DESIGN OF BLOOMED FLOWER PATTERNED SOLAR COLLECTOR

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Abstract: A River Trash Collector System (RTCS) which powered by several DC batteries has been designed. This system is run to control waste and trash pollution at several areas along Malacca River. The objective of this work were to design an aesthetic solar panel as charging station for the RTCS and study the electrical output of solar cell use in the prototype. A bloomed flower shape of solar panel design was selected from four concept designs by Pugh Method. Five criteria were applied for the selection and the final concept was selected from concept model with highest score. Prototype of the selected model was fabricated by rapid prototyping method and sixteen commercially available solar cells with size of 65 mm×65 mm×3 mm were used for the prototype. Electrical output from single solar cell was examined to study the power output of the cell. It was found that single solar cell able to produce minimum electric power of 0.01 watt and maximum power of 0.353 watt. The power output of the solar cells was significantly affected by temperature of solar cell and increasing of relative humidity which consider to reduce sunlight intensity.

Keywords: Aesthetic Design, Solar Collector, Solar Energy

1.0 INTRODUCTION
As one of tourist attraction in Malaysia, Malacca River is required to provide good, healthy and clean environment. With the increasing of number of population, waste and trash that flow through Malacca river’s streamline is considered increased as well. A River Trash Collector System (RTCS) has been designed and developed in order to control waste and trash pollution in several areas along Malacca River. This system use two pumps that powered by several 12 VDC batteries. The use of battery powered pumps makes the cleaning system able to travel across the river when cleaning up the river. Therefore this system require a charging station located on the river side to recharge the batteries.
Solar energy is the most abundant, limitless and infinite energy. It is completely environmentally friendly form of energy as the alternative solution to fossil fuel. Solar charging system has been acknowledged as a versatile charging system to provide electric energy. The solar charging station typically consist of solar panel to collect sun energy and distribute the converted electric power to several charging outlets. Solar panel basically a device that converts the solar energy into electrical energy by using semiconductor, mostly silicon as a medium for the electrons to flow and generates electricity.

Solar collector with various designs and functions has been designed which mostly influenced by current customer’s demands, electrical output, available space, etc. One of the demands for solar panel is mobility where the customer need to travelling away from their home or doing outdoor activities and sometimes hard to search for the plug or power supply thus required solar panel that easily to be placed and carried along. Another current demand is aesthetics design which require solar panel to be more look attractive and its appearance can disguise to the surroundings [1-2]. Moreover, the effect of solar panel surrounding such as relative humidity and temperature has been found to determine the performance of solar cell output which need to be considered as well. The solar panel was lost its efficiency when ambient temperature is too high or too low which related to installation location of the solar panel [3 - 5].

Various size of solar cells with various electrical output have been design and sold in the market which increase the possibility of various solar collecting system to be design according to customer demands. Moreover, several patents on aesthetically mobile solar panel have been published as well. A solar panel product that matches the underlying rooftop had been developed by a Boston-based company [1]. This kind of solar panels reflect back an image of the roof below while still letting light through to the photovoltaic cells. Moreover, a Maryland-based company had developed invisible window coatings that house ultra-small solar cells designed to convert light from both the sun and artificial sources into electricity [2]. A closable solar collector designed and patented by Wu et.al utilized 6 solar panels which can be folded into hexagonal shape in order to easily transported [6]. The apparatus can be opened in pinwheel shape for sunlight harvesting. A cone shape pattern mobile solar panel has been patented by Clark [7]. The solar panel can be opened to form cone shape where the panels connected to each other by a yoke and catch at one end, the yoke and pivot connect to a tripod stand. Other closable solar collector made up of a stand, solar panel body, ball screw with a linking assembly and large surface solar panel which increase efficiency of solar energy harvesting has been patented by Chu [8]. This solar collector can be folded and unfolded like an inverted umbrella. Furthermore, a closable solar module comprising a group of lamellar solar panels mounted on a common axis which form pinwheel shape recently patented by Swatek et.al [9]. Most of these invention use silicon, polycrystalline or monocrystalline based solar cells to convert solar energy to electric. Based on the aforementioned design, an aesthetic solar collector which nice to look can be designed and installed at the side of the Malacca river to recharge the RTCS battery. This work was subjected to design an aesthetic solar collector as charging sources for the RTCS.

2.0 CONCEPT DESIGN

2.1 Concept Design Selection

The design interest was to design a solar panel which mimics bloomed flower shape. The solar panel is expected to be easily kept inside a closeable compartment in night time. In addition, it also require to be able to carry around to any location thus weight factor become necessary. To ensure the solar collector system not damage becaused of the rain, typhoon, wind, storm, lightning and etc., the solar collector was intended to be able to stored inside a compartment.

To produce solar panel that aesthetically able to blend in to its surroundings, four concept design were developed by using SolidWorks shown in Figure 1 to Figure 4. Concept design 1 and 2 were designed as a bloomed flower with petal shape. The petals and center part of the panel connected through hinges so the
petals can be folded onto the center part then panel can be stored inside a storage box when not used. Concept design 3 and 4 were made up of lamellar panels arranged one over another pinned on a common axis. This arrangement makes the panel able to tangentially folded then kept in storage box when not used and appears like a blooming flower when unfolded.

Figure 1. Concept design 1

Figure 2. Concept design 2
Selection of the final design was based on Pugh method (decision-matrix method) [10]. Five factors such as mechanism simplicity, weight, installation method, packing size and production cost were employed and ranked from scale 1 – 5 to represent their significances.

2.2 Storing and Erecting Mechanism

The designed solar panel should able to be stored in a container when not operated to ensure the safety of the solar panel from storm or heavy rain when not used. The storage box also make the solar collecting system possible to be carry around to other location when necessary. Consequently, a system to ascend or
descend the solar panel from storage box should be designed as well. Sun beam direction known to relatively differs over time. Therefore, a mechanism that able to adjust the relative position of the panel to sun beam according to time should be designed as well.

2.3 Electric output
A prototype of the solar collector system was fabricated by the selected concept design by rapid prototyping. Schematic arrangement of the designed solar collector system is shown in Figure 5. Commercially available monocrystalline solar cell with size of 65 mm × 65 mm × 3 mm (Figure 6) was installed to collect sun energy in the prototype. The solar cells then connected to the a solar charger controller (Figure 7) which able to regulate solar energy output to directly charge 12 or 24 VDC battery. To charge 12-Volt battery, the charger controller able to regulate up to 390 watt electric power input from the solar cell. Therefore, the output voltage V and current I of single solar cell was measured by using a digital multimeter to ensure electric output of the solar cell prior to connect the solar cell to solar charger controller. Temperature of solar cell was recorded by K-Type thermocouple. The data was taken for 3 days from 8.00 am – 6.00 pm within 2 hours’ interval.
3.0 RESULTS AND DISCUSSION

3.1 Concept Scoring
The result of concept scoring on the concept design is shown in Table 1. Based on the concept selection, concept design 4 was selected for further steps.

| Criteria                  | Weight | Design 1 Rating | Mark | Design 2 Rating | Mark | Design 3 Rating | Mark | Design 4 Rating | Mark |
|---------------------------|--------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|
| Simplicity                | 2.5    | 3               | 7.5  | 4               | 10   | 5               | 12.5 | 5               | 12.5 |
| Weight                    | 2.5    | 2               | 5    | 3               | 7.5  | 4               | 10   | 5               | 12.5 |
| Package size              | 2      | 3               | 6    | 3               | 6    | 4               | 8    | 4               | 8    |
| Ease of installation      | 1.5    | 3               | 4.5  | 3               | 4.5  | 5               | 7.5  | 5               | 7.5  |
| Production cost           | 1.5    | 3               | 4.5  | 3               | 4.5  | 3               | 4.5  | 4               | 6    |
| Total                     | 10     | 27.5            | 32.5 | 42.5            | 46.5 |

3.2 Storing and Erecting
Storage box designed for the solar shown in Figure 8. The top and bottom part of the box connected by a small gas spring so it can easily open and a latch was installed to lock the box. A bevel gear system, which controlled by microcontroller, was installed at base of the solar panel so it can tangentially folded and unfolded if user want to use it. To ascend or descend the solar panel from storage box, an electric linear actuator was fixed to the solar panel pole or support as shown in Figure 9. A link rod was connected to the linear actuator so the solar panel can be titled and adjusted easily by a microcontroller. In case of adjustment to sun beam direction, the relative position of the panel to sun adjusted by using a gear system which installed between solar panel and the support. This angle adjustment can be accomplished by using a microcontroller.
3.3 Electric output

Figure 10 show the average voltage output and temperature of single solar cell for 3 days. The voltage output of the solar cells was stable throughout the range of temperature. It can be seen that maximum voltage output produced at 12.00 pm where temperature of the solar panel also high (41°C). The highest voltage produced was 5.2 Volt at 12 pm and this voltage was maintained even the temperature declined to 33°C at 2 – 4 pm. The lowest voltage recorded was 3.5V at 6.00 pm although the temperature still quite high (31°C). Low current of 3.3 mA was produced in the morning time where temperature was 29°C (Figure 11), so it can be determined that lowest power generated was 0.01 watt. In addition, the maximum current output observed at 12.00 pm, which 68 mA of electric current observed at 12 pm as shown in Figure 11. This output indicates that maximum power produced by the solar cell was 0.353 watt. However significant current drop observed at 2 pm, where the current drop to 30 mA at 2 pm. The current then drop
again to 22 mA at 4 pm although the temperature was still 33°C and furtherly dropped to 4.7 mA although the temperature was 31°C at 6 pm. These results indicates that the solar cell loss its power due to temperature.

The performance of a photovoltaic system depends not only on its basic characteristics but also on the environmental issues which means that solar modules work best in certain weather conditions. One such environmental issue like the ambient temperature plays an important role in the photovoltaic conversion process [7]. Although the ambient temperature has a positive correlation with the efficiency of the solar cell system [8], the data obtained show significant current drop although temperature still quite high. A possible reason of the finding is the effect of humidity. Figure 12 shows plot of relative humidity to temperature of the solar cell. From this graph, it can be concluded when the relative humidity high, output current and voltage of the solar cell can be decreased. This finding also stated by Panjwani and Parejo work [11] which conclude that humidity drastically effect the performance of solar panel and proves out that humidity decrease the power produced by Solar Panels up to 15-30%. Moreover, study by Kazeem and Chaichan also shows the deterioration in the solar power with the relative humidity increment [12]. A
study by Mekhilef et.al [13] also indicates the effect of relative humidity to efficiency of solar cell where when the light hits water droplets, the sun energy may be refracted, reflected or diffracted.

Figure 12. Temperature of solar cell and ambient relative humidity during test

4.0 CONCLUSION

A proposed design of solar panel that is mimic blooming flower was successfully obtain. This solar panel is expected to get attention from tourist when installed around Malacca river as charging station for the River Trash Collecting System. Based on electrical output testing, the temperature of solar cell significantly affect the power output of the solar cells. Increasing of relative humidity is considered to affects the electric output of the solar panel.

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