IMPROVEMENT DESIGN OF SOLAR CHIMNEY

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Bachelor of Engineering with Honors
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This project is submitted in partial fulfillment of the requirements for the degree of Bachelor of

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Faculty of Engineering
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Dedicate to:

My Beloved Family

And Friends

UNIVERSITI MALAYSIA SARAWAK

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BORANG PENYERAHAN TESIS

Judul: **IMPROVEMENT OF SOLAR CHIMNEY DESIGN** .

.

SESI PENGAJIAN : 2008/2009

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ABSTRACT

Renewable energy has become more preferable to the society compare with conventional energy. This project presents the design, fabrication and performance analysis of the improved solar chimney power generator. The solar chimney apply hot air rise concept to generate power. The design consists of a chimney tower connected on top of the circular solar collector with a chimney support. Within the chimney tower lie two generators, one above another to generate power. Below of the solar collector lays the heat absorber tiles and water tubes. The water tubes absorb heat during the day time, and release the heat during the night for the power generation. An air flow director is placed below the chimney tower to direct the air into the tower and then turn the electrical generators. In this project, air flow simulation and fabrication method were employed. The performance of the solar chimney is dependent to the solar radiation, solar collector's size, chimney tower's height, collector's transparency and type of heat absorber. The night operation performance is dependent on the water tube and heat absorber type. The solar chimney is 4.2 meter diameter and 3.6 meter height. The simulation will simulate the air behaviors within the solar chimney.

Keyword: Solar chimney, renewable energy

ABSTRAK

Tenaga yang boleh diperbaharui semakin mendapat tempat di hati masyarakat berbanding dengan tenaga yang tidak boleh diperbaharui. Projek ini bertujuan untuk mengetengahkan reka bentuk, pembuatan serta analisa terhadap prestasi penjana kuasa cerobong suria yang telah dipertingkatkan. Cerobong suria ini menggunakan konsep udara panas untuk menghasilkan tenaga. Reka bentuknya terdiri daripada menara cerobong yang dihubungkan dengan penyokong cerobong di atas pengumpul suria berbentuk bulat. Terdapat dua penjana di dalam cerobong suria, bertindih di antara satu sama lain untuk menjana tenaga. Di bawah pengumpul suria terdapat jubin penyerap haba dan tiub air. Tiub air ini berfungsi untuk menyerap haba pada siang hari dan membebaskan haba pada waktu malam untuk penjanaan tenaga. Sebuah pengarah aliran udara diletakkan di bawah menara cerobong untuk mengarahkan aliran udara ke menara dan kemudian memutarkan penjana electrik. Dalam projek ini, simulasi aliran udara dan cara pembuatan diambil kira. Prestasi cerobong solar bergantung kepada radiasi solar, saiz pengumpul solar, tinggi cerobong solar, kelutsinaran pengumpul dan jenis penyerap haba yang digunakan. Prestasi pada waktu malam bergantung kepada tiub air dan jenis penyerap haba. Cerobong asap inimempunyai diameter sebanyak 4.2 meter dan berketinggian 3.6 meter. Simulasi akan digunakan untuk mengetahui kelakuan aliran udara dalam cerobong suria.

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NOMECULATURE

Latin

p	Pressure
V	Wind velocity
v	Volume
ρ	Density [kgm^{-3}]
e	Maximal net work output [J/kg]
ŋ	Efficiency
H	Stagnation enthalpy
h	Convection heat transfer coefficient [W/m^2K]
f	Friction factor
Re	Reynolds number
Pr	Prandtl number
k	Thermal conductivity [W/m K]
d	Diameter
μ	Dynamic viscosity [kg/m s]
g	Gravitational acceleration
c	Specific heat coefficient
T	Temperature
N	Number of gear tooth
w	Gear speed

R	Gear ratio
Q	Heat energy
c	Specific heat capacity
θ	Temperature gradient

Prefix

Δ	Change in value

Subscript

Hc	Chimney height
a	Atmosphere
$coll$	Collector
tot	Total
tt	Circumferential component
t	Total (stagnation) or turbine
$Loss$	Loss
rh	Collector roof to air under collector roof
h	Air under collector roof or hydraulic
ra	Collector roof to ambient air
m	Mean
p	Pressure
M	Motor
D	Driven

CHAPTER 1

INTRODUCTION TO SOLAR CHIMNEY

1.1. Introduction

Solar chimney generator is a hybrid system of solar and wind energy, which are using convection of air heated by passive solar energy generate electric energy. It is also referred as the thermal chimney.

By considering all forms of energies options available, renewable energy has become more preferable to the society compare with conventional energy resources such as petroleum, coal and natural gas. The solar chimney is an alternative source because it is cheap and green energy, which is affordable for developing country and preferable for advanced country that demand for unpolluted and stable price energy. This renewable energy fulfills the demand of the society to achieve a better, healthier and safer life style.

Solar chimney is getting the attention due to the new renewable power generator that meets the current demand. Researchers are interested in this sector

and many researches were conducted, but the efficiency of the renewable energies is still not running at its efficient state.

The solar chimney was first originated by German author, Hanns Günther in 1931. In Manzanares, (Spain), a small scale working model of solar chimney was successfully built by Prof. Dr. Ing. Jörg Schlaich, Bergerman and Partner. In 1982, the chimney had a diameter of 10 meters and height of 195 meters, with a collection area (greenhouse) of 46,000m2 (about 11 acres) obtaining a maximum power output of about 50kW. The solar chimney function around 8 years before it was destroyed in a thunderstorm. Before the incident happened, the optimization data was collected and was lincensed to EnviroMission and SolarMission Technologies Inc. USA.

Solar chimney power plant consists of transparent glass canopy roof raised a certain height from the ground and surrounding the black chimney circular tower. Inside the chimney tower lays one or more turbo-generators at its center base. Black color heat absorber is laid and the water tubes are place between the heat absorber to allow night tie power generation.

Current prototype has a chimney tower of 3.6 meter height. Inside the chimney tower lie two generators, a nozzle is installed for the second generator to function using water mill concept. The chimney tower is built on circular solar

collector, which is connected by a chimney support. The solar collector is 4.2 meter in diameter. The solar collector is raise 15 millimeter from the ground and incline till 50 millimeter. Below the collector lie the black heat absorber tiles and water tubes. Water tubes absorb heat during the day time and release it at night time for plant operation.

1.2. Objective of the project

Objectives of this project are to made modification on the existing solar chimney. To do so, the chimney will be reassembled. Some parts of the current chimney will be improved such as the main generator and chimney tower. For modifications part, the processes include reducing the air leakage from the chimney, to improve power output by studying the generator and implementation of water tube. Then simulation will be applied to the modified chimney. Lastly testing will be run to observe the overall performances. All those are to increase the solar chimney efficiencies.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Since the year electricity was discovered, the demand of electricity has been increasing. Societies now no longer just demand for simple electricity, they also demand for environment friendly energy or so called the green energy. Green energies that that are common found are the hydroelectricity, geothermal, wind power generator and photovoltaic cell. Another green energy that researcher are interested recently is the solar chimney power generator. This chapter contains the literature review of some researches done previously by various researchers regarding solar chimney power generator. In this chapter also, the working concept, the solar chimney structure, and environment factors to be consider will be discuss.

2.2. The Working Concept of Solar Chimney

The working principle of the solar chimney is actually originated from the natural occurrence of hot air rises. An easy illustration of this concept is by considering the sea breeze, which is shown in Figure 2.1.

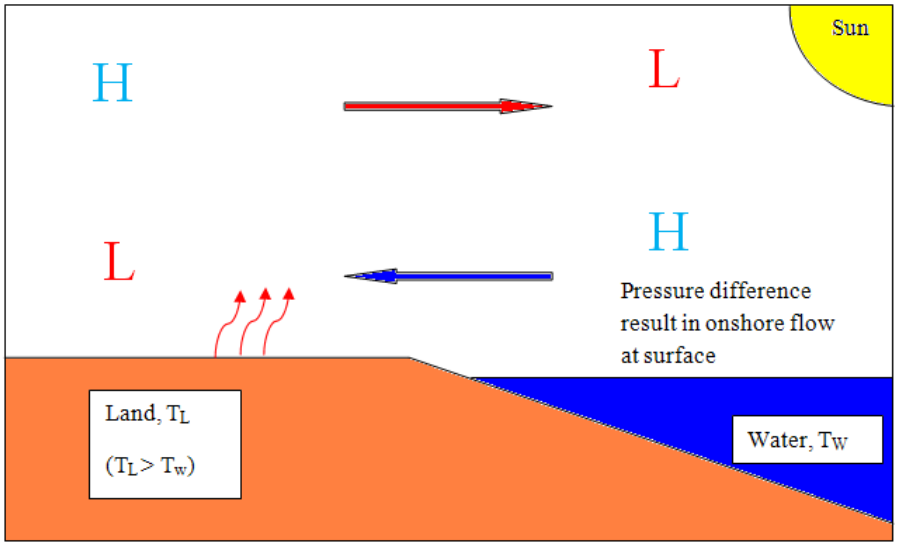

Figure 2.1: Sea Breeze

The sun heated up both land and sea. Land heats up faster than sea to higher temperature, causing the air on the surface of the land hotter than air on the surface of the sea. The hot air on the surface of land raises and creates a low pressure condition on the land surface. Air on sea surface, which experience higher pressure, will move toward the lower pressure land surface replacing the raised hot air. While moving from sea to land surface, the air is being heated by the hot land temperature and hence the air will rise again, creating an infinite

cycle. This cycle result a steady wind moving from sea to land and that is basically the sea breeze theory.

In the solar chimney, the heat absorber will heated up faster than it's surrounding; causing the air on the surface of the heat absorber to raise and flow toward the chimney tower. At the same time, the pressure on the heat absorber surface will drop to a point which lowers than the surrounding pressure. Hence cool air from the surrounding which has higher pressure will flow into the solar collector, due to air flow from high pressure to low pressure area. While the cool air flow in solar collector, it will slowly heated up by the heat from the heat absorber. Cool air temperature rises across the heat absorber and finally flows out through the chimney tower. The air flow through the chimney tower will be harvest by the generator turbines and generates electricity. This concept is illustrated in Figure 2.2.

During the day, heat absorber and water tube were heated up together. When come to night time, the heat collected in the water will be released to continue heating up the surface air as to replace the heat absorber. Heat release from the water tube heated up the surface air to a higher temperature causing them to rise. This creates a pressure difference between the air inside the solar collector and the surrounding, hence wind flow created between these areas. Cool air moving into the solar collector is slowly heated up by the heat released from the