AN AUTOMATIC SOLAR TRACKING SYSTEM FOR A PARABOLIC TROUGH
CONCENTRATING COLLECTOR

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ABSTRACT

In this research, the solar tracking system using automated circuits for the parabolic trough
concentrating collector is presented. The fabricated electronic circuits were divided into two
parts. Firstly, the sunlight searching circuit was made-up for motor driving of a parabolic
trough to monitor the sunlight by using the variable intensity of sunlight between the two light
diode resistance (LDRs). However, the motor driving of the sunlight searching circuit was
energetic all day, so the parabolic trough can revolve to track the sun. Consequently, the
automatic power switch circuit was added to inhibit the power cut off and to protect the motor
from rotating in horizontal direction more than 180 degrees. The research was carried out by
comparing between systems without solar tracking and with solar tracking. In conclusion, the
solar tracking system was significantly better than the ordinary parabolic trough system.

Keywords: parabolic trough; solar tracking system; solar radiation.

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1. INTRODUCTION

Energy is a fundamental factor in meeting the basic needs of human beings and it is fundamentals of manufacturing in business and industry since the Industrial Revolution. Today, most of the energy comes from fossil fuels, including coal and natural gas, which are running out of money and rising. Therefore, it is necessary to find new sources of energy to replace these energies. The sun is an important source of renewable energy and does not cause any environmental impact, so it is suitable to use as a source of renewable energy in Thailand. Many researchers have been interested about the solar system [1-3]. The sun tracker system has been researched and developed [4-6]. A lot of new materials and technologies have been discovered [7-9]. Thus, this paper studied the solar tracking system using electronic circuits for parabolic trough concentrating collector. Because it can easily build, have efficiency for local system in Thailand and reduce cost. The remainder of this paper is organized as follows. In section 2, prototype design. Then, the automatic solar tracking circuits, the experiments, the experimental results and conclusion are explained in sections 3, 4, 5 and 6 respectively.

2. PROTOTYPE DESIGN

All heat generated by the solar system depends on the amount of light intensity that affects the object. Because each day the sun moves its position at all times, it is difficult to find the full power of the sun. Therefore, a solar tracking system is an appropriate and necessary alternative to highly receive solar energy. This paper invented a parabolic trough with a single-axis automatic sun-trading system because it was cheap and easy to build.

2.1. Parabolic Trough Structure Design

The parabolic trough structure is made from PVC pipe. Then, the surface of galvanized sheet is aluminum foil applied to the surface of zinc sheet. It is able to reflect the light and cheap to find the market. For the structure, zinc plate in the size of 80 cm width wide and 90 cm length was bent into a parabolic shape with a radius of 24 cm and in the length of 90 cm. Then, the black pipe was set up at the focal point as shown in Fig. 1, 2, 3 and 4.
Fig. 1. Side view of the parabolic trough

Fig. 2. Front view of the parabolic trough

Fig. 3. Top view of the parabolic trough
According to the parabolic theory, it always reflects into the focal point. Therefore, the contact at the focal point of the parabolic trough is very important to find the focal point. The calculation uses Equation (1)

\[ f = \frac{D^2}{16d} \]  

(1)

where D is the diameter of a parabolic trough 53.5 cm and d is its depth 24 cm. It has a focal length (f) 7.45 cm or 2.93 inches.

2.2. The Light Screen System Design

From the sensor set, both LDRs were set up between the two light screens as shown in Fig. 5. When the sensor receives sunlight, it will send the signal to order the transistor to control the flow of electricity to the driver's sector. The function of the detector device when the light detector is shown at Fig. 6 and 7.
Fig. 5. Detection system setting up with a light screen

Fig. 6. Function of the detector device when the light detector

Fig. 7. Moving rails to make the device detect sunlight
3. THE AUTOMATIC SOLAR TRACKING CIRCUITS

3.1. Sunlight Searching Circuit

The drive of the solar tracking system uses a single-axis DC motor, the horizontal axis. The motor is a 12 V DC motor with round head gear. In the circuit of the motor is used to set up in a horizontal. A horizontal drive circuit which uses the drive circuit as shown in Fig. 8.

![Schematic of the sunlight searching circuit](image)

The solar tracking circuit consist of two LDRs in order to find the sunlight. Both LM1458s were gathered into a group in order to compare the different light intensity signal from the LDRs. Two LDRs have a light screen between each other for comparison of light intensity. The signal from the LDRs was sent to the driver's sector, which consists of four transistors and four diodes become the switching circuits. It is the driver to rotate the left or right, depending on the intensity of the light that affects the two LDRs equally. If both LDRs have the same voltage or get the same light, there is no signal from the LM1458s to the driver sector. Nevertheless, if anyone has less light or the shadow of the scene covered, driver sector will also work. The motor will rotate until the two LDRs receive the same light.

3.2. Automatic Power Switch Circuit

This paper uses photo transistors as a device to detect sunlight in order to control relay, which is used as an electronic switch to the motor driving circuit and the solar search. The principle of the light detection circuit is that when the photo transistor detects light from the sun, the relay will work in on state. Then, electric current will go on to the motor driving circuit. At
night, phototransistor does not detect light. It will be in the off state position. After that, there is no electric current supplying for the motor driving circuit. The circuit of the motor is in the off state position. The light detection circuit is shown in Fig. 9.

![Schematic of the light detection circuit](image)

**Fig.9.** Schematic of the light detection circuit

For the operation of the light detection circuit, which uses a phototransistor as a current controller, it flows through the relay. This helps to turn on and turn off the power to control circuit all day. It affects to the motor in a positive way, the motor does not keep running all the time. The position of the phototransistor and the indicator light state is shown in Fig. 10.

![The position of phototransistor and indicator light state](image)

**Fig.10.** The position of phototransistor and indicator light state
The automatic power switch part was added by using micro switches to prevent power cutoff, assisting to inhibit the motor from rotating in horizontal direction more than 180 degrees. For the part of the motor drive circuit and the light search, if LDR is in an error state, micro switches will avoid the motor from rotating. The micro switch is a device to control bound of the motor rotating. It set up on both sides of the frame. When the motor is rotating, the micro switch will switch down with the iron rod in order to cut off the motor.

4. THE EXPERIMENTS

4.1. Experiment For Finding a Focal Point

Experiments are done by using Infrared thermometer guns to measure temperature to follow the height of the rail at different distances as shown in Fig. 11. The parabolic trough was experimented on days of clear weather at 12.00 p.m.-01.00 p.m. when the sun is perpendicular to the earth. Then leave the rails in the sun for a period of time, 15 minutes. After that, measure the temperature of each height. The experiment for finding a focal point is illustrated in Fig. 12.

Fig.11. Infrared thermometer for temperature measurement
4.2. Experiment of the Parabolic Trough With and Without Solar Tracking

The experiment is a comparison between the systems without solar tracking and with solar tracking as Fig. 13. The temperature was measured every half hour from 10:00 a.m. to 03.00 p.m. Then, the data results were compared.
5. EXPERIMENTAL RESULTS

The experiments were divided into 2 sections. Firstly, the experiment for finding a focal point was conducted on 10\textsuperscript{th} June 2017 from 12.00 a.m. to 01.00 p.m. Secondly, the experiment was conducted during 11\textsuperscript{th}-17\textsuperscript{th} June 2017 from 10.00 a.m. to 3.00 p.m. The results of the experiment are as follows the titles of 6.1, 6.2, 6.3 and 6.4.

5.1. The Experiment Result of Finding a Focal Point

<table>
<thead>
<tr>
<th>Height (In inches)</th>
<th>Temperature (ºC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
</tr>
<tr>
<td>3</td>
<td>86</td>
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<tr>
<td>4</td>
<td>80</td>
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<td>5</td>
<td>71</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
</tr>
</tbody>
</table>

Based on the calculations to follow the Equation (1) and the results in Table 1, it is concluded that the optimal focus point is 3 inches height from the bottom of the parabolic trough.

5.2. The Result of Environmental Temperature

The thermometer was used to measure the environmental temperature. The experiment was conducted during 11\textsuperscript{th}-17\textsuperscript{th} June 2017. From the time of 10.00 a.m. to 3.00 p.m., the results are shown in Fig. 14.
Fig. 14. The environmental temperature at various times on 11th - 17th June 2017

5.3. The Result of Parabolic Trough Without Solar Tracking System

During 11th-17th June 2017 from the time of 10.00 a.m. to 3.00 a.m., the temperature of the receiver starts at about 29 °C and then rises to 85 °C. Because the parabolic conductor is perpendicular to the sun, the steel pipe is in the focal point, resulting in the high heat. Then, when the sun moves out of the vertical, the focal point changes, resulting in lower tube temperatures to about 45 °C which will result shown in Fig. 15.
5.4. The Result of Parabolic Trough Solar Tracking System

During the 18th - 24th June 2017 from the time of 10.00 a.m. to 3.00 a.m., the temperature of the receiver starts at 29 °C, then increases rapidly to 87 °C and maintains the temperature of the receiver more than 70 °C during the experiment. Because the parabolic trough was perpendicular to the sun at all times, the water pipe was at the focal point, making it the most heat-resistant as shown in Fig. 16.

Fig. 15. The parabolic trough receiver temperature at various times on 11th-17th June 2017
6. CONCLUSION

In this paper, a solar tracking system made of low cost LED sensor circuit for a parabolic trough tracking is presented. The application of automatic solar tracking system equipped with a parabolic trough concentrating collector are water heater, air heater and heat exchanger. The experimental result the optimal focal point of a parabolic trough is 3 inches height from the bottom of parabolic trough. The average highest temperature of the system without solar tracking is about 79 °C at 11.00 a.m. The average lowest temperature is about 47 °C at 2.00 p.m. The average highest temperature of the system with solar tracking is about 83 °C at 11.00 a.m. The average lowest temperature is about 71 °C at 2.00 p.m.. The average temperature of the system with solar tracking is slightly changing, while the average temperature of the system without solar tracking is considerably changed. Therefore, the solar tracking system is suitable to use in the local area in Thailand. Because it can easily build, have the efficiency of
the local system and reduce the cost of fabrication.

7. REFERENCES


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