflector's material and suitable angle for the reflector to reflect radiation to the solar dryer. The design of reflector was to concentrate both the direct and diffuse radiation of the sun on the solar collector. The reflector's design was designed that can be adjust angle of reflector to make sure the sun radiation was diffuse to the solar collector and drying tray. At the end of the reflector's development process, the experiment will be carried out at solar dryer to study the solar dryer's performance when the reflector installed and to analyse the temperature difference on the solar dryer with and without reflector.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses previous researchers that have been involved in this project. This project requires a good knowledge about the design of existing solar dryers and perform as well as that reflector effect on the performance of solar dryers. Therefore, research is needed to obtain all available information associated with the topic. Review information or literature obtained in principle to assist in the PSM creation and requirement. On this basis, the project can be achieved with the guidance and decision in achieving the target mark. Source of reviews taken from the journal.

2.2 Solar Dryer

Figure 2.1 shows the existing solar dryers. The design and development of an existing solar dryer is a combination of all the various ways of drying or drying a blended model that a combination of direct and indirect dryers. The direct model is a food system directly exposed to solar radiation just where the material to be dried is placed in a glass or plastic transparent or with radiation reflected as a box. The reflected radiation is used to increase the temperature in the box. Indirect Mode is a system where sunlight does not fall directly into the dried product, but collectors are used to raise the hot air temperature in the drying chamber. This method is a simple and economical way to preserve food for long-term storage because easily built with cheap and available material (Sharma et al., 2009).

The design of drying systems for solar drying is the renovation and improvement of the previous design study. The design concept is that the air cell solar absorber plate is mounted on both sides of the drying chamber to increase the temperature of the drying chamber to improve system efficiency (Alqadhi et al., 2017). The solar dryer design also has recirculated pipe from the chamber's exit and return to the bottom inlet of the chamber. The speeding fan located at the bottom of the chamber inlet of the air is used to get good airflow circulation. Figure 2.2 shows the configuration of the mixed-mode solar dryer.

Figure 2.1:Existing solar dryer (Misha et al., 2018)

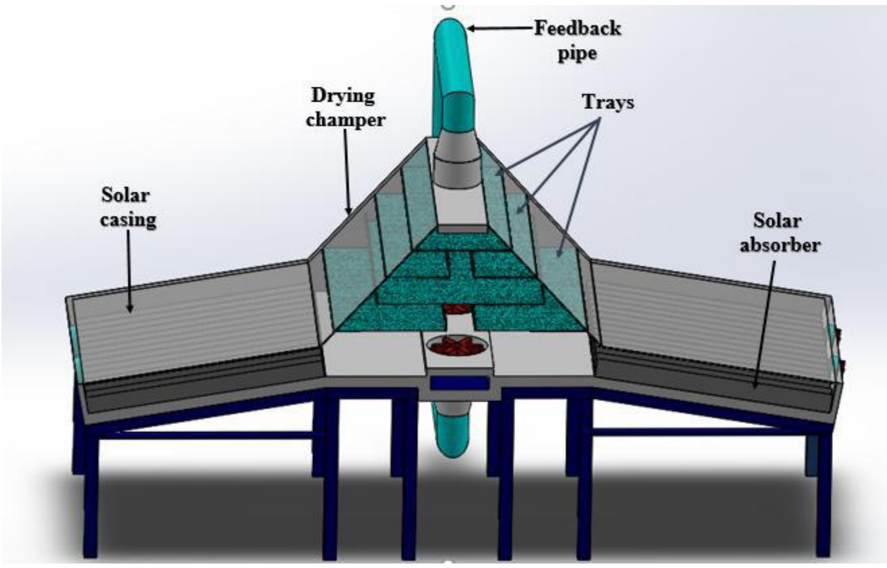

Figure 2.2:Design of the mixed mode solar dryer (Alqadhi et al., 2017)

2.2.1 Air Solar Heater

The design of solar dryer absorber mounted by both sides in solar air drying. It has a solar collector that are used to collect and concentrate solar radiation or heat by absorbing sunlight to raise the temperature in the solar casing. Solar radiation is absorbed and distributed uniformly in the area of flat plate solar collectors, which have an absorbent layer (Prakash & Nandan, 2018). No insulation at solar absorber leads to heat loss (Thakur, 2017). The insulation was attached to maintain the high temperature of the dryer and heat leakage. The panel was horizontal to achieve the possible heat from solar radiation. The solar collected were shaped V Groove with fixed 60 degrees. The V Groove shape increases the drying chamber's temperature and efficiency because the surface area of the absorber increases (Karim et al., 2014).

2.2.2 Drying Chamber

Based on Figure 2.1, the drying chamber was located between two solar absorber panels and perpendicular to the horizontal plane. These drying chambers integrate with a mixed-mode system that direct and indirect method to receive heat from solar radiation in two methods. The drying chamber is covered with a transparent cover by the glass in the dryer's direct method. Figure 2.3 shows the working principle of a direct of the solar dryer. Solar radiation is reflected from the glass cover to the atmosphere and remaining part of solar radiation transmitted inside the drying chamber and absorbed by the surface of the drying product or crop (Sharma et al., 2009). The glass cover cause the temperature inside the dryer increase and reduce direct convective losses to the surrounding (Harmain, 2012). The convective and evaporative losses occur inside the drying chamber from the heated product. Inside the drying chamber have tray to located food product to drying.

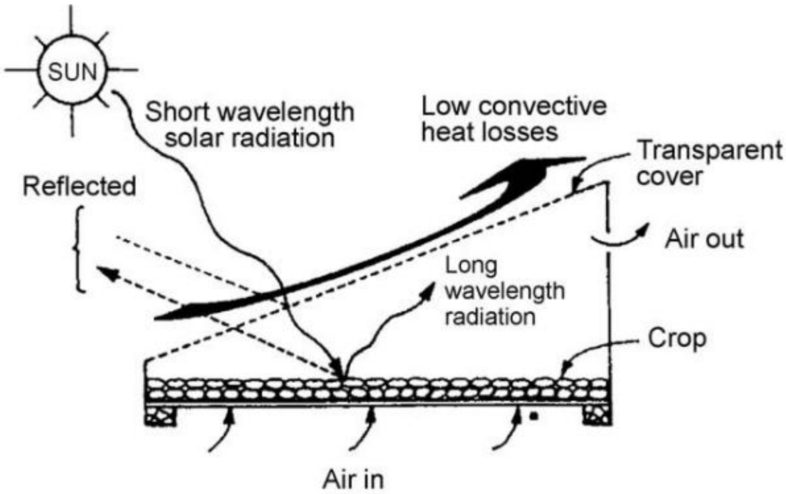

Figure 2.3: working principle of direct solar dryer (Sharma et al., 2009)

However, the indirect method consists of a drying chamber and solar absorber. Figure 2.4 working principle of the indirect solar dryer. Indirect drying food products are not directly exposed to the sun to minimize discoloration and cracks on the product's surface. Solar energy is collected in separate equipment called a solar collector closed by a transparent glass. Solar absorbers have solar collectors to absorb solar energy for heating air entering the drying chamber of the heating the food products directly. The heated air can flow through the wet product, and at the side of the solar absorber has two fans each side of the solar absorber for air enter from the solar absorber to the drying chamber to be dried and exit through the chimney by taking moisture released from the substance. The heat from moisture evaporation between hot air and wet crop or food product because of the convective heat transfer (Sharma et al., 2009). The drying is the difference in moisture concentration between the drying air and the air in the vicinity of crop or food product surface (Shrivastava et al., 2014). The heated air is then passed over the material to be dried and often out of the chimney, take the moisture is removed from the material. (Bhendwade & Dube, 2018) has carried out the experiment performance indirect solar dryer and the efficiency of the solar chamber increase to 60.40%

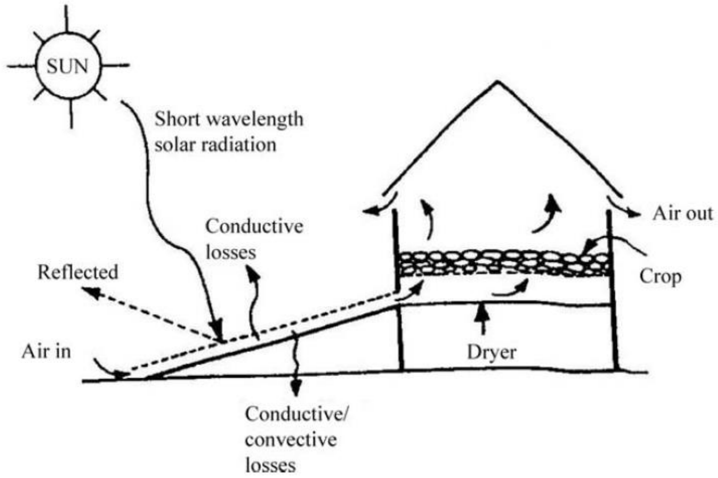

Figure 2.4: working principle of indirect solar drying system (Sharma et al., 2009)

2.2.3 Recirculate Pipe

The recirculate pipe is connected between the top of the drying chamber and at the bottom of the drying chamber. The air inlet from top to bottom that connected by the drying chamber. (Alqadhi et al., 2017) has stated that the during the daytime, the bottom inlet of drying chamber were closed but the top of drying chamber was attached with the fan is opened to remove wet air from drying chamber however during night both side of solar collector that attached 2 fan and the top of the drying chamber were closed to avoid air humidity during night enter the drying chamber. The air will recirculate inside the drying chamber, and the moisture removes through recirculate pipes that have desiccant material that will absorb moisture. The air inside the drying chamber with low humidity and the process repeated until the desiccant saturated during the daytime.

2.3 Solar Reflector

The solar dryer system development can be visualized that operate with renewable energy that is environmentally friendly by using solar radiation to generate heat for the drying method. However, a simple method to improve the solar dryer's performance with the reflector mirror is attempted in this study to construct the natural convection solar drying system (Sivasundar et al., 2018). A solar panel with a reflector produces more energy generation thereof with minor modifications. Reflectors are used in solar to concentrate solar radiation to the solar panel (Akhtar et al., 2018).

The solar collector with a solar reflector increases the collector's thermal efficiency. The sun radiation was reflected and concentrated radiation toward the solar collector. The reflector allows changing the angle during the day to maximize the incident radiation intensity. The sun radiations are converted into heat then transferred to the collector. The construction of a solar water heating system prototype has obtained the improvement of the collector efficiency around 10% with the solar reflector (Bhowmik & Amin, 2017).

Drying efficiency during its operation has been estimated and compared with sun drying, forced solar drying with a reflector, and the average drying temperature rise is 8ºC more than without a reflector (Nandakumar et al., 2018). The drying rate of tested samples of solar drying with reflective mirrors and electric hot air-drying methods faster than solar drying without reflective mirrors and it can meet the requirements in the drying of foods like a short time of operation, the drying efficiency, cost of operation, and quality of dried products (Badry et al., 2016). Reflector focuses both direct and diffuse solar radiation towards the flat plate collector, and reflector can change the trend in the sun's direction to maximize the concentration of the incident radiation. The result has achieved an increase in the collector plate's efficiency is about 12% -13%, so this is the best thermal performance compared with existing systems (Rajashekaraiah et al., 2019). Solar reflectors focus solar radiation on solar cells or solar heat absorbers to improve the radiation absorber to produce heat and thermal electricity.

2.3.1 Solar Reflector Material

Solar reflectors can be used to bake, cook, or fry all kinds of food to produce steam based on the Scheffler type built from steel parts that feature high-quality reflective aluminium. The reflector is configured to angle the sun. The reflector increases the amount of solar radiation reflected in the solar collector and drying chamber, thus the thermal productivity and the temperature inside the drying chamber increase. Reflector aluminium foil increase the solar panel's power output by around 31.5, and mirror stainless steel can increase solar panels' power output by around 21.5% (Setiawan & Dewi, 2013). This shows aluminium foil is the best reflector. Effects of a reflector material in the solar dryer, among many different materials for solar reflector dish like Polymeric Films Non-Metallic, Polished Stainless Steel, and Aluminium anodes torque is 98%, 50%, and 86.8% (Hafez et al., 2016).

Table 2.1 show the characteristic of solar reflector material. The suitable material for solar reflector can be used aluminium because it can reflect 98% with emissive 2%. The best performing aluminium sheet with an unmatched minimum total reflectivity of 98% it can be reflected with virtually no loss. Aluminium for solar applications that reflect the intensive spectrum of the solar spectrum reduces the dispersion and high reflectance values (Kulkarni et al., 2014). The use of aluminium-plated steel reflector polymeric solar concentrator rated 1 day after outdoor exposure, total solar reflectance and specular have declined less than 1%. However, after 2000 hours of damp heat and simulated sunlight of 1000 W / m2, the optical properties have changed significantly (Brogren et al., 2004).

Table 2.1: Characteristic of solar reflector material. (Hafez et al., 2016)

Materials	Reflective (%)	Emissive (%)	Refs.
Polymeric film, non metal	98	2	[69,70]
Aluminum, acrylic	98	2	[69–71]
Silver, aluminum acrylic	97	3	[69–71]
Silver, acrylic	95	5	[70,72,73]
Aluminum	86	14	[70,74,75]
Aluminum, polyethylene	97	3	[76]
Plexiglas with mirror	90	10	[70,77]
Thermoplastic, silver, gold, brass, etc.	80	20	[70,78]
Aluminum mylar	97	3	[79]
Polymer, copper, silvered, alumina	97	3	[80,81]
Polished stainless	50	50	[82]
Ceramic metallic coating layer	95	5	[83]
Glass/silver 4 mm	93.8	6.2	[70,84]
Glass/silver 2 mm	94	6	[70,84]
Glass/silver 1 mm	94.6	5.4	[70,92]
Miro 2–95	88.6	11.4	[70,73,85]
Miro 3–95	91.1	8.9	[73,86]
Anod aluminum	86.8	13.2	[84,87]
1000.90	89.8	10.2	[84]
ECP305+/aluminum	95.6	4.4	[88]
ECP305+/glass	96.1	3.9	[88]
Sunflex (polymer/aluminum)	86.9	10.1	[69]
SA 85/glass	88.1	11.9	[88]
SA 85/steel	88.2	11.8	[88]
Sol-gel coated silver	95.5	4.5	[81,91,92]
Sol-gel coated aluminum	91	9	[93–96]

Requirements must be met for the reflector material in the solar thermal application is high across the reflection wavelength range of the solar spectrum. Solar reflectors should be reflected as possible sunlight absorption into the sun and maintain high reflectivity. Reflective materials should be environmentally friendly and contain no harmful compounds. Metal, silver, and aluminium is suitable as a reflector for solar thermal applications that absorb in the near-infrared, but not optimal for photovoltaic (Brogren et al., 2004). The most widely used material for solar reflectors is anodized aluminium. Damage to aluminium in principle does not as quick as silver because silver has the corrosion resistance of metals such as free electron limited. Still, glass mirrors tend to be fragile and heavy. The solar reflector is not subject to the same high-temperature solar absorber.