SOLAR POWERED BICYCLE SHAPE DESIGN WITH THE IMPLIMENTATION OF ERGONOMIC AND AERODYNAMIC

SAKINAH ABDUL MANAF

Universiti Malaysia Sarawak
2000

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Date: 10 April 2000

(Nazeri Abdul Rahman)
Co-ordinator
Program Mechanical & Manufacturing
Faculty of Engineering
Universiti Malaysia Sarawak

SOLAR POWERED BICYCLE SHAPE DESIGN WITH THE IMPLIMENTATION OF ERGONOMIC AND AERODYNAMIC

by

Sakinah Abdul Manaf

This report is submitted in partial fulfillment of the requirement for the degree of Bachelor of Engineering (Hons.) Mechanical Engineering and Manufacturing System from the Faculty of Engineering

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2000

This thesis is dedicated to my family for their trust.

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Abstract

There are two types of solar vehicle, solar car and solar bicycle. Currently the solar bicycle is build without any ergonomic and aerodynamic consideration. So the objective of this thesis is to design a new solar bicycle with both considerations. Ergonomic is the driver conformability at the driver workspace while the aerodynamic is due to the air resistance. Based on the antropometric data and the aerofoil shape, a solar bicycle with both considerations was designed. The new solar bicycle is called UNIMAS solar bicycle or USB.

Abstrak

Terdapat dua jenis kenderaan berkuasa solar iaitu basikal solar dan kereta solar. Buat masa sekarang, solar basikal direka tampa mengambilkira faktor ergonomik dan aerodinamik. Jadi matlamat tesis ini adalah untuk mereka sebua basikal solar denagn mengambilkira kedua dua aspek tersebut. Ergonomik merujuk kepada keselesaan pemandu di kawasan dimana beliau memandu. Semantara itu aerodinamik merujuk kepada kadar rintangan kenderaan tersebut terhadap pergerakkan udara. Berdasarkan data yang didapati dari jadual antropometrik dan bentul aerofoil, sebuah basikal solar yang baru telah direka. Basikal ini mempunyai kedua-dua aspek ergonomik dan aerodinamik. Basikal solar ini dikenali sebagai basikal solar UNIMAS atau USB.

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Nomenclature

A	Projected area
B	Transverse width
C_D	Overall drag coefficient
C_F	Friction drag coefficient
C_P	Normal to flow time coefficient
ρ	Density of fluid
F_D	Drag force
F_F	Friction force
F_P	Drag force
L	Length of surface parallel to flow
V	Velocity flow

Chapter 1

Introduction

1.1 Overview

A few years ago the proposal regarding to the usage of solar energy for electricity production were received with the utmost skepticism [Raj, 1993]. This attitude now begins to change. Nowadays, the solar energy has been utilized (with application of modern technology) for daily life. According to the Encyclopedia of Energy [1993], the **solar energy** is defined as the energy transmitted from the sun in the form of electromagnetic radiation at a total rate of 380 x 10^{24} W on earth. It can be used either in the form of heat, energetic chemical of directly converted into electricity. **Insolation** is the term describe the amount of solar radiation receive by the earth or the incident solar radiation.

At the moment, the sun provides energy for heating and electricity purposes. Flat-plate collectors (FPC) are the devices, which used to heat water and building. The device, which converts the solar heat (radiation) into the electrical energy with high reliability and fair efficiency, is called **solar cell** or **photovoltaic cell.** The examples of available devices based on the solar energy are the **solar cooker**, **water heater** and **solar furnace**.

The **solar cooker** is the device, which used the direct heat from the sunlight to cook food. The cooker is placed in the sunlight and the reflector is adjusted until the strong beam of sunlight falls over the cooker top. The cooker consists of four major components; an insulated metal box or wooden box which the inside sides of the box painted in black for heat absorption purpose, plane mirror for sun ray reflection, thick glass sheet cover for the "green house effect" and a container where the food to be cooked (painted black from outside).

The devices that are used to heat water by the utilizing energy radiated by the sun are called **solar heater**. The reflector reflects the sunlight to the black pipe containing water. While the **solar furnace** is the devices which contain thousands of small plane mirrors. These mirrors were arranged in curve shape to form a big concave reflector. If enough heat energy of the sun was concerted it can even melt the steel [Raj, 1993].

The four basic systems for solar thermal technology are the collector, receiver, transport-storage and power conversion. These are as shown as in **Figure 1.1**. The collector captures and concentrates the solar radiation, then concentrates it to the receiver. The receiver will absorb the concentrated sunlight and transferring the heat energy to the working fluid. The transport-storage system transmits the fluid from the receiver to the power conversion system. The power conversion system consists of a heat engine and related equipment for converting thermal energy into electrical energy. Some of design also include a secondary, fossil- fuel driven heat engine that can either change the storage system or driven with the power-conversion system during the period of low sunlight [Johansson, 1993].

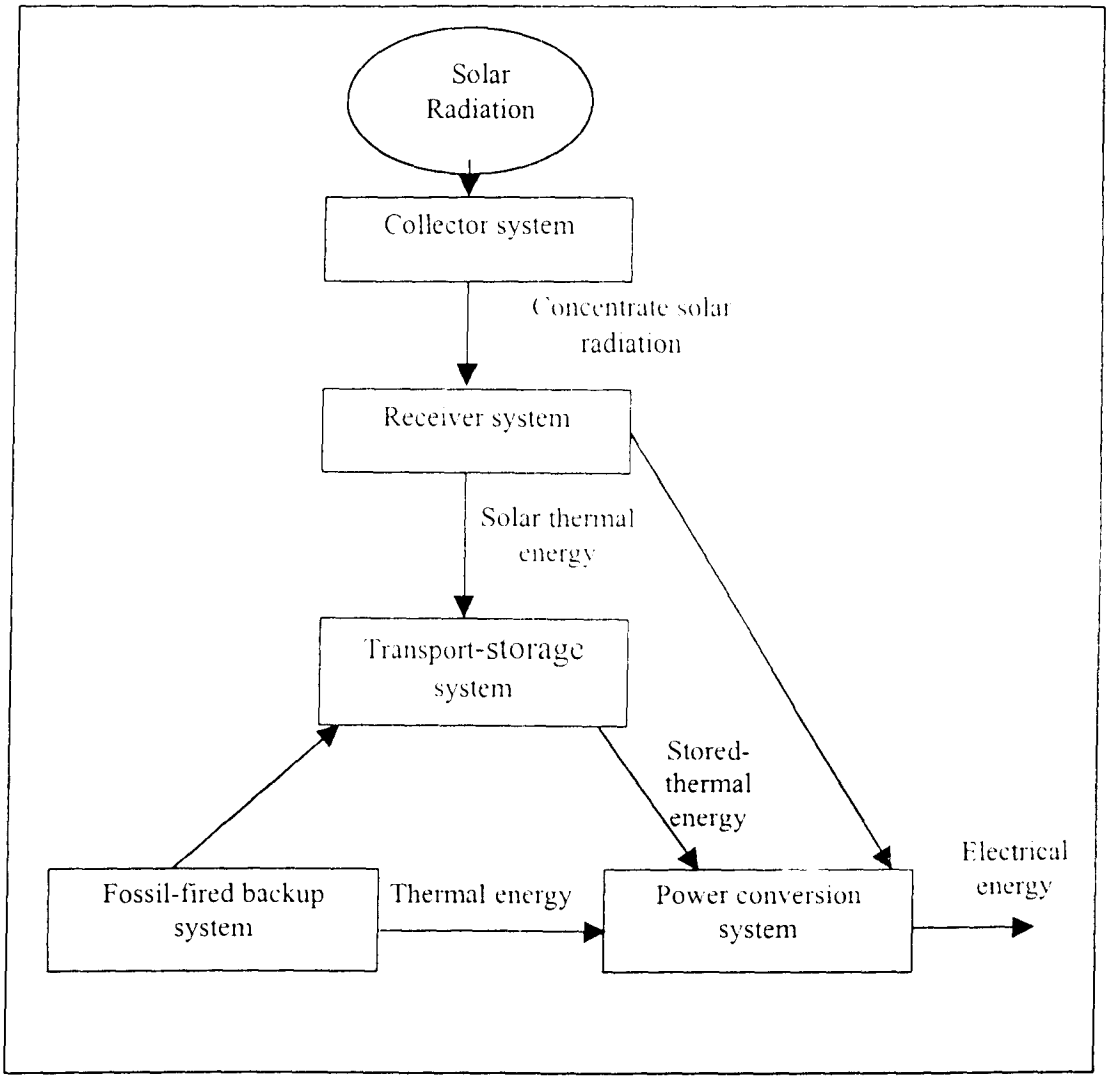

Figure 1.1: Four basic system of solar thermal technology [Johansson, 1993].

1.2 Solar cell

Generally solar cell or photovoltaic cell (PV cell) is referring to a slab of high purity single-crystal silicon, 0.05 mm thick which used to convert sunlight directly into electricity. It is a type of semi conductor and have no moving parts. Mostly the solar cell is made of crystalline silicon. Silicon has been chosen because it has no free electron. Solar cell is construct of two type of slab: positive and negative slab. The solar cell construction is shown in the **Figure 1.2.**

During the construction process, silicon is mixed with a small amount of arsenic. This mixture is then formed into large crystal. The crystal is cut into thin wafer about 1/25 of an inch (1mm) thick. The wafer then exposed to a vapor containing boron. The boron penetrates into the wafer about 1/10 000 of an inch (1/400 mm) deep. Then, two wires are attached to the wafer. One is attached to the silicon center, and the other to the boron penetrates surfaced. [Bohn, 1986]

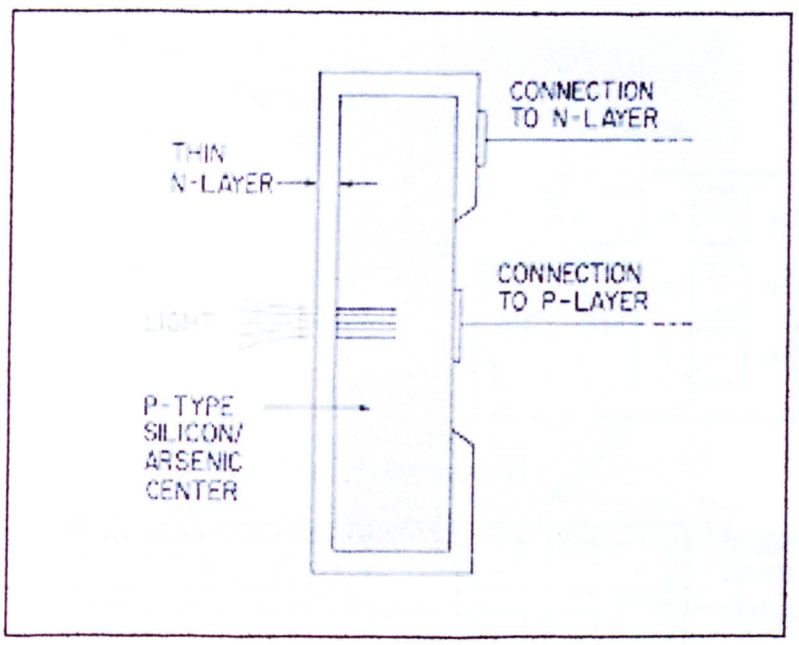

Figure 1.2: Solar cell construction [Bohn, 1986]

The silicon/arsenic layer is labeled as Positive layer (p-type) and the boron layer labeled as Negative layer (n-type). In **p-type** slab, there are a few free electrons but many empty holes that move freely at room temperature. These hole acts just like positive charge. The impurity of the slab is increased when some boron doped to the silicon slab. While in negative slab or **n-type** slab, the impurity of this slab is increased by diffusing the phosphorus to the silicon slab. [Johnson, 1993]

The principal operation of the solar cell can be easily explained by referring to the **Figure 1.3**. The principle of this operation was discovered by Heinrich Hertz in 1887 and was explain in detail by Albert Einstein in 1905. When the light strikes certain metal, electrons are emitted. This phenomenon is known as **photoelectric effect**. Einstein explained the principle by considering that the light behaves like a particle called photon rather than light wave. [Hinrichs, 1991]

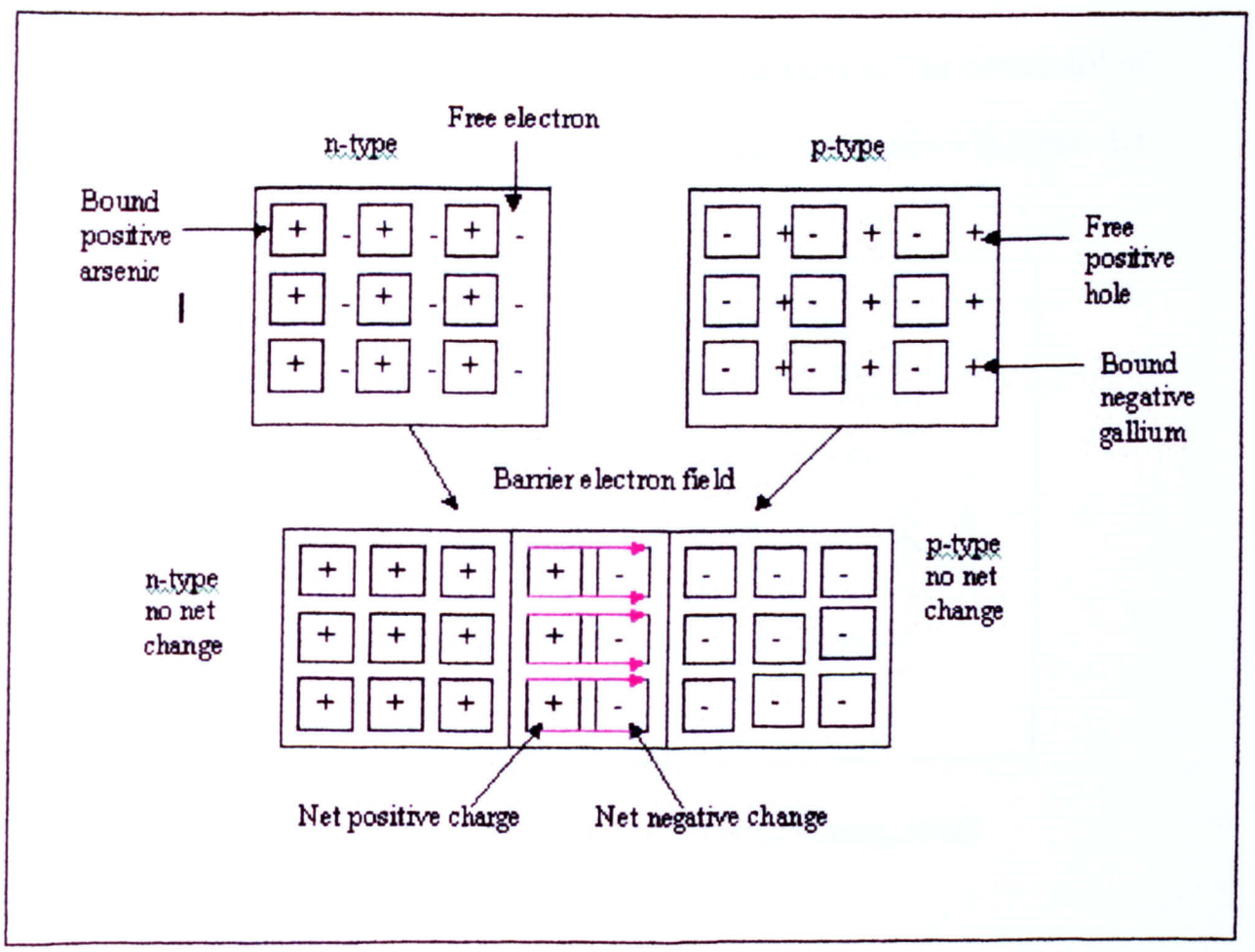

Figure 1.3: Operating principle of p-n junction [Raj, 1993].

An interface between p-type and n-type silicon is called a **p-n junction**. At the room temperature, this junction produced a potential different. It is causes by the

electron or negative charge force toward to the p-type slab, and the holes or positive charge force toward the n-type slab. The free electron and holes try to intermix like gases. [Raj, 1993]

The voltage across the junction keep increasing until the number of electron driven across the junction equal to the rate flow of holes drifting across the junction [Johannson.1993]. When there are more light concentrate on the solar cells, the effect of happened faster. The electron then have enough energy to escape from their bound state and making a voltage appear at the output terminal [Oman, 1986]. The output of solar cell is the direct current. The operational of solar cell can also be described using the equivalent circuit as shown in **Figure 1.4** below.

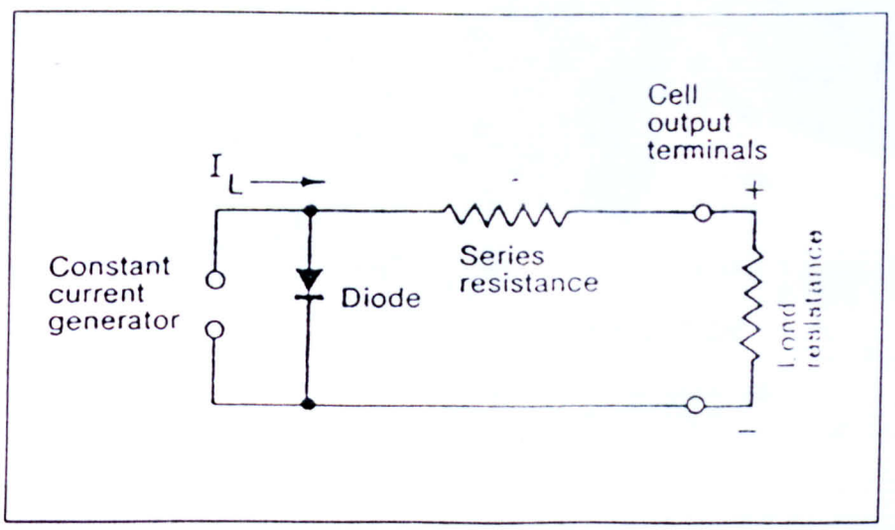

Figure 1.4: Equivalent solar cell circuit [Oman, 1986].

According to Oman [1986] the energy feature of solar cells were generally made in size under 10 cm in maximum dimension. A number of solar cells must be connected in series or parallel to generate the required voltage and current.

1.3 Solar collector

Solar collector is the device used to provide the solar heating by collecting the sun short-wave radiation on a suitable blackened surface. The surface is converted the incident solar radiation to thermal energy [Raj, 1993]. The efficiency of this device is depending on the operating temperature of the collector. There are two principle of type of solar collector, **flat plate** and **concentrator**.

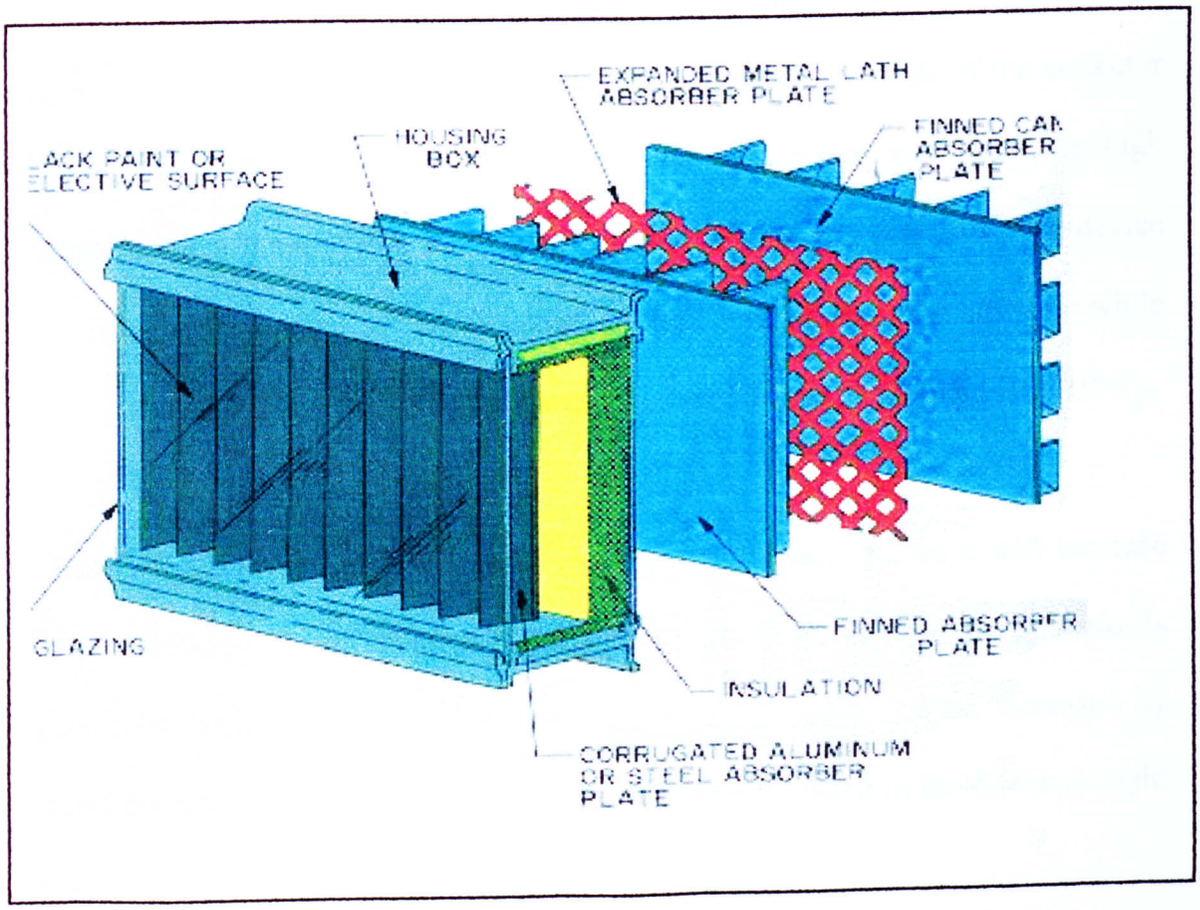

Figure 1.5: Flat-plate collector [Bohn, 1986]

Basically **flat plate collector** as shown in **Figure 1.5** is thin, flat metal used to absorb radiation. It is consists of five components. The components are a transparent cover, collector plate, tube, insulator and container. The transparent cover used to admit the incoming solar radiation. It is depending to the type

material being used. Usually glass will be used because it can act as a radiation shield to trap heat emitted from the absorber plate and it is also lid to suppress heat loss by simple vertical convection.

The collector plate is used to convert the incoming radiation. It is usually made of copper, aluminum, or steel and blackened which used to convert the radiation into heat. The plate collector usually painted in black to increase the efficiency of absorption. The fastener are use to joint the tube to plate collector. The insulation is the devices, which used to minimize heat loss from the back of the collector plate. The good insulator material is the material, which can stand the high temperature without giving any vapors or any essential characteristic. The device used to keep the entire system is known as the container. It is the dust-free while letting the certain differential enlargement of the collector component [Raj,1993].

Usually the flat plate will operate at the high temperature where it will increase their efficiency of performance. The maximum insolation is when the collector is perpendicular to the sunray. The concentration of the plate can be increased by using the mirror or the lens. These devices can be only used in the direct sunlight and the system must track the sun.

Solar concentrator are referring to the reflector or lens design to focus a large amount of solar radiation into a small area, thus it will increased the temperature of the radiation.