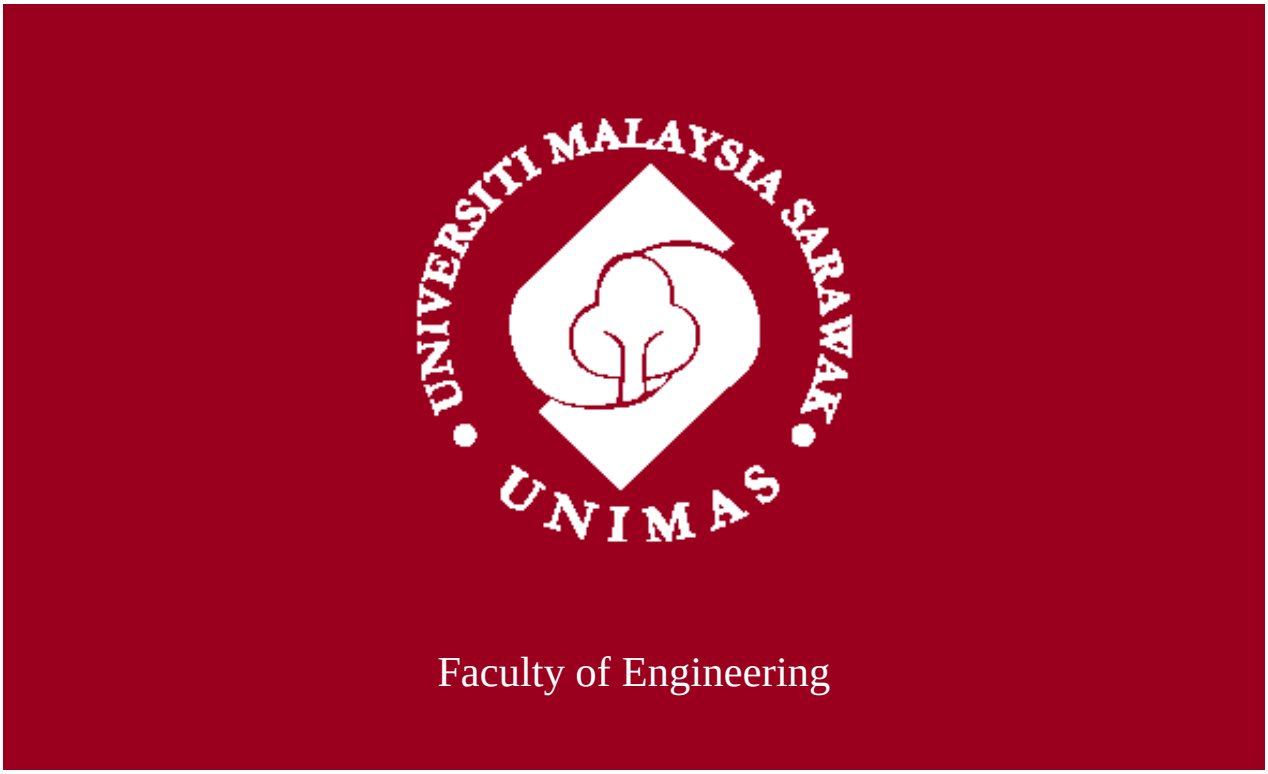

MODIFICATION AND FABRICATION OF A HYBRID SOLAR PELTIER-ADSORPTION COOLER

Tie Soon Hieng

Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)
2008

UNIVERSITI MALAYSIA SARAWAK

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The project report attached here to, entitle “Modification and Fabrication of A Hybrid Solar Peltier-Adsorption Cooler” prepared and submitted by Tie Soon Hieng, 13133, in partial fulfillment of the requirement for Bachelor of Engineering with Honours in Mechanical and Manufacturing Engineering in hereby read
and approved by:

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Dr. Mohammad Omar bin Abdullah Date

Supervisor

MODIFICATION AND FABRICATION OF A HYBRID SOLAR PELTIER-ADSORPTION COOLER

TIE SOON HIENG

Thesis Is Submitted To
Faculty of Engineering, Universiti Malaysia Sarawak
In Partial Fulfillment of the Requirements
For the Bachelor Degree of Engineering
with Honours (Mechanical and Manufacturing Engineering) 2008

For my Father and Mother
And
My beloved family

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ABSTRACT

Modification of Solar Peltier-Adsorption cooler has been done and fabricated during the Final Year Project. The main purpose of the project is to improve the performance of the Solar Peltier-Adsorption cooler. The device is using solar radiant to produce power from photovoltaic panel for generating the thermoelectric device in the daylight. Then, the device using adsorption and desorption theory to generate cooling effect during the night time. The device consists of a few main parts assembly which is solar collector, adsorber box, condenser, reservoir, evaporator and support frame. Solar flat plate collector type has been used for the system which can support an adsorber bed charcoal capacity of 5 kg. The adsorption cycle operates intermittently where provide only one cycle per day. The cooling effect occurs during the adsorption process at night. Photovoltaic panel provides electricity to peltier cooler to produce cooling effect during the day time. Therefore the cooling effect of the hybrid device can produce cooling effect continuously for day and night time period. Experimental results show that lowest temperature achieves is 9.3˚C in Peltier during daylight and 13.6˚C during the night by using 300ml load of water.

ABSTRAK

Penambahbaikan alat Peti Sejuk Suria telah dilakukan dan siap dibina. Tujuan utama projek ini ialah memperbaiki sistem ini. Alat ini menggunakan radiasi dari cahaya matahari pada waktu siang untuk menghasilkan kuasa elektrik untuk menghidupkan peti sejuk. Pada waktu malam, alat ini menggunalan teori menyerap dan memeluwap untuk menghasilkan kesejukan dalam peti sejuk. Alat ini terdiri daripada beberapa cantuman bahagian-bahagian kecil seperti penyerap matahari, kotak penyerap, pemeluwap, tangki pengumpul, penyejat, and rangka sokongan. Pengumpul cahaya matahari jenis rata dan berkotak telah digunakan untuk sistem ini yang mana ianya boleh memuatkan tiub penyerap yang boleh menampung kapasiti karbon aktif sebanyak 5kg. Proses penjerapan di dalam sistem berlaku dalam satu kitaran dalam sehari. Oleh itu, proses penjerapan yang berlaku pada waktu malam memberikan kesan penyejukan di dalam peti sejuk. Panel 'photovoltaic' berupaya membekalkan tenaga elektrik untuk menghasilkan kesan penyejukan pada waktu siang. Oleh yang demikian, kombinasi alat ini menghasilkan kesan penyejukan yang berterusan pada waktu siang dan malam. Hasil daripada eksperimen menunjukkan suhu terendah yang dicapai ialah 9.3˚C di dalam "Peltier" pada waktu siang and suhu 13.6˚C pada waktu malam dengan menggunakan 300ml air.

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COP	Coefficient of performance
Psia	Absolute pressure [Pa]
Psi	Pressure [pa]
G	Global irradiance, [J Kg^{-1} K^{-1}] [Wm^{-2}]
L	Evaporation latent heat for water [J kg^{-1}]
Q	Heat quantity [J]
N	Number
A	Area [m^2]
T	Temperature [K]
t	Time [s]
$\overline{m}$	Mass flow rate [kg s^{-1}]
ΔT	Changes of temperature [K]
Q	Heat energy
$\overline{Q}$	Input energy rate [KJ s^{-1}]
P	Power [Watt]
R	Specific gas constant [J/gK]
ρ	Density [kg m^{-3}]
v	Volume
m	Mass [kg]
η	Efficiency
k	Thermal conductivity [W/m K]
C	Specific heat capacity [J/kg K]
d	Diameter [m]
PV	Photovoltaic
W	Work
SCP	Specific ice production
τ	Cooling power

Indexes

c	Condenser	L	Liquid
d	Day	S	Solar
ev	Evaporator	tl	Thermal losses
g	Generating	p	Peltier
ad	Adsorption	rej	Rejection
l	Load	H	Hybrid

CHAPTER 1

INTRODUCTION

1.1 Introduction

In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy. Solar energy is the cleanest and most inexhaustible of all known energy sources. Solar radiation is the heat, light and other radiation that is emitted from the sun. Solar radiation contains huge amounts of energy and is responsible for almost all the natural processes on earth. In this study, a hybrid solar peltier-adsorption cooler was constructed and it could reduce power and utilising the solar as a renewable energy.

Peltier cooler is a solid-state active heat pump which transfers heat from one side of the device to the other side against the temperature gradient which is from cold side to hot side, with consumption of electrical energy. [1] Absorption cooler is a device that involves the absorption of a refrigerant by a transport medium. The adsorption cooler mainly consists of a collector box which containing absorbers, a

condenser, an evaporator and a reservoir. Combination of those two devices can obviously save non-renewable energy and reduce the hazardous to the environment.

1.2 Overview of research

The research is based on the hybrid solar peltier-adsorption cooler which was modified and built by Muhamad Zuhairi bin Sulaiman (2007). The coefficient of performance (COP_H) of the hybrid solar peltier-adsorption cooler was calculated as 0.05, i.e. cooling effect of 5%.

1.3 Problems statement

According to Muhamad Zuhairi bin Sulaiman (2007), there are several problems identified on the previous fabricated device. During the project, leakage was found on the system and caused the efficiency of the device decreased. Besides that, unsuitable sensor also stated as the problem because large amount of heat loss from the peltier cooler due to bigger thermocoupler. The amount of activated carbon is believed not sufficient. [2]

Inconstant schedule of the open-close valves also will affect the measurement taken during the testing operation. Muhamad Zuhairi bin Sulaiman (2007) recommended using vacuum collector is better than solar flat plate collector. He also advised using boiled water in order to provide constant heat. He also suggested that use automated data logger to record the data more efficiency. The Pyranometer is suggested for determine the solar radiation for the day. [2]

1.4 Objectives of project

Objectives have been identified in this research which is stated below:

- To study the working principle of hybrid solar peltier-adsorption cooler.
- To modify and improve the functional of the device.
- To analyse and determine the new coefficient of performance (COP) of the new modified device
- To increase the efficiency of the device.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Solar energy had been proven that bring greater benefits to the cooling application. Solar cooling is important to our daily life application because it is friendly to environment by reducing the use of non-renewable energy. Researchers over the past few decades have developed and invented a number of additional solar thermal applications, such as industrial process heat, refrigeration and air-conditioning, drying and curing of agricultural products and electric power production by solar thermal conversion.

Normally there are two ways to achieve refrigeration by using of solar energy. One of the methods are by converting the solar energy to electricity which by means of photovoltaic cells to provide electricity to run the domestic refrigerator. Another one is using the solar thermal radiation directly to make refrigeration by adsorption and desorption systems.

The one that are being studied in this project is combination of both of the methods by hybridisation peltier cooler by using photovoltaic power source in daylight and solar radiation for desorption and adsorption operation.

2.2 The benefits gained from solar energy

In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative is solar energy.

Solar energy is quite simply the energy produced directly by the sun and collected elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. [3] The process creates heat and electromagnetic radiation. The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions.

Much of the world's required energy can be supplied directly by solar power. More still can be provided indirectly. The heat energy from solar radiant promise a good alternative to be utilise in cooling technologies especially in solid adsorption technology and photovoltaic technology.

2.3 Adsorption cycle

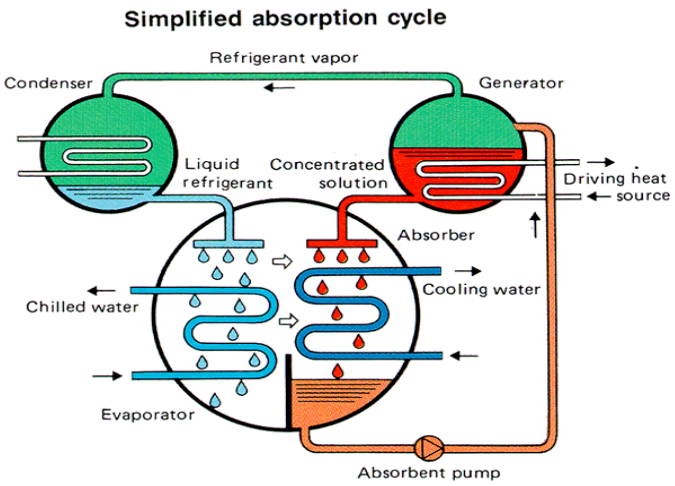

Figure 2.1: Simplified absorption cycle [4]

The basic absorption cycle employs two fluids, the absorbate or refrigerant, and the absorbent. The most commonly fluids are water as the refrigerant and lithium bromide as the absorbent. These fluids are separated and recombined in the absorption cycle. In the absorption cycle the low-pressure refrigerant vapor is absorbed into the absorbent releasing a large amount of heat. The liquid refrigerant/absorbent solution is pumped to a high-operating pressure generator using significantly less electricity than that for compressing the refrigerant for an electric chiller. [4]

Heat is added at the high-pressure generator from a gas burner, steam, hot water or hot gases. The added heat causes the refrigerant to desorb from the absorbent and vaporize. The vapors flow to a condenser, where heat is rejected and condense to a high-pressure liquid. The liquid is then throttled though an expansion