EFFECT OF WIRE MESH ASSISTED SOLAR CHIMNEY ON PERFORMANCE OF SOLAR PV COOLING SETUP

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THESIS SUBMITTED IN FULFILLMENT FOR THE DEGREE OF BACHELOR OF MECHANICAL ENGINEERING

FACULTY OF ENGINEERING

UNIVERSITY MALAYSIA SABAH

2022

DECLARATION

I hereby declare that this thesis, submitted to Universiti Malaysia Sabah (UMS) as partial fulfilment of the requirement for the degree of Bachelor of Mechanical Engineering, has not been submitted to any other university for any degree. I also certify that the work subscribed herein is entirely my own, except for quotation and summaries sources of which have been duly acknowledged.

15th July 2022

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CERTIFICATION

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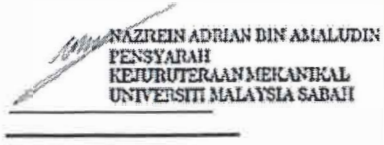

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Ericson Raidi

15 July 2022

ABSTRACT

Renewable energy is becoming more popular as an energy source as non – renewable energy sources become less prevalent. One of popular renewable energy that used is solar photovoltaic to generate electric energy. However, its efficiency reduced when its operating temperature increased with the increase of solar radiation. Therefore, a cooling system is necessary for solar PV. The aim of this study is to provide a passive cooling system using solar chimney assisted with wire mesh. In this study, it investigates the effect of wire mesh assisted solar chimney on performance of solar PV cooling in terms of power output, efficiency and temperatures of solar panel surface. The wire mesh assisted solar chimney was put at the outlet of solar chimney. Three test rigs known as configuration 1 (solar PV without cooling), configuration 2 (solar PV integrated with solar chimney as cooling), configuration 3 (solar PV integrated with solar chimney and wire mesh as cooling) were fabricated. The experimental conduction was carried out in the Faculty of Engineering, University Malaysia Sabah. The result showed that the effect of wire mesh in solar chimney has the highest increase electrical efficiency of solar PV which is 15.45% and has highest temperature reduction of solar panel surface which is 12.88%. The effect of wire mesh also showed that it can increase the flow rate of air inside the solar chimney, thus improved the ventilation of solar chimney. This is due to the higher buoyancy effect can be produced when air received more heat by restrict the flow rate at first by wire mesh. To conclude, wire mesh has helps in increasing the performance of solar PV setup cooling.

ABSTRAK

Pada masa kini, tenaga boleh diperbaharui semakin popular untuk digunakan sebagai pembekal tenaga memandangkan sumber tenaga tidak boleh diperbaharui semakin berkurangan. Salah satu tenaga boleh diperbaharui yang popular yang digunakan ialah solar photovoltaic untuk menjana elektrik. Walau bagaimanapun, kecekapannya berkurangan apabila suhu operasinya meningkat dengan peningkatan sinaran suria. Oleh itu, sistem penyejukan diperlukan untuk PV solar. Matlamat kajian ini adalah untuk menyediakan sistem penyejukan pasif menggunakan cerobong solar berbantukan jaringan dawai. Dalam kajian ini, ia menyiasat kesan cerobong suria berbantu jaringan dawai terhadap prestasi penyejukan PV suria dari segi output kuasa, kecekapan dan suhu permukaan panel solar. Cerobong suria yang dibantu jaringan dawai diletakkan di saluran keluar cerobong solar. Tiga pelantar ujian yang dikenali sebagai konfigurasi 1 (PV solar tanpa penyejukan), konfigurasi 2 (PV solar disepadukan dengan cerobong solar sebagai penyejukan), konfigurasi 3 (PV solar disepadukan dengan cerobong solar dan jaringan dawai sebagai penyejukan) telah dibuat. Pengaliran eksperimen telah dijalankan di Fakulti Kejuruteraan, Universiti Malaysia Sabah. Hasil kajian menunjukkan bahawa kesan jaringan dawai dalam cerobong solar mempunyai peningkatan kecekapan elektrik PV solar yang paling tinggi iaitu 15.45% dan mempunyai pengurangan suhu permukaan panel solar tertinggi iaitu 12.88%. Kesan jaringan dawai juga menunjukkan bahawa ia boleh meningkatkan kadar aliran udara di dalam cerobong solar, sekali gus meningkatkan pengudaraan cerobong solar. Ini disebabkan oleh kesan keapungan yang lebih tinggi boleh dihasilkan apabila udara menerima lebih banyak haba dengan menyekat kadar alir pada mulanya dengan wire mesh. Sebagai kesimpulan, jaringan dawai telah membantu dalam meningkatkan prestasi penyejukan persediaan PV solar.

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LIST OF SYMBOLS

P_{output}	-	Power Output
P_{input}	-	Power Input
V_m	-	Maximum Voltage
I_m	-	Maximum Current
η_{pv}	-	Efficiency of Solar Panel
I	-	Solar Radiance

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Overview

Background and principles of the cooling system of solar photovoltaic (PV) was explained in section 1.1. Problem statement, research objectives, scope of work, general research methodology, research contribution and research commercialization was discussed on section 1.2 to section 1.8.

1.2 Research Background

A rapid growth of populations increases the dependency of electricity. A big uses of fossil fuels for the electricity power generation while its sources lessen each decade and emitting hazardous emissions lead to global warming and bad health impacts. New alternative which is using renewable energy such as solar, hydropower, wind etc. By using renewable energy, we can reduce our reliance on fossil fuels, thus prevent greenhouse effect which mainly causes by electricity generation (Jonathan et al., 2019). To improve the energy efficiency, solar chimney is use to provide good ventilation and control temperature. Solar chimney is a system of passive solar cooling and heating which take part in natural processes such as convection, conduction and radiation (Donev et al., 2021). Solar chimney required no external energy to operate while maintaining its functionality. The material of the solar chimney is black or dark to maximize the absorbing heat from the radiations and to minimize the reflection of the sunlight.

The process of the heating is rather simple, the air inside the solar chimney will heated when solar radiation transfer heat to the body of the chimney. As the air inside is heated, it will flow in upward direction. The hot air that flows out from the

chimney will then replace by cold air by convection process (Bernards et al., 2003).

Solar photovoltaic (PV) system is one of renewable energy that largely use to generate electrical energy nowadays. The efficiency of the solar PV is about 15% - 20% (Saleem et al., 2019). Therefore, it is crucial to maintain the efficiency as possible. The efficiency will gradually decrease when the operational temperature increased (Lupu et al., 2018). The reason that the surface of the PV panel is overheating due to high ambient temperature and excessive solar radiation (Moharram et al., 2013). The excessive temperature decreases the efficiency of PV panel. The solar cells temperature increases while the maximum power output is decreasing. The normal operating temperature for PV panel is 35 °C while its maximum allowable operating temperature (MAT) is 45 °C. There are many ways to cool the PV panels such as Hybrid Photovoltaic/Thermal (PV/T) solar system. Its system comprise of solar PV panels and a cooling system. The cooling agent are air or water which is circulated around photovoltaic panels to cool the solar cells. Thus, the purpose of this project is to design a cooling system for solar PV using solar chimney which is quite low cost and required little maintenance.

1.3 Problem Statement

The solar PV performance decreased when its surface or the solar cell overheated. Hence, cooling system is compulsory to maintain its efficiency and prevent fast damage on solar PV itself. Therefore, solar chimney is taking part in cooling system of the solar PV. Other than that, cold inflow, cross wind and hot air recirculation decrease the performance of the solar chimney (Chu et al., 2011). The side wall can lessen the influence of the cross wind on the solar chimney, but cold inflow or flow reversal effects still present in the chimney, as can be observed in the solar chimney, according to the study (Mizanur et al., 2018). The wire mesh screen assisted chimney, which can greatly reduce cold inflow, recover draught loss, and increase air flow rate in the chimney (Chu et al., 2011) in 2011. The same approach will be applied to the solar chimney ventilation system, with the goal of determining the impact of wire mesh screens on solar chimney performance.

1.4 Research Objectives

The objectives of this project:

1. Study the effect of wire mesh screen on solar chimney in a solar pv setup.
2. To study the effect of solar chimney on solar pv cooling.
3. To compare the efficiency of solar panel without solar chimney, with solar chimney and with solar chimney and wire mesh

1.5 Scope of works

Scope of work is established as a way to regulate the flow of this project. The scope of work in this study includes:

i. Studying and reviewing past research papers that is related to solar pv cooling, solar chimney and wire mesh as guide for any considerations for the project.
ii. Planning of a solar PV cooling assisted solar chimney prototype which includes the material selections for the body part of solar pv cooling system.
iii. Using SOLIDWORK software to design the systems.
iv. Planning and fabricating solar pv cooling system
v. Conducting the experiment, to determine the solar output power, solar panel efficiency for three configurations which is solar pv only, solar pv with solar chimney as cooling system and the combination of solar chimney and wire mesh screen.
vi. Making documentation of this project

1.6 General Research Methodology

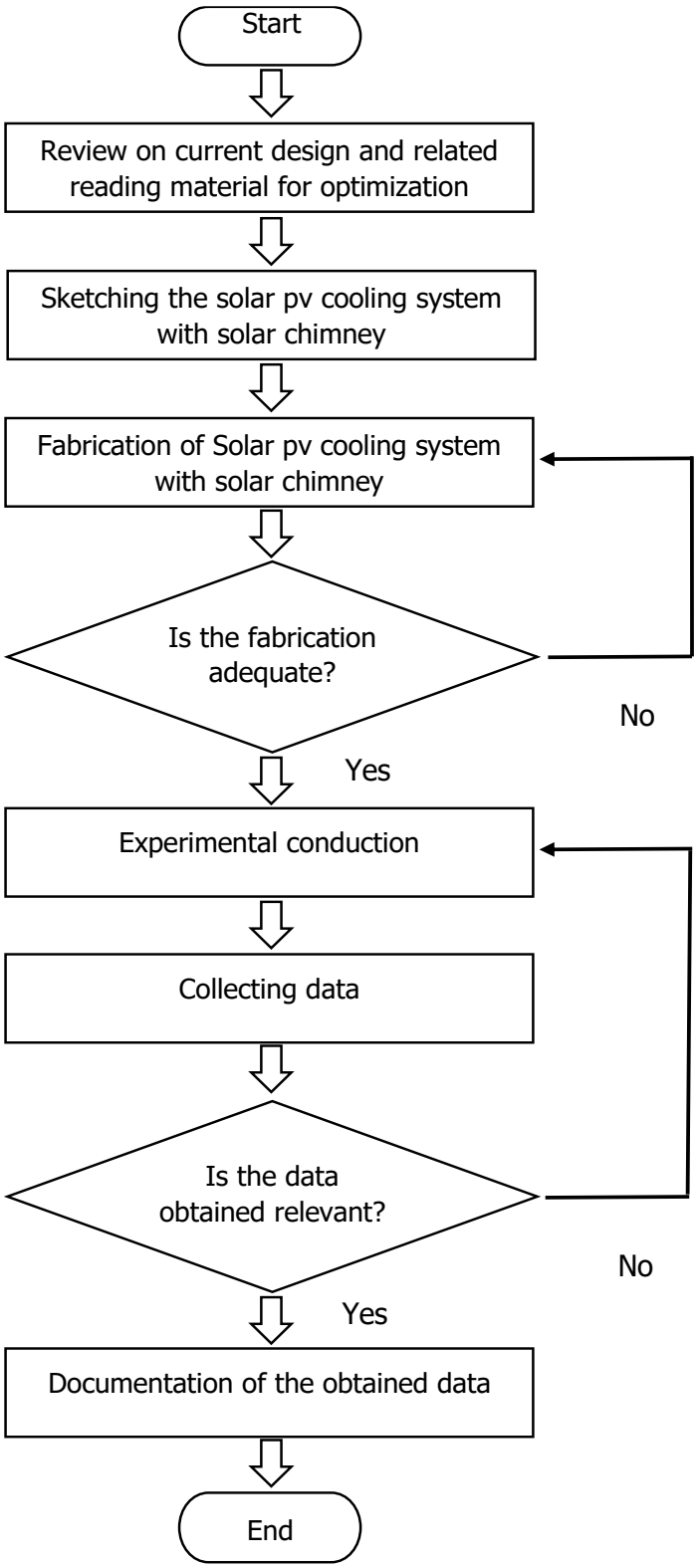

Figure 1.1: Flow Chart for general methodology

1.7 Research Contribution

This project can make some contribution to increase the efficiency of solar pv by installing passive cooling system which is simple, easy to fabricate and low cost. The implementation of solar chimney as solar pv cooling system may be use widely as it is simple yet increasing the solar output power and easy to install it even in every house. The optimization of this implementation would increase the usage of solar panel system as a renewable energy worldwide.

1.8 Research Commercialization

Since the implementation of solar chimney in solar PV cooling which required no auxiliary energy, it is low cost in making and operating it, it is also required less maintenance. The government of Malaysia already started to implement solar energy as one of their sources of electricity energy generation and with the introduction of solar chimney in solar PV cooling, its reduce the amount of cost to build the solar PV system while maintaining the efficiency of photovoltaic cells.

1.9 Research Gantt Chart

Table 1.1: Gantt Chart for Semester 1 Session 2021/2022

No.	Item	Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	First Project Briefing														
2	Project Proposal														
3	Proposal submission														
4	Literature review														
5	Writing of the project progress report														
6	Editing of the project progress report														
7	Submission project report report progress														
8	Project 1 presentation														

Table 1.2: Gantt Chart for Semester 2 Session 2021/2022

No.	Item		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Discussion with supervisor														
2	Testing and experimental														
3	Data analysis														
4	Modification and optimization														
5	Retest and Analysis														
6	Verification of result														
7	Writing and editing final report														
8	Final report submission														
9	Project 2 presentation														
10	Thesis correction														
11	Submission hard bound thesis														