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Solar Power System for Flexitank Electrical Heating Pad

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Abstract: Generally, a steamed powered heating pad is used to heat up liquid products in a flexitank. However, it takes time for the liquid to melt and melting is only done when destination is reached [3]. The aim of this project is to design and implement a solar power system for electrical heating pad. This will save more time as the liquid can be heated continuously through the journey. A solar charge controller is used to control the voltage from the solar panel and allow the required voltage needed to power the heating element. In this project, a 12 V heating pad is used as the heating element and the system is tested to heat a 12x12 cm dimension of LLDPE. A 12 V battery is used as storage and can be used as a power supply during night transportation or when there is no sunlight.

Keywords: Flexitank, Solar, Heating Pad

1. Introduction

Theoretically, the amount of sunlight striking is enough to power electrical appliances by converting the solar energy to electrical energy through photovoltaic panels (PV). The converted energy can also be stored as extra power supply [1]. One benefit of using solar energy is the energy is a renewable energy and will not go to waste [4]. Photovoltaic cells are commonly found in solar panels. Electricity is generated due to the motion created when photons knock free electrons. A solar charge controller is essential to prevent overcharging and discharging of battery during night time. Two types of solar charge controllers are maximum power point tracker (MPPT) and pulse width modulation (PWM) [6].

Flexitank is a container used to transport liquid products. These flexitank are commonly implemented with heating pads and are usually powered by steam energy. However, this energy requires the flexitank to be at a discharged state to heat the heating pad. During a long transportation hour, the heating pad will eventually lose heat which then will affect the liquid's state in the flexitank. To ensure

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the liquid's state remain during transportation, a solar power system is designed and set up. The performance of the fabricated system prototype is evaluated to solve the occurring problem. For this project, the solar panel used has a dimension of 60 cm long and 30 cm wide. A solar charge controller with 1000 W/m^2 of solar radiance and an output current of 30 A. the system is tested to power a 12 V electrical heating pad.

2. Methodology

2.1 System Block Diagram

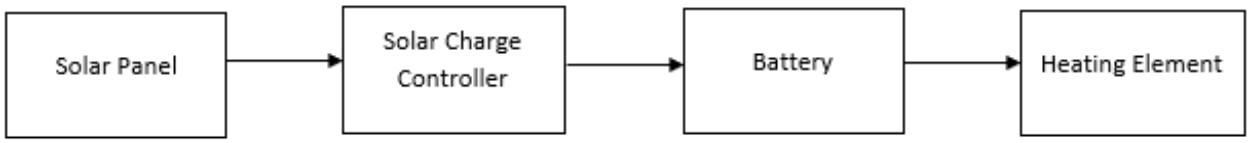

Figure 1: System Block Diagram

Figure 1 shows the block diagram of this system where the solar panel is the main source of this system. A lead acid battery is used as a storage place which act as a second power source. A solar charge controller is used to control and allow only the required voltage needed to power the heating element. The heating element is the output of this system which is an electrical heating pad.

2.2 Solar Panel

The solar panel used in this project is a monocrystalline solar panel. The specifications are obtained by measuring the irradiance, output voltage, output current and output power. These values can be obtained using a pyranometer and a multimeter. Theoretically, the higher the irradiance, the higher the value of voltage and current.

Table 1: Solar Panel Specification

MODEL TYPE: SY-20	
Maximum Power Current (Imp)	1.12 A
Maximum Power Voltage (Vmp)	18.0 V
Short-Circuit Current	1.20 A
Open-Circuit Voltage	22.10 V
Maximum System Voltage	1000 V
Wind Resistance	2400 Pa
All technical data at standard test condition	AM=1.5, E=1000 W/m^2, Tc=25 °C

For this project, the solar panel is tested to compare the value of open circuit voltage. The first solar panel is tested directly facing the sun while the other one is tested slightly tilted. As a result, the multimeter of the tilted solar panel shows a value of 20.0 V which is slightly lower than the solar specification value in Table 1.

Figure 2: Tilted Solar Panel

2.3 Heating Pad

Table 2 shows the specification of heating pad used in this project. A heating pad testing is done to confirm the specifications. An alternating power supply is with a voltage of 12 V and a current of 1.21 A. A thermostat is used to measure the temperature of the heating pad.

Table 2: Heating Pad Specification

HEATING PAD	
Material	Silicone rubber, alloy heating wire
Colour	Orange
Voltage	12 V
Dimension	15x15 cm

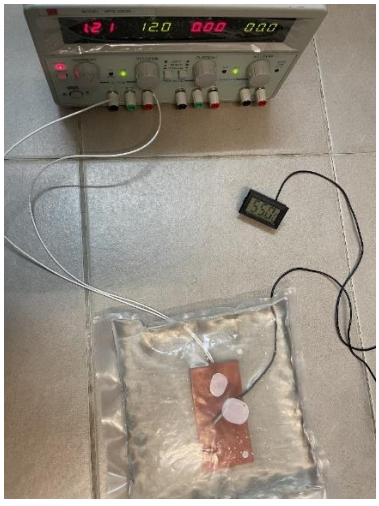

Figure 3: Heating Pad with LLDPE

Since the system is to be implemented in a flexitank, a test is done to find the heat resistance of an LLDPE. Figure 2 shows the highest temperature the heating pad can reach when heating the LLDPE which is 55.0 °C. Although the heating pad could reach the maximum boiling point of 100 °C, the temperature remains at 55 °C with an LLDPE on top.

3. Results and Discussion

3.1 Solar Panel Testing

Solar irradiance is the power unit per area, W/m^2 and is measured using a pyranometer. The testing results are incompatible as the country's weather is inconsistent. The solar irradiance test took place for two days at different hours.

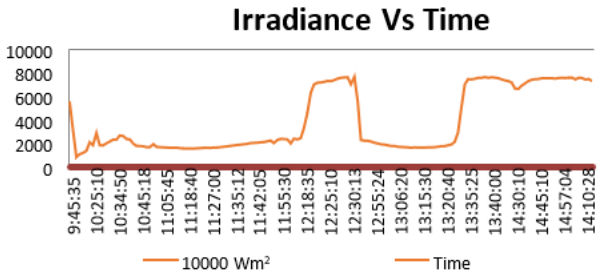

Figure 4: Solar Irradiance Day 1

Figure 3 shows the graph for day 1 of testing. Data for day 1 was taken from 9.45 am until 4.10 pm. From the graph, the irradiance peak point is at 12.30 pm with a value of 8000 W/m^2. At 9.45 am, the graph shows the minimum irradiance point with the value of 1000 W/m^2. From the graph, the peak hour where the most sunlight hits the solar panel is at 12.18 pm until 12.30 pm. Then the graph shows a decrement in the plot, where the sun was blocked and the weather became slightly cloudy. At 1.35 pm, the sun appeared and sunlight hit the solar panel resulting an increment in the graph plot.

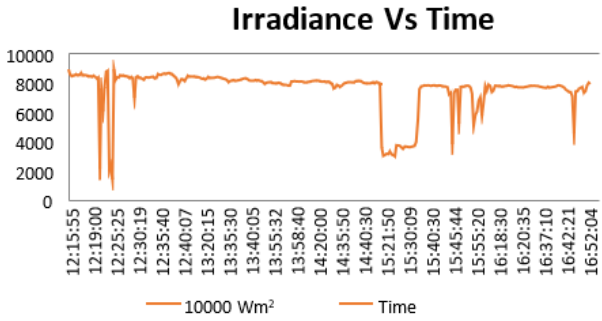

Figure 5: Solar Irradiance Day 2

Figure 4 shows the solar irradiance for day 2. For day 2, the solar irradiance testing started during the peak hour therefore automatically sets the peak irradiance value of 10000 W/m^2 at 12.19 pm. From the graph, can be seen that day 2 is a very sunny day as the irradiance value is still high which is 8000 W/m^2 in the evening. The minimum irradiance point for day 2 is 850 W/m^2 at 12.25 pm. Since day 2 is a sunny day, the graph plot maintained with a high irradiance value ranging from 8000 W/m^2 and 10000 W/m^2.

3.2 Hardware Setup

Figure 6: Hardware Setup

As mentioned, the solar panel is used as the power source of the system. The battery acts as a storage and a second power source. The solar charge controller was set to allow an output voltage of 12 V because the output voltage of solar panel is 18 V. From figure 4.3, can be seen that 12.6 V is the step-down voltage of the battery since the figure was taken indoors. The solar charge controller is connected to the solar panel, battery and a current sensor. A heating pad is connected to the system as the output.

4. Conclusion

To conclude, a solar power system was designed to heat an electrical heating pad. By using a solar charge controller, the system was able to supply a voltage of 12 V which is required to heat the heating pad. The system prototype is able to perform well and accordingly. The battery connected is able to act as a second source and the heating continues. The system still has some weakness that can be improved in the future. Some features can be added to improve this project:

i. A converter can be added to the system to get a stable output voltage.
ii. A solar tracker can be implemented to achieve a consistent amount of sunlight.
iii. Increasing the size of the heating pad can maximize the heat spreaded in the flexitank.

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