UNIVERSITI PUTRA MALAYSIA

TROPICAL FIELD ASSESSMENT IN DEVELOPMENT OF DUAL-PASS PHOTOVOLTAIC TRAY DRYER

ABDURRAHMAN BIN NOOR ISKANDAR

TROPICAL FIELD ASSESSMENT IN DEVELOPMENT OF DUAL-PASS PHOTOVOLTAIC TRAY DRYER

By

ABDURRAHMAN BIN NOOR ISKANDAR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

August 2020

DEDICATION

This thesis dedicated to:

To my parents,

NOOR ISKANDAR BIN ABDUL MAJID & ROSNAH BINTI SHAMSUDIN

To my siblings,

ABDULLAH, AISHAH, ANAS & AYUNIE

To in-laws,

AIDA LIYANA & NURUL AFIQAH

To my project supervisor,

IR. DR MUHAMMAD EFFENDY BIN YA'ACOB & DR.SAMSUL BIN ANUAR

To all my friends,

Especially **MOHAMMAD HAFIZ OTHMAN, MOHD ALLIPH MARYANI, & NOOR SYAFIQ IQBAL ALUWI.**

To most supportive elder,

IR. DR. JOHARI ENDAN

Late **CIKGU ABDUL RAHIM MARIUN** (Al-Fatihah)

Thanks for all your support.

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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August 2020

Chair : Mohammad Effendy bin Yaacob, PEng., PhD
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Renewable Energy (RE) concept and solution are currently being discussed and favoured worldwide due to future energy consumption. A sustainable solution, which is dependent upon sunlight, normally involving energy conversion methods being further researched due to its low efficiency. Drying technology, which utilizes sunlight is known since ancient times, having various techniques through indirect and direct method. The main problem resulted from photovoltaic technology is the electric conversion efficiency is being lowered due to heat trapped in the PV panel, hence, this project will be focused on the utilizing of heat under the same PV for drying purpose. Contribution of this research mainly be positioned on the design, planning and prototype development of a novel and new technology of dual-pass PV tray dryer intended for herbs drying controlled in a closed system. The uniqueness and distinctiveness of the system is that energy is combined to make use of heat energy dissipated under PV panel with heat energy produced by electrical heater, where heat flow controllable by dedicated temperature controller. A prototype is designed and fabricated in a manner having lightweight and portable, structured in aluminium profile, defined and specified dimension in 1.1m (L) x 0.6m (W) x 0.2m (H) with crops holding capacity of 200g (tested using Peppermint leaves), and other herbs depending on crops density and structural form. Equipped with 120W heater, temperature feedback is supplied with the heater control system. Drying temperature can be regulated to temperature around 40ºC. Two tropical assessments were successfully carried out for finding effect of RH and temperature on a dual- passes heating system under the environmental impact factors and justifications were made on the capability and efficiency to harvest heat under PV panel. The dried sample quality is validated via visual means and determined using intensity of dried sample colour. The prototype is able to drain moisture by rate of 45g/hour H20. High chlorophyll content observed in the final sample, and calculated data bringing solar heat collector efficiency (η) is 50%.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Sarjana Sains

PENILAIAN PRESTASI KAJIAN LAPANGAN TROPIKA DALAM PEMBANGUNAN DULANG PENGERINGAN FOTOVOLTAIK DWI-PEMERINGKATAN

Oleh

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Konsep dan penyelesaian melalui Tenaga Diperbaharui (RE) kini sedang dibincangkan dan diminati di seluruh dunia kerana kadar penggunaan tenaga pada masa hadapan. Penyelesaian yang mampan, yang bergantung pada cahaya matahari, biasanya kaedah penukaran tenaga sedang diteliti lebih lanjut kerana kecekapan rendah. Teknologi pengeringan yang memanfaatkan cahaya matahari dikenal sejak zaman kuno, mempunyai pelbagai teknik melalui kaedah tidak langsung dan langsung. Masalah utama dari teknologi fotovoltan ialah kecekapan penukaran elektrik semakin rendah kerana haba yang terperangkap dalam panel PV, dan kajian projek ditumpukan untuk menggunakan haba di bawah PV yang sama untuk tujuan pengeringan. Sumbangan utama penyelidikan ini terletak pada reka bentuk, perancangan dan pembinaan prototaip kebaharuan, serta teknologi terbaharu pengering dulang PV dwi-pemeringkatan yang bertujuan untuk mengeringkan herba yang dikendalikan dalam sistem tertutup. Keunikan dan keistimewaan sistem adalah tenaga digabungkan untuk menggunakan tenaga haba yang disebarkan di bawah panel PV dengan tenaga panas yang dihasilkan oleh pemanas elektrik, di mana aliran haba dapat dikendalikan oleh pengawal suhu khusus. Prototaip direka dan dibuat dengan cara yang ringan dan mudah alih, dibentuk menggunakan profil aluminium, berdimensi 1.1m (Panjang) x 0.6m (Lebar) x 0.2m (Tinggi) dengan kapasiti hasil tanaman 200g (diuji menggunakan daun pudina), dan tanaman lain bergantung pada kepadatan dan bentuk strukturnya. Dilengkapi dengan pemanas 120W, sistem maklum balas suhu dibekalkan dengan kawalan pemanas. Suhu pengeringan dapat diatur hingga suhu sekitar 40ºC. Dua penilaian tropika berjaya dilakukan untuk mencari kesan kelembapan relatif dan suhu pada sistem pemanasan dwi-pemeringkatan di bawah faktor kesan persekitaran dan justifikasi dibuat untuk keupayaan menuai haba di bawah panel PV, dan seterusnya kecekapan penuaian dapat ditentukan. Kualiti sampel kering diperhatikan melalui cara visual dan ditentukan menggunakan warna sampel kering. Prototaip ini dapat membuang

kelembapan dengan kadar 45g/jam H_20. Kandungan klorofil tinggi dapat diperhatikan dalam sampel akhir, dan data yang dikira menunjukkan kecekapan pengumpul haba solar (η) ialah 50%.

ACKNOWLEDGEMENT

Alhamdulillah. Glory and praise to Allah the Almighty for His blessing, giving me strength and power to complete this thesis.

To begin with, I would give my thanks to my family for their supports and encouragements.

I also give my sincerest appreciation and respect to my dearest supervisors Ir. Dr. Mohammad Effendy bin Ya'acob and Dr. Shamsul bin Anuar for their keen guidance and advised me through the phase of the study period. Their effort and time given for nurturing me is priceless and irreplaceable, which is vital in completing the research combined with the countless debate with RMC, resulting in an award (Gold medal in EINA Germany), patent acquirement (Malaysia PI 2016703907), approval of research funding under the IPS Putra Grants Scheme (Vote no: 99459400) and Product Promotion Fund.

Thanks to Prof. Hashimoto Yoshio and Dr. Myo Than Htay for giving me chance for experience technological research in Shinshu University and also Japanese cultures for one month. Your support may not be forgotten in my life.

Special thanks to UPM Research Management Centre (RMC) for endorsing and approving funds with paperwork for the research.

I am also grateful to have friends that understand and always supports and encouraging anything I do. Thanks for their support and motivation.

Finally, I shall give my thanks and appreciation to others which is not stated where they may aid directly or indirectly to this research.

Thank you very much.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

Δ	Change of
CdTe	Cadmium Telluride
CIGS	Copper Indium Gallium (di)selenide
DC	Direct Current
DoD	Dept of Discharge
DSSC	Dye sensitized PV cell
GaAs	Gallium Arsenide
GDP	Malaysian Gross Domestic Product
HAVs	Hybrid AgriVoltaic System
IR	Infrared
LED	Light Emitting Diode
MCB	Miniature Circuit Breaker
NIR	Near Infrared
NTC	Negative Temperature Coefficient
PID	Proportional-Integral-Derivative
PSH	Peak Sun Hour
PV	Photovoltaic
PVC	Polyvinylchloride
PWM	Pulse-Width Modulation
RACD	Reverse Absorber Dryer Cabinet
RE	Renewable Energy
RH	Relative Humidity
SEDA	Sustainable Energy Development Authority Malaysia

Si	Silicon
SIRIM	Standard and Industrial Research Institute of Malaysia
SnO_2	Tin Oxide
STC	Standard Test Conditions
SV	System Voltage
TCO	Transparent Conducting Oxides
TNBR	TNB Research
UPM	Universiti Putra Malaysia
UV	Ultraviolet
UVA	Ultraviolet type A
η	Efficiency

CHAPTER 1

INTRODUCTION

1.1 Overview

Drying techniques and technologies are important and indispensable knowledge derived from the start of human civilization. In the ancient time of human civilization, human could only preserve things using drying, salting, smoking, pickling, sweeting, fermentation, freezing and cooling techniques (Abdel-Aziz, 2016). Drying is commonly used as the influencing factors are freely available on earth till now, namely, humidity, pressure and temperature. As temperature control is concerned, common drying method available is to provide a heat source, which could be applied using electric to heat converter (heater), water particle heating by magnetic radiation (microwave), combustion, chemical reaction and natural sources (sun radiation) (Pirasteh et. al., 2014).

In general, industrial players that are using dryers are generally users of electric heater, fuel, biomass and/or charcoal (multiple derivatives), as energy sources (Murthy, 2009). When a country is developing rapidly, the demand for energy will be increased, where non-renewable sources can result to excessive depletion. Malaysian Government initiative for Renewable Energy (RE) scheme is available from Sustainable Energy Development Authority Malaysia (SEDA), where the agency controls RE source quota, and the use of solar energy through RE is vital as an alternative to some conventional energy sources.

In agriculture, solar energy can provide sufficient amount of energy for the drying process. Traditionally, the usage of solar energy has long been practiced in the areas of agriculture and food processing, especially for drying purposes (Fudholi, 2015). Drying process is one of the major parts in the food processing industry, which is related to the drying of agricultural products for the purpose of better preservation, long-term storage and exporting requirement, which harness high electrical energy and human resources (Brunetti et. al., 2015). Among the major commodities in trading industry, which require drying processes are herbs, rice, seaweed, cocoa, rubber, coffee, tea and many more other agricultural produces. Several drying techniques are being used in this industry, which are traditional method (crops are spread on a mat or floor to the sun), heater system (electrical heater coils or heat exchanger) or hybrid of traditional and heater system (Moses et. al., 2014).

The major disadvantage associated with traditional solar drying is deterioration caused by insects' infestation, enzymatic reactions, microbial growth, and development of mycotoxins (Sontakke& Salve, 2015). Furthermore, traditional solar drying is a process that is known to be labour-intensive and time-consuming and its dried product maybe prone to theft, damage and infection of zoonotic diseases that can be caused by birds or other animals (Sahu, 2016).

Therefore, to overcome the disadvantages of traditional solar drying, several modern solar dryers have been developed. Solar drying can be identified into three main of groups, which are active, passive and hybrid systems. Three subclasses of its generic have been identified, namely: direct mode- (unit collection of solar energy is an important part of the drying overall system), indirect-mode (solar collectors and a drying room are a separate unit) and mixed-mode dryer (solar collectors mixed with other sources e.g. diesel generator) (Kumar, 2016).

Most dryers utilizes heat as the mechanical process such as oven dryers, microwave dryers, spray dryer, conveyer dryer, solar dryer and many more (Orphanides et al., 2016). Drying system for agricultural commodities mostly requires temperature around 40 to 70°Cespecially in tropical countries similar to Malaysia (Yusof, 2002).

In recent years, the type of natural convection solar dryer widely used in the industries is equipped with integrated heat storage units, where by air heating can be chargeable at the solar peak hour and use (discharge) at the shaded hours or at night to a continuous supply of heat energy. This technique offers continues drying process, which is not possible with traditional solar drying after hours of exposure to sunshine. However, the disadvantages of the natural convection dryer are the process of temperature control and air velocities are having limited control, which is difficult to be regulated (Jain& Tewari, 2015)

With the downtrend in the cost of Photovoltaic (PV) solar system technology and appreciation for the need for development of solar power (Guwaeder& Ramakumar, 2017), the drying system using Solar Photovoltaic technique is introduced in this study. The basic concept of the idea is to convert the solar energy into electrical energy followed by electricity that generates thermal energy for drying purposes.

1.2 Problems Statement

In general, Photovoltaic (PV) Solar Panels produces dissipated heat energy from electric power conversion (photon conversion effect). Unused heat under the solar panel can be gathered by using many technologies (e.g. heat pipe, heat spreader and heat sink), where such collecting methods are typically costly and promoting high loss during heat transfer. For example, heat pipe utilizes material such as copper or aluminium, with fluid flowing into the pipe cavity. These heat pipes frequently need maintenance and uninterruptable flow is required in the pipe itself, plus requires scheduled maintenance on the pump (Tonui et. al., 2008).

Crops having high moisture content (Onwude et. al., 2016) such as herbs leaves, tomatoes, vegetables and many others must be dried to preserve them, giving longer and better storage life. Crop storage life is substantially improved, if the crop is dried before storage. For an example, newly harvested herb leaves typically have a moisture content of around 50% to 80% of its weight. For conserving quality and improving the storage life of the herbs leaves, the herbs leaves are required to be desiccated to a point where the moisture content is around less than 10% of its weight (Jain & Tiwari, 2004; Kant et. al., 2016). Some methods of crop drying have been attempted in the past (Essalhi et. al., 2018) where one of the conventional methods, the fruits are harvested and then dried under the sun in loose fruit form in the field for 201 hours to allow complete moisture evaporation when the fruits are not stacked to one another. If it has not been dried efficiently, it is required to be spreaded out on the ground again and allowed to dry further. This method is very inconvenient and inefficient as it requires a lot of time, even multiple days. In another conventional method developed by Costa (2018), some farmers have to spray chemicals on the harvested crop to quicken drying time of the crop (crop desiccation). This further adds on to expenses and is generally undesirable due to possible harmful effects of the chemicals used in this technique.

In conventional method, the herb leaves are gathered and placed on a large dryer system, and then heated air is forced to pass through it in order to carry away excess moisture. The dried crop is then removed and placed into storage (Onwude et. al., 2016). In this conventional method, the crop is required to be transported to the dryer system, which is not portable and fixed in one place, for example, in food processing factories. However, if the crop is grown in remote areas, such as mountains or forests, transportation of the crop to the food processing factory may take longer time, and some of the crops may rot along the way, as the crop should be dried as soon as possible to preserve its quality (Onwude et. al., 2016).

Therefore, there is a huge demand for an improved crop dryer system, which can solve above mentioned problems associated with conventional crop dryers, by using a dual pass heating system that utilizes heat under PV combined with heater mechanism, in a closed system. The technology to be improved and developed in this study shall benefit the food processing, agricultural and research and development sectors for a more effective, cost-saving, time-saving and mass productive drying system that will further improve the economic sector in Malaysia and other countries, when the exported commodities are in high quality and quantity in meeting the international market standards.

1.3 Research Aim and Objectives

The aim of this project is to study and improve the technique utilization of solar energy for the purpose to develop a Dual-Pass PV-Tray-Dryer for the agricultural product (crops) in addition to promote clean energy system, while providing sustainability.

The objectives of this project are:

1. To develop the Dual-Pass PV Tray Dryer prototype.
2. To conduct field assessment on meteorological factors under tropical climatic condition.
3. To analyse the dryer performance based on the efficiency of heat collector.

1.4 Significance of study

Modern solar dryer has been developed over the last decades and many studies and improvements have been carried out. However, most of the dryers are designed using the concept of capturing direct-energy from sunlight, targeting thermal radiation and exploits the thermal energy as the drying mechanism. This study shall bring the potential for new path in developing a method of solar utilization and improve the common drying system, which can be adjusted with optimization. The main uniqueness of this solar energy utilization method is the heat dissipated by PV panel combined with electrical energy produced by solar PV, then applied for drying process besides the drying process parameters (e.g. temperature, humidity and pressure) applicable to control and management. The opportunity and advantages for drying system is through observation of the control system itself, whereby better control system can be improved through solar dryer technique, thus, indirectly improving the quality of dried product.

1.5 Scope of Work and Research Contributions

This research is focused on an herb dryer with the capability of easy-assembly, portability, and reliability, which proves practice on its concept. The work is bringing Renewable Energy (RE) with sustainability concept, containing a lightweight dryer and a solar panel. The dryer is constructed with a tray, which can be used to shield crops from sand, dirt or any impurities, which makes use of food grade material throughout product development. The research is focused to find: (1) environmental or external values: ambient temperature, wind speed, humidity and solar radiation; (2) internal values: solar panel surface, heat collector area, and drying chamber temperatures.

Research scope is described as follows:

1. The project outcome is to produce a prototype as a proof of concept on the Dual-pass drying. It has achieved the field assessment and some output for performance indicator. The requirement for food standard is a critical part to be considered, especially when this prototype is to be extended to stage of commercialization. Thus, the requirement is a good potential for further research.

2. The Assessment 1 test has been performed at Universiti Putra Malaysia (UPM) Solar PV Pilot Plant, located at 2.988974, 101.725115 or 2° 59'

20.3064" N, 101° 43' 30.414" E. The sample test have been tested under normal wind condition under 1.8 m/s, relative humidity under 85% and solar irradiation more than 200W/m^2. The Assessment test has been performed at Universiti Putra Malaysia (UPM) Hybrid AgriVoltaic System (HAVs), Faculty of Engineering, located at 3.008328, 101.722170 or 3° 0' 29.9808" N, 101° 43' 19.812" E.

3. The Assessment 1 sensors are RH (ambient, weather station), pyranometer (solar irradiation), anemometer (wind speed), T1 (top surface PV), T2 (drying chamber area), T3 (bottom surface PV), T4 (ambient temperature), T5 (heat collector air temperature), RH1 (ambient at prototype), RH2 (drying chamber) and RH3 (Air after through 2nd pass).

4. The Assessment 2 is comprised of sensors such as RH1 (ambient), RH2 (dryer chamber), T1 (drying chamber), T2 (ambient temperature) and T3 (Heat Collector).

5. The samples used in this test are distinguished based onsize and shape, but limited to herbs, i.e. peppermint (*Mentha Lamiaceae*). Shape of the sample, which is quality attributes of the leaves, is affecting the research output, namely, humidity and temperature, but the main consideration is for product user-endpoint, where product-user use the proposed system with varying degrees of shape. By-product usage limitation, the sample attributes can be considered as beyond control of researchers, which is known as influence to research.

6. A limitation on operational aspect arises where drying time is highly dependent on battery and solar input. As peak-sun-hour (PSH) is needed for maximum operational capability, the study is designed to operate in 3-4 hours on PSH mode, which is appropriate and applicable for tropical region. However, the system is equipped with off-solar mode, considering possibility of low or no solar input (i.e. direct grid power supply or additional battery power bank).

7. Due to the assessments, no general comparison can be made with other drying methods, as the prototype is proven to be newly developed and novel in dual-pass drying technique. This work provides the potential field performance as the initial base line.

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APPENDICES

Appendix A: File for Patent

Patents Form No.1 PATENTS ACT 1983 REQUEST FOR GRANT OF PATENT (Regulations 7(1)) To: The Registrar of Patents Patents Registration Office Kuala Lumpur, Malaysia	For Official Use APPLICATION NO: **PI 2016703907** Filing Date: **25/10/2016** Fee received on: **25/10/2016** Amount: **RM360**
Please submit this Form in duplicate together with the prescribed fee	Applicant's file reference: **U035/P/UPM/16MY2/FR**

THE APPLICANT(S) REQUEST(S) THE GRANT OF A PATENT IN RESPECT OF THE FOLLOWING PARTICULARS:
I. TITLE OF INVENTION: **DUAL-PASS PHOTOVOLTAIC TRAY DRYER**

II. APPLICANT(S) (the data concerning each applicant must appear in this box or , if the space insufficient, in the space below):

Name: **UNIVERSITI PUTRA MALAYSIA**
I.C./Passport No:
Address: **PUTRA SCIENCE PARK, PEJABAT TIMBALAN NAIB CANSELOR (PENYELIDIKAN DAN INOVASI), UNIVERSITI PUTRA MALAYSIA, UPM SERDANG, 43400 SELANGOR MALAYSIA**
Nationality: **MALAYSIA**

Address for service in Malaysia: **C/O ADASTRA INTELLECTUAL PROPERTY SDN. BHD., A-39-10 PENTHOUSE, MENARA UOA BANGSAR, NO.5, JALAN BANGSAR UTAMA 1 59000 KUALA LUMPUR MALAYSIA**
* Permanent resident or principal place of business:
Telephone Number (if any) Fax Number (if any) Additional Infomation (if any)

Additional Infomation (if any)

III.INVENTOR:

Applicant is the inventor: Yes No √
If the applicant is not the inventor
Name: **MOHAMMAD EFFENDY BIN YAACOB**
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Applicant is the inventor: Yes No √
If the applicant is not the inventor
Name: **ABDURRAHMAN BIN NOOR ISKANDAR**
Address: **FAKULTI KEJURUTERAAN, UNIVERSITI PUTRA MALAYSIA, UPM SERDANG 43400 SELANGOR MALAYSIA**

A statement justifying the applicant's to the patent accompanies this Form
Yes No √

Additional Information (if any)

IV.AGENT OR REPRESENTATIVE:

Applicant has appointed a patent agent in accompanying Form No. 17 Yes √ No
Agent Registration No: **PA/2004/0141**
Applicant has appointed to be their representative: **MOHAN K.**

V. DIVISIONAL APPLICATION:

This application is a divisional application
The benefit of the filing date priority date
of the initial application is claimed in as much as the subject-matter of the present application is contained in the initial application identified below :
Initial Application No:
Date of filing of initial application:
Additional Information (if any)

VI. DISCLOSURE TO BE REGARDED FOR PRIOR ART PURPOSES:

(a) Disclosure was due to acts of applicant or his predecessor in title
Date of disclosure:
(b) Disclose was due to abuse of rights of applicant or his predeceesor in title
Date of disclosure:
A statement specifying in more detail the facts concerning the disclosure accompanies this Form. Yes No √

Additional Information (if any)

VII. PRIORITY CLAIM (if any)

The priority of an earlier application is claimed as follows :
Country (if the earlier application is a regional or international application, indicate the office with which it is field) :
Filing Date:
Application No:
Symbol of the International Patent Classification:
If not yet allocated, please tick
The priority of more than one earlier application is claimed

Yes No √
The certified copy of the earlier application(s) accompanies this Form

Yes No √
If No, it will furnished by Date:

Additional Information (if any)

VIII.CHECK LIST

A. This application contains the following:

1. Request	1	sheets
2. Description	10	sheets
3. Claim	3	sheets
4. Abstract	1	sheets
5. Drawings	6	sheets
Total	21	sheets

B. This Form, asfiled, is accompanied by the items checked below :
(a)Signed Form No. 17
(b)Declaration that inventor does not wish to be named in the patent
(c)Statement justifying applicant's right to the patent
(d)Statement that certain disclosure be disregarded
(e)Priority document (certified copy of earlier application)
(f) Cash, cheque, money order, bank draft or postal order for the payment of application fee
(g)Other documents (specify)

IX.SIGNATURE: **mail=account@adastra.com.my, cn=MOHANA MURALI KODIVEL, ou=Contact Number - 0322842281,ou=Identity Card / Passport No -##############, ou=Terms of use at www.msctrustgate.com/rpa (c)00, ou=Bahagian Teknologi Maklumat V2, o=Perbadanan Harta Intelek Malaysia, l=&quotA-28-10 MENARA UOA BANGSAR, NO.5 JALAN BANGSAR UTAMA 1&quot, st=&quot59000 KUALA LUMPUR, WILAYAH PERSEKUTUAN&quot, c=MY, CertSerialNo=2216e31ce4afd0990dda52aab89933e3|** **25/10/2016**

**(~~Applicant~~/Agent) (Date)

If Agent, indicate Agent's Registration No.: **PA/2004/0141**

For Official Use
Date application received: **25/10/2016**
Date of receipt of correction, later filed papers or drawings completing the application: **-**

* Delete whichever do not apply
** Type name under signature and delete whichever do not apply

DUAL-PASS PHOTOVOLTAIC TRAY DRYER

FIELD OF THE INVENTION

[001] Embodiments of the present invention, generally relate to a dryer for drying agriculture raw materials, and in particular relate to a photo voltaic dryer system for drying the agriculture raw materials.

BACKGROUND

[002] Crops having high moisture content (for example, grass, wheat etc.) must be dried before storage in order to preserve them. Storage life of a crop is substantially improved if the crop is dried before the storage. For example, newly cut grass typically has a moisture content of around 50 to 80% of its weight. For preserving quality and improving the storage life of the grass, the grass is required to be dehydrated to a point where the moisture content is approximately less than 10% of its weight.

[003] Many methods of crop drying have been attempted in the past. In one of the conventional method, the grass is cut and then dried under the sun as a loose mass in the field for a couple of days. Then, the grass is turned upside down so that the sun can dry the material that was on the ground. If it has not dried sufficiently, it is required to be spread out on the ground again and allowed to dry further. This method is very inconvenient and inefficient as it requires lot of time, even multiple days.

[004] In another conventional method, some farmers spray chemicals on the cut crop to quicken drying time of the crop. This adds to expense and is generally undesirable due to the possible harmful effects of the chemicals in future uses of the grass.

[005] In yet another conventional method, the grass is gathered and placed on a large dryer system, and then heated air is forced to pass through it in order to carry away excess moisture. Following drying, the dried crop is then removed and placed into storage. In this conventional method, the crop is required to be transported to the dryer system, which is not portable and fixed at one place, for example, food processing factories. However, if the crop is grown in remote areas, such as mountains or forests, transportation of the crop to the food processing factory may take a lot of time, and some of the crop may get wasted as the crop should be dried as soon as possible to preserve its quality.

[006] Therefore, there is a need for an improved crop dryer system, which solves above mentioned problems associated with conventional crop dryers.

SUMMARY

[007] According to an aspect of the present disclosure, a photo voltaic dryer system (100) for drying agriculture produces is provided herein. The photo voltaic dryer system (100) includes a photo voltaic module (11) configured to receive sunlight, convert the sunlight into direct electricity, and charge a battery (30). The photo voltaic dryer system (100) further includes a heater (26) configured to receive energy from the battery (30) and provide heat to incoming air.

[008] The photo voltaic dryer system (100) further includes a tray (18) located between the photo voltaic module (11) and the heater (26), the tray (18) configured to receive a crop desired to be dried. During operation, the air is driven at bottom of the photo voltaic module (11) to collect dissipated heat from the photo voltaic module (11), and further the air is driven to absorb heat from the heater (26) to become heated air, and the heated air is driven through the crop to absorb moisture content from the crop.

[009] The preceding is a simplified summary to provide an understanding of some aspects of embodiments of the present invention. This summary is neither an extensive nor exhaustive overview of the present invention and its various embodiments. The summary presents selected concepts of the embodiments of the present invention in a simplified form as an introduction to the more detailed description presented below. As will be appreciated, other embodiments of the present invention are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The above and still further features and advantages of embodiments of the present invention will become apparent upon consideration of the following detailed description of embodiments thereof, especially when taken in conjunction with the accompanying drawings, and wherein:

[0011] FIG. 1 illustrates a schematic diagram of a isometric view of a photo voltaic dryer system, according to an embodiment of the present invention;

[0012] FIG. 2 illustrates a schematic diagram of a bottom view of the photo voltaic dryer system, according to an embodiment of the present invention;

[0013] FIG. 3 illustrates a schematic diagram of an exploded view of the photo voltaic dryer system, according to an embodiment of the present invention;

[0014] FIGS. 4A and 4B illustrate a schematic diagram of a top view and a side view of the photo voltaic dryer system, according to an embodiment of the present invention;

[0015] FIG. 5 depicts an exemplary comparison of a dried crop, which has been dried using direct sun in first method and using photo voltaic dryer system in second method, according to an embodiment of the present invention; and

[0016] FIG. 6 depicts a graph illustrating enhanced efficiency of drying the crop by the photo voltaic dryer system using temperatures inside drying chambers.

[0017] To facilitate understanding, like reference numerals have been used, where possible, to designate like elements common to the figures.

DETAILED DESCRIPTION

[0018] As used throughout this application, the word "may" is used in a permissive sense (*i.e.*, meaning having the potential to), rather than the mandatory sense (*i.e.*, meaning must). Similarly, the words “include”, “including”, and “includes” mean including but not limited to.

[0019] The phrases “at least one”, “one or more”, and “and/or” are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions “at least one of A, B and C”, “at least one of A, B, or C”, “one or more of A, B, and C”, “one or more of A, B, or C” and “A, B, and/or C” means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

[0020] The term “a” or “an” entity refers to one or more of that entity. As such, the terms “a” (or “an”), “one or more” and “at least one” can be used interchangeably herein. It is also to be noted that the terms “comprising”, “including”, and “having” can be used interchangeably.

[0021] The term “automatic” and variations thereof, as used herein, refers to any process or operation done without material human input when the process or operation is performed. However, a process or operation can be automatic, even though performance of the process or operation uses material or immaterial human input, if the input is received before performance of the process or operation. Human input is deemed to be material if such input influences how the process or operation will be performed. Human input that consents to the performance of the process or operation is not deemed to be “material”.

[0022] FIG. 1 illustrates a schematic diagram of an isometric view of a photo voltaic dryer system (100), according to an embodiment of the present invention. The photo voltaic dryer system (100) is configured to receive agriculture produce in a drawer chamber (7) such as a crop desired to be dried, and dry the crop in order to be preserved. According to an embodiment of the present disclosure, the photo voltaic dryer system (100) is portable and can be easily assembled and disassembled. Those skilled in the art will appreciate that the portability allows usage of the photo voltaic dryer system (100) in remote areas, for example, mountains and forests.

[0023] The photo voltaic dryer system (100) includes a solar photo voltaic module (11) and an induction heater (26) (shown in FIG. 4). According to an embodiment of the present disclosure, the solar photo voltaic module (11) is configured to absorb sunlight, convert the sunlight in direct electricity, and charge a battery (30). The induction heater (26) is configured to take energy from the battery (30) and provide heat to incoming air. Those skilled in the art will appreciate that, in remote areas, direct charging of the battery (30) from the photo voltaic module (11) provides an easy and reliable source of charging to the battery (30).

[0024] Further, the incoming air is also heated from heat dissipated from the solar photo voltaic module (11). Thus, the photo voltaic dryer system (100) system is configured to utilize heat from bottom of the photo voltaic module (11) which otherwise would have been wasted. Those skilled in the art will appreciate that photo voltaic dryer system (100) provides exhaustive usage of the sunlight and heat generated at the bottom of the photo voltaic module (11).

[0025] In an embodiment, the solar photo voltaic module (11) is configured to give a power output of 100 watt. However, in another embodiment, the solar photo voltaic module (11) may be configured to give any other power output as per the requirement. Further, in an embodiment, temperature inside tray (where crop is put for drying purpose), may reach up to 80 degree C with safety features (for example, DC circuit breakers, temperature controller, charge controller, power inverter, hand rail etc.). Further, in an embodiment, weight of the photo voltaic dryer system (100) may be around 12 kg and is configured to be easily assembled and storage.

[0026] As shown in FIG. 1, the solar photo voltaic module (11) is located above an aluminium plate (1). Further, in an embodiment dimensions (length and width) of the aluminium plate are 1.10 meter and 0.59 meter. In another embodiment, any other dimension may be preferred. Those skilled in the art will appreciate that dimensions of the aluminium plate have been chosen so as to keep the photo voltaic dryer system (100) portable.

[0027] Below the aluminum plate (1), a first hollow rectangle (2) is located. In an embodiment, the first hollow rectangle (2) provides a passage to incoming air to enter into the photo voltaic dryer system (100) and collect the dissipated heat from bottom of the photo voltaic module (11). Below the first hollow rectangle (2), there is second hollow rectangle (9). The second hollow rectangle (9) includes an air outlet (10) (shown in Fig. 4). The air outlet (10) is configured to provide an exit path to the moist air coming from the crop after providing drying effect to the crop.

[0028] Below the second hollow rectangle (9), there is a third hollow rectangle (7). The third hollow rectangle (7) is configured to house a tray that can be inserted inside as well as withdrawn from it. The tray may contain a crop that is desired to be dried. Below the third hollow rectangle (7), there is a fourth hollow rectangle (31). The fourth hollow rectangle is configured to provide housing to the induction heater (26) (shown in FIG. 4).

[0029] According to an embodiment of the present invention, size/dimensions (length and width) of the first hollow rectangle (2) are larger than the second hollow rectangle (9), third hollow rectangle (7), and fourth hollow rectangle (31). In an embodiment, such arrangement (i.e. larger dimension of the first hollow rectangle (2) than other hollow rectangles) provides space for an air inlet (24), a power inverter (29), and a PV charge controller (28) (shown in FIG. 2) at bottom of the aluminum plate (1). Further, dimensions of the second hollow rectangle (9), third hollow rectangle (7), and fourth hollow rectangle (31) are almost equal. Furthermore, in an embodiment, combined breadth of the second, third, and fourth hollow rectangles is 0. 21 meter. Those skilled in the art will appreciate that any other dimensions may be chosen as long as the chosen dimensions facilitate portability of the photo voltaic dryer system (100).

[0030] FIG. 2 illustrates a schematic diagram of a bottom view of the photo voltaic dryer system, according to an embodiment of the present invention. As shown in FIG. 2, the photo voltaic dryer system 100 includes the air inlet (24), which is configured to let fresh air enter the photo voltaic dryer system (100). The photo voltaic dryer system (100) further includes the photo voltaic charge controller (28). The photo voltaic charge controller (28) is configured to control charging of battery (30) from the photo voltaic module (11). In an embodiment, the charge controller (28) is configured to provide output voltage 5V to 12 V DC, which can be fed to electronic appliances such as smartphone, laptop charging, LED lighting etc. Further, the charge controller (28) also provides safety feature and may be embedded with a monitor panel (not shown in figure).

[0031] Further, the photo voltaic dryer system (100) includes the power inverter (29) and the battery (30) (not shown in figure). The inverter (29) is configured to receive direct current from the battery (30), convert the direct current taken from the battery (30) into alternating current, which may be used to rotate the fan (27).

[0032] FIG. 3 illustrates a schematic diagram of an exploded view of the photo voltaic dryer system, according to an embodiment of the present invention. As shown in the figure, the solar photo voltaic panel (11) rests at top of the photo voltaic dryer system (100). In an embodiment, the solar photo voltaic panel (11) is flexible solar photo voltaic panel. The aluminum plate (1) is provided below the flexible solar photo voltaic panel (11). In another embodiment, the plate (1) may be formed using any other material. Below the aluminum plate (1), the first hollow rectangle (2) is located. In an embodiment, the first hollow rectangle (2) provides a passage to incoming air to enter into the photo voltaic dryer system (100). Further, inside the first hollow rectangle (2), a socket (4) is provided.

[0033] Further, the first hollow rectangle (2) includes a handle (23), as shown in the figure. In an embodiment, the handle (23) is made of high-density polyethylene (HDPE). Below the first hollow rectangle (2), there is another aluminum plate (16). Below the aluminum plate (16), there is an air flow socket (13). In an embodiment, the air flow socket (13) is made of aluminum. In another embodiment, the air flow socket (13) may be made of any other material. Below the aluminum air flow socket (13), the second hollow aluminum rectangle (9) is located. The second hollow rectangle (9) includes the air outlet (10), which is configured to provide an exit path to the moist air after drying the crop. Below the second hollow aluminum rectangle (9), the third hollow aluminum rectangle (7) is located, which may contain the crop.

[0034] The third hollow aluminum rectangle (7) is configured to receive a tray (18), which is used to contain crop that is desired to be dried. The tray (18) includes a socket (21). Further, the tray (18) includes an edge (20), which is made of aluminum and is L-profile shaped. The tray (18) further includes a hollow rectangle (5) made of aluminum. Below the third hollow rectangle (7), the fourth hollow rectangle (31) is located. The fourth hollow rectangle is configured to provide housing to the induction heater (26). Below the fourth hollow aluminum rectangle (31), there is an insulator polystyrene (8), which is followed by an aluminum insulator sheet (15). At the bottom of the photo voltaic dryer system and below the aluminum insulator sheet (15), there is an aluminum plate (14).

[0035] FIGS. 4A and 4B illustrate a schematic diagram of a top view and side view of the photo voltaic dryer system (100), according to an embodiment of the present invention. As shown in FIG. 4A, the solar photo voltaic module (11) is located above the aluminium plate (1). Further, the top view includes the handle (23).

[0036] As shown in FIG. 4B, the photo voltaic dryer system 100 includes an air inlet (24) and the air outlet (10). Further, the photo voltaic dryer system includes the crop (25) and the heater (26). Further, the photo voltaic dryer system includes a fan (27). The fan (27) is configured to drive in fresh air inside the photo voltaic dryer system (100) and drive out moist air from the crop for drying the crop. In an embodiment, the fan is connected to the power inverter (29). Further, the power inverter (29) is connected to the battery (30), which is being charged by the solar photo voltaic module (11).

[0037] In operation, the fan (27) is configured to force the air to flow from fresh air source towards a bottom surface of the photo voltaic panel (11). When the air comes into contact of the bottom surface of the photo voltaic panel (11), the air collects dissipated heat, which is available after the conversion of the sunlight into direct electricity. The bottom surface of the photo voltaic panel (11) provides first round of heating to the air inside into the photo voltaic dryer system and the air may become warm air.

[0038] Further, the fan (27) is configured to drive the warm air in contact with bottom surface of the photo voltaic panel (11), towards the heater (26). In an embodiment, the heater (26) is an induction heater, which takes energy from a battery attached with the photo voltaic dryer system. In another embodiment, the heater (26) may be any other type of heater. The induction heater (26) is configured to provide second round of heating to the warm air to turn it into heated air. Further, the fan (27) drives the heated air towards the crop that is desired to be dried. Next, the heated air passes through the crops to absorb moisture content. Next, the fan (27) drives the wet air to flow outside of the photo voltaic dryer system, through the air outlet (10).

[0039] Those skilled in the art will appreciate that since the air is heated from two sources (one from bottom surface of the photo voltaic panel and another from the induction heater), the photo voltaic dryer system (100) provides an intense heating of the air, which may dry the crop in a substantially lesser time. Further, the photo voltaic dryer system utilizes heat from the bottom surface of the photo voltaic panel (11), which otherwise would have been wasted.

[0040] FIG. 5 depicts an exemplary comparison of a dried crop (502), which has been dried using direct sun in first method, and another dried crop (504) which has been dried using the photo voltaic dryer system (100), according to an embodiment of the present invention. As shown in the figure, quality of dried crop (504) is much better than the dried crop (502). Those skilled in the art will appreciate that the improved quality of the dried crop (504) is due to much less time taken by the photo voltaic dryer system (100) than the conventional drying system.

[0041] FIG. 6 depicts a graph illustrating enhanced efficiency of drying the crop by the photo voltaic dryer system (100) using temperatures of the drying chamber. Since, the photo voltaic dryer system (100) provides dual-source of heating the air, the photo-voltaic dyer system (100) provides enhanced values of drying chamber temperatures for both with and without air convection (as shown in figure also). Further, the photo voltaic dryer system (100) works far more efficient in drying of crops (time taken, crops quality, etc.) as compared to natural drying of the crops.

[0042] The photo voltaic dryer system (100) advantageously provides a dual-pass heating mechanism for drying crops, in order to preserve the crops. The photo voltaic dryer system (100) advantageously provides harvesting of the dissipated heat from photo voltaic module (after electricity conversion process or photonic effect) as well as absorbing heat energy from the induction heater.

[0043] Further, the photo voltaic dryer system (100) is constructed in such a way so that the air convection (inside heating chamber) flows directly from these two heating source towards the crops for drying process. Further, the photo voltaic dryer system (100) provides portability feature that enables users to dissemble and pack the equipment to mobilise in remote areas to preserve collected sample. Further, the photo voltaic dryer system (100) provides a tray that can be custom-made and easily attached. Furthermore, the photo voltaic dryer system (100) may aslo be used as a multi purpose system for electronic devices.

[0044] The foregoing discussion of the present invention has been presented for purposes of illustration and description. It is not intended to limit the present invention to the form or forms disclosed herein. In the foregoing Detailed Description, for example, various features of the present invention are grouped together in one or more embodiments, configurations, or aspects for the purpose of streamlining the disclosure. The features of the embodiments, configurations, or aspects may be combined in alternate embodiments, configurations, or aspects other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention the present invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment, configuration, or aspect. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of the present invention.

[0045] Moreover, though the description of the present invention has included description of one or more embodiments, configurations, or aspects and certain variations and modifications, other variations, combinations, and modifications are within the scope of the present invention, *e.g.*, as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments, configurations, or aspects to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

CLAIMS

1. A photo voltaic dryer system (100) for drying agriculture produces, the photo voltaic dryer system (100) comprising:

    a photo voltaic module (11) configured to receive sunlight, convert the sunlight into direct electricity, and charge a battery (30);

    a heater (26) configured to receive energy from the battery (30) and provide heat to incoming air; and

    a tray (18) located between the photo voltaic module (11) and the heater (26), the tray (18) configured to receive a crop desired to be dried,

    wherein in operation, the air is driven at bottom of the photo voltaic module (11) to collect dissipated heat from the photo voltaic module (11), and further the air is driven to absorb heat from the heater (26) to become heated air, and the heated air is driven through the crop to absorb moisture content from the crop.

2. The photo voltaic dryer system (100) of claim 1, wherein the battery (30) is attached to the photo voltaic dryer system (100).

3. The photo voltaic dryer system (100) of claim 1, further comprising a photo voltaic charge controller (28) connected between the battery (30) and the photo voltaic module (11).

4. The photo voltaic dryer system (100) of claim 1, further comprising a fan (27) configured to drive fresh dry air inside the photo voltaic dryer system (100).

5. The photo voltaic dryer system (100) of claim 4, wherein the fan (27) is configured to drive the fresh air towards the bottom of the photo voltaic module (11).

6. The photo voltaic dryer system (100) of claim 5, wherein the fan (27) is configured to drive warm air from the bottom of the photo voltaic module (11) towards the heater (26).

7. The photo voltaic dryer system (100) of claim 6, wherein the fan (27) is configured to drive the heated air towards the crop to absorb moisture from the crop.

8. The photo voltaic dryer system (100) of claim 7, wherein the fan (27) is configured to drive the air outside from an outlet (10) after the heated air has passed through the crop.

9. The photo voltaic dryer system (100) of claim 1, wherein the heater (26) is an induction heater.

10. The photo voltaic dryer system (100) of claim 1, wherein the photo voltaic dryer system (100) is portable.

11. The photo voltaic dryer system (100) of claim 1, further comprising a first hollow rectangle (2) located below the photo voltaic module (11), and configured to provide a passage to the incoming air to come in contact with the bottom of the photo voltaic module (11).

12. The photo voltaic dryer system (100) of claim 11, further comprising a second hollow rectangle (9) located below the first hollow rectangle (2) and configured to have an air outlet (10).

13. The photo voltaic dryer system (100) of claim 12, further comprising a third hollow rectangle (7) located below the second hollow rectangle (2), and configured to have the tray (18).

14. The photo voltaic dryer system (100) of claim 13, further comprising a fourth hollow rectangle (31) located below the third hollow rectangle (2), and configured to house the heater (26).

15. The photo voltaic dryer system (100) of claim 14, wherein size of the first hollow rectangle (2) is larger than the second hollow rectangle (9), the third hollow rectangle (7), and the fourth hollow rectangle (31).

ABSTRACT

DUAL-PASS PHOTOVOLTAIC TRAY DRYER

A photo voltaic dryer system (100) for drying agriculture produces is provided herein. The photo voltaic dryer system (100) includes a photo voltaic module (11) configured to receive sunlight, convert the sunlight into direct electricity, and charge a battery (30). The photo voltaic dryer system (100) further includes a heater (26) configured to receive energy from the battery (30) and provide heat to incoming air. The photo voltaic dryer system (100) further includes a tray (18) located between the photo voltaic module (11) and the heater (26), the tray (18) configured to receive a crop desired to be dried. During operation, the air is driven at bottom of the photo voltaic module (11) to collect dissipated heat from the photo voltaic module (11), and further the air is driven to absorb heat from the heater (26) to become heated air, and the heated air is driven through the crop to absorb moisture content from the crop.

Most illustrative drawings: figure 1

100

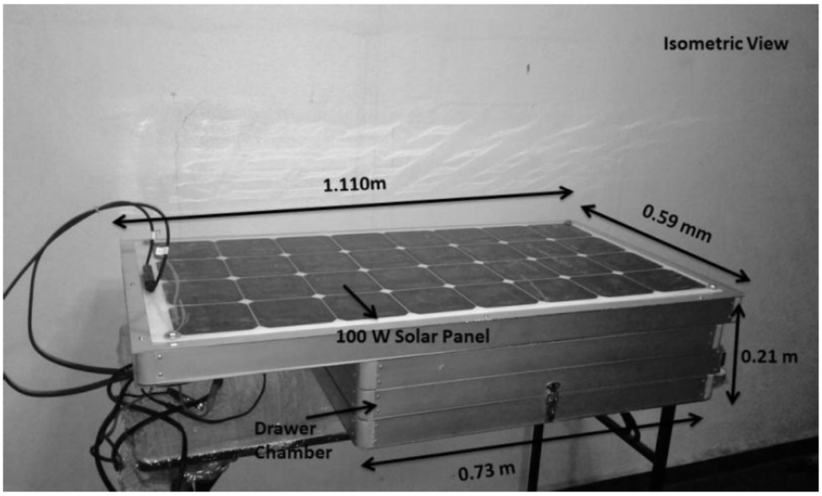

Isometric View
1.110m
0.59 mm
100 W Solar Panel
0.21 m
Drawer
Chamber
0.73 m

FIG. 1

100

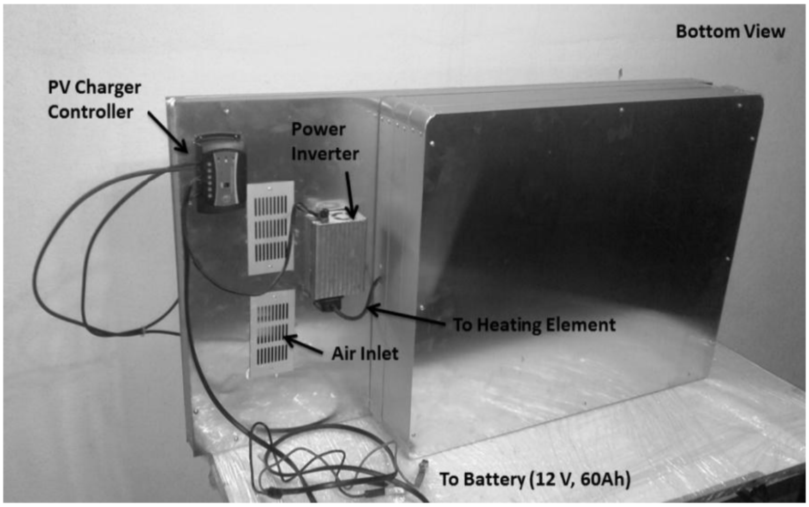

Bottom View
PV Charger Controller
Power Inverter
To Heating Element
Air Inlet
To Battery (12 V, 60Ah)

FIG. 2

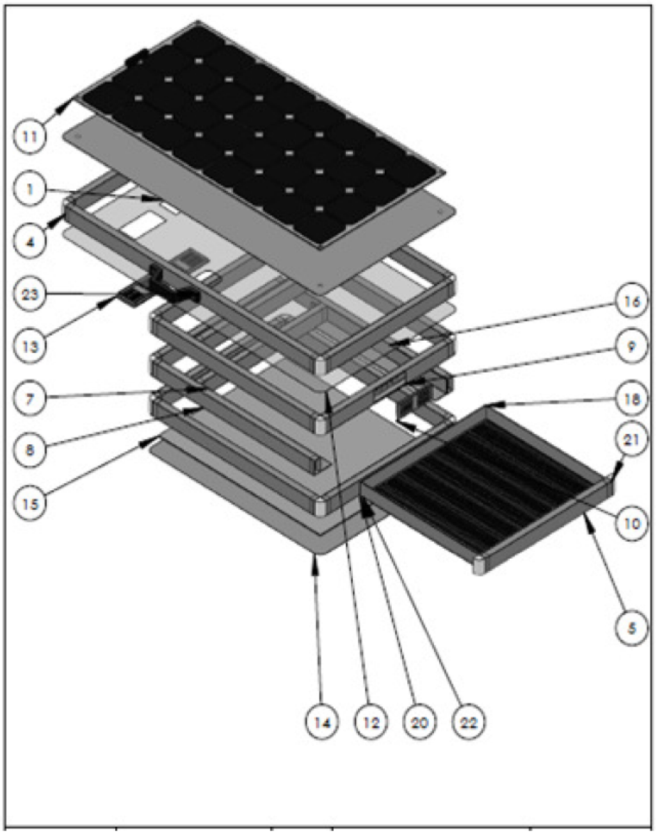


FIG. 3

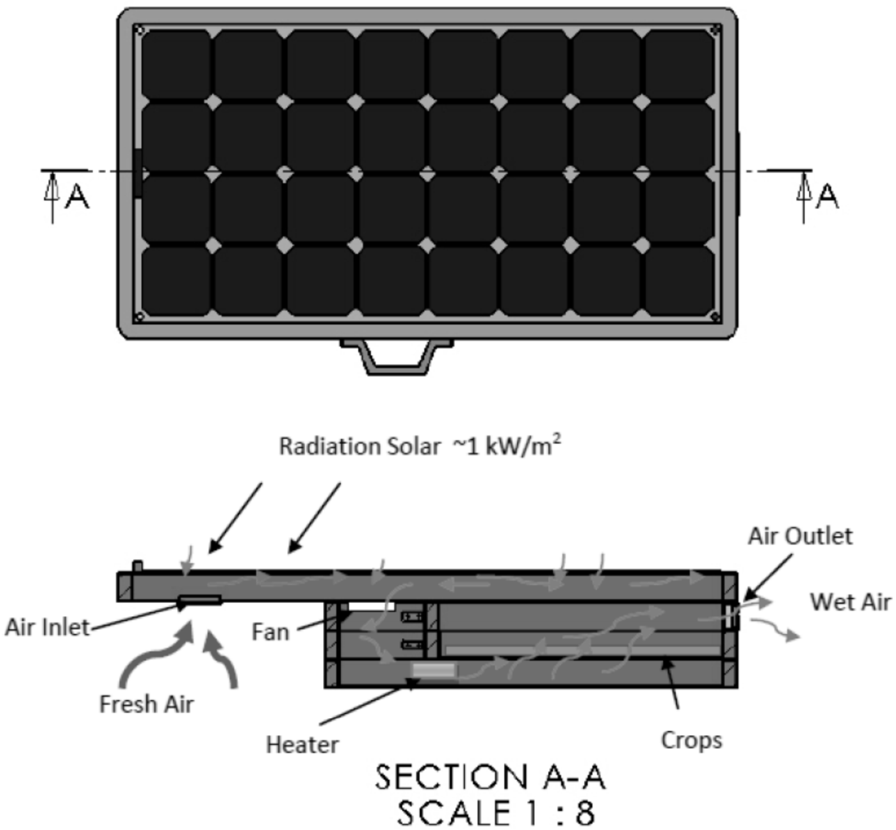
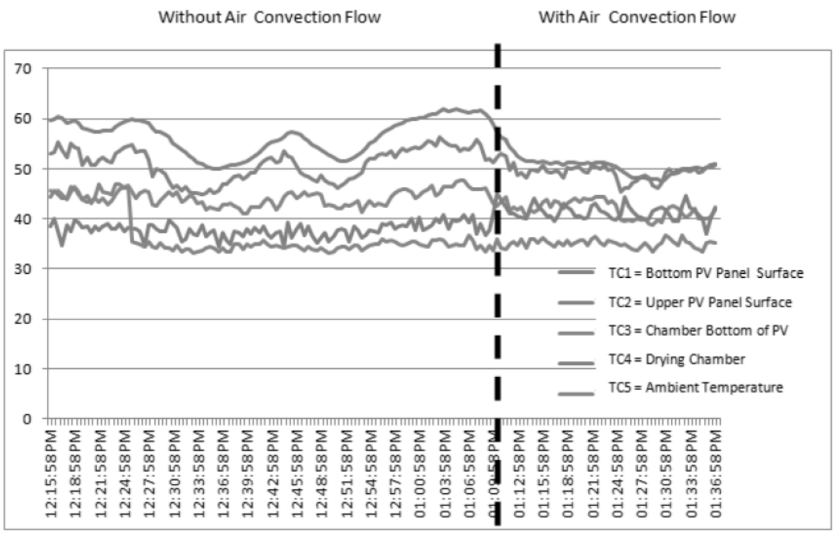

A
A
Radiation Solar ~1 kW/m2
Air Outlet
Wet Air
Air Inlet
Fan
Fresh Air
Heater
Crops
SECTION A-A
SCALE 1 : 8

FIG. 4

FIG. 5



Without Air Convection Flow
With Air Convection Flow
70
60
50
40
30
20
10
0
TC1 = Bottom PV Panel Surface
TC2 = Upper PV Panel Surface
TC3 = Chamber Bottom of PV
TC4 = Drying Chamber
TC5 = Ambient Temperature
12:15:58PM
12:18:58PM
12:21:58PM
12:24:58PM
12:27:58PM
12:30:58PM
12:33:58PM
12:36:58PM
12:39:58PM
12:42:58PM
12:45:58PM
12:48:58PM
12:51:58PM
12:54:58PM
12:57:58PM
01:00:58PM
01:03:58PM
01:06:58PM
01:09:58PM
01:12:58PM
01:15:58PM
01:18:58PM
01:21:58PM
01:24:58PM
01:27:58PM
01:30:58PM
01:33:58PM
01:36:58PM

600

FIG. 6

BIODATA OF STUDENT

Abdurrahman bin Noor Iskandar graduated from Universiti Putra Malaysia in bachelor degree Food and Process Engineering (Hons.) in 2016 and continues his study on Master in Sciences by Thesis in Agriculture Process Engineering. Before his study in bachelor degree, he experiences engineering technical field area as a mechanical, agriculture, electronics and control system designer and programmer. He also involve in social field area such as education and motivation consultation. He was registered as Graduated Engineer (GE161125) in the Board of Engineer Malaysia (BEM) on 2018. During his Master's study period, he was active researching on Green and Renewable Energy (RE) initiatives especially in Solar PV System. His interest is in research of Agrivoltaic system and environmental impact, integrated with modern farming system which involving instrumentation and mechanization.

LIST OF PUBLICATION

Iskandar, A. N., & Ya'acob, M. E. (2016, November). Temperature performance of a 3-tier solar PV drying chamber. In *2016 IEEE Industrial Electronics and Applications Conference (IEACon)* (pp. 112-115). IEEE. DOI: 10.1109/IEACON.2016.8067365

Iskandar, A. N., Ya'acob, M. E., & Anuar, M. S. (2017, September). Tropical field performance of dual-pass PV tray dryer. In *AIP Conference Proceedings* (Vol. 1885, No. 1, p. 020016). AIP Publishing LLC. DOI: 10.1063/1.5002210

PATENT

Title Invention: DUAL-PASS PHOTOVOLTAIC TRAY DRYER
Patent No : Malaysia PI 2016703907

PRESS RELEASE

Harian Metro, Agro, pg. 3
May 13th, 2017

PENGERING MUDAH ALIH

Dual-Pass Tray Dryer guna kuasa solar keringkan hasil tanaman atau makanan

DR Mohammad Effendy menunjukkan daun yang dikeringkan.

INOVASI

Mohamad Hussin
mohamad_hussin@hmetro.com.my

Bayangkan betapa sukarnya peladang teh yang bekerja keras di atas bukit dan gunung memetik daun teh untuk diproses.

Mereka bukan saja perlu membawa daun yang lembap dengan lori ke tempat peranginan, malah daun teh yang masih lembap juga terdedah kepada bakteria.

Masalah ini dapat diatasi berikutan kejayaan penyelidik UPM menghasilkan inovasi alat pengering dikenali sebagai Dual-Pass PV Tray Dryer.

Teknologi itu bukan saja boleh digunakan untuk mengeringkan tanaman khususnya herba, malah usahawan industri kecil dan sederhana (IKS) juga boleh mengeringkan keropok dan ikan kering.

Penyelidik dari Fakulti Kejuruteraan UPM, Dr Mohammad Effendy Ya'acob berkata, projek berkenaan dimulakan Januari tahun lalu bersama pembantu penyelidik yang juga pelajar Master UPM, Abdurrahman Noor Iskandar, 30.

Beliau berkata, Dual-Pass Tray Dryer bukan saja untuk mengeringkan hasil tanaman atau makanan, malah ia juga berfungsi sebagai pengecas peralatan elektronik.

"Proses pengeringan boleh dilakukan secara in-situ kerana alat ini berkonsepkan mudah alih dan menggunakan kuasa solar 'Photovoltaic'.

"Menerusi kuasa teknologi hijau, ia mudah digunakan di mana saja termasuk di dalam hutan, pulau atau kawasan pergunungan bagi memelihara produk yang dihasilkan," katanya di UPM, Serdang, baru-baru ini.

Dr Mohammad Effendy berkata, ia berfungsi secara 'dual-pass' melalui perolakan pengaliran udara, sekali gus kelembapan dapat dinyahkan dengan mudah kerana udara lembap ditolak keluar dengan bantuan dua kipas yang membawa udara panas.

"Bekalan kuasa elektrik adalah daripada simpanan bateri yang dicaj 100 watt fleksibel PV Module yang dipasang di atas alat berkenaan.

"Ia disambung terus ke kotak kawalan 'direct-current' (DC) untuk agihan ke beban pemanasan, kipas DC dan pelbagai fungsi beban.

"Kuasa lebihan yang tersimpan boleh menyalakan lampu perimeter sesebuah ladang yang terletak di luar capaian grid pencawang elektrik," katanya.

Menurutnya, suhu alat pengering berkenaan boleh mencapai hingga 80 darjah Celcius dengan ciri keselamatan pemutus litar.

"Masa untuk proses pengeringan bergantung kepada ketebalan sesuatu produk tetapi yang lebih penting kita dapat menjaga kualiti produk.

"Ia kerana bahan makanan terdedah kepada bakteria dan pemanasan tidak sekata jika ia melalui proses pengeringan secara tradisional," katanya.

Beliau berkata, produk protaip Dual-Pass Tray Dryer dengan saiznya yang berdimensi 1.1 meter (m) panjang x 0.6 m lebar dan x 0.2 m tinggi itu seberat 12 kilogram (kg) tanpa bateri.

"Alat berkenaan yang diperbuat dari struktur aluminium mudah dibawa kemana-mana," katanya yang memenangi pingat emas pada Pameran Perdagangan Antarabangsa (IENA) 2016 di Jerman.

ANUGERAH yang dimenangi di Jerman.

DR Mohammad Effendy dan Abdurrahman (kanan) menunjukkan Dual-Pass PV Tray Dryer.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : 2020/2021

TITLE OF THESIS / PROJECT REPORT :

Tropical Field Assessment in Development of Dual-Pass Photovoltaic Tray Dryer

NAME OF STUDENT :

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