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The development of the Solar Bicycle in the Northeast of Thailand

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Abstract

This research aims to develop and design the solar bicycle. The design of a solar bicycle consists of 1) solar cell of 12 V, 0.29 - 0.49 A of 2 panels, 2) the controller of the electronic charging of 24 V, 3) the Controller DC power supply and electronic throttle lever, 4) the DC motor driver of 350 W 24 V, 5) the 2 batteries charging of 12 V 12 Ah was connected in a series that was the power supply source of the motor driver and 6) the bike weight of 70 kg and one seat. Thus, the operating of the solar bicycle is designed with some modifications to the standard bicycle that the devices can be installed. The installation of the solar cells was arranged in the position to receive the most sunlight. When the sunlight falls on the solar cell, the solar cells will change the solar energy into the electrical direct current. Then the electrical energy is sent to the charging controller and charging to the batteries. The solar bicycle operated by twisting the throttle lever which is connected to the control power, which controled the power from the battery to the motor driver. The motor driver is connected to a gear driven by bicycle. The speed of the rotation motor or the speed of the bicycle is based on twisting the throttle in the desired position and velocity. From the study of the energy consumption of the solar bicycle, it was found that the voltage measured at the solar cell poles average of 27.04 V. The direct current measured from solar cells to batteries charging average of 0.36 A. And the voltage measured at the battery poles average of 25.78 V. The direct current of the power supply measured from the battery to the motor average of 5.80 A. And the energy consumption of the battery power supply to the motor driver is 149.52 W at the speed of the bicycle of 23 km/hr. And the value of electrical charging average daily of the solar bicycle was found that during 09:00 - 10:00 pm. average of 8.30 - 9.46 W. It increased during 12.00 pm. - 01.00 am. average of 12.26 W, which has the highest average daily value. And it begins to decline during 01.00 - 04.00 am. average of 11.72 - 7.79 W, respectively. And found that the power supply to the motor driver is based on the speed of a bicycle or twisting the throttle lever. The energy consumption average is 26.55 – 149.52 W at the average velocity is 5 – 23 km/hr, respectively. With a bicycle rider weight of 57 kg, the energy efficiency of 42.72 % was reached. It took 4 hours and 45 minutes to charge the batteries.

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Keywords: The solar bicycle, The solar cell, Sunlight

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1. Introduction

Thailand imported energy mainly from abroad. Data from the Department of Energy were found that in 2011 over 60 percent of commercial energy demand was from importing. The proportion of oil imports was 80 percent of oil consumption in the country and also tends to be higher because [1] the production cannot increase to keep pace with the demand for domestic work, and it was also found that the price of oil on world market fluctuates over time and tends to increase as the oil in the market is expensive and needs foreign oil imports. The rate of oil consumption has increased. The imported oil is demanded. Its amount was 39,846 million liters in 2007 and increased to 47,365 million liters in 2011 – or increased at a rate of 5.32 percent per year; and [2] Thailand needs to exchange large amounts of energy each year. Thus, the government's energy policy has promotion of some energy for more funding. The price of energy will become a burden to the public.

Department of Energy of Thailand has forecast the country's future energy needs. In 2022 it is expected to 99,838 ktoe from currently 71,728 ktoe. [1] In Thailand, power generation is dependent on natural gas more than 70 percent. The renewable energy target is a fuel that can be used in the production of electricity. In the future, renewable energy may be developed as a primary energy to produce electricity for Thailand.

Solar energy is renewable energy. However, the solar energy equipment is used effectively to realize the potential of solar energy and to use them. The use of solar energy used in energy conversion to electricity needs solar cells. [3,4] The study found that the power can take advantage from many forms, such as fans, lights and appliances on the cooker. It is also found to be associated with the electric motor that is mounted on a vehicle. [5] The researcher had the idea of bringing solar energy to be utilized, for example, to set up on bikes to convert sunlight into electrical energy. The electric motor is used to rotate the drive gear on the bike to make a move.

2. Solar Energy

2.1 Solar Energy

Whether the potential of solar energy will be higher or lower is depending on the amount of solar radiation in each area. The area that has the most solar radiation exposure has high potential solar energy. For the use of solar energy, light devices have to be installed. In Thailand, solar energy potential is in various areas all year, from the high potential of solar radiation over the north-east area to the middle area of Thailand.

From the study, the area was 14.3% of the total area in Thailand. The annual average daily solar radiation is in the range of 19-20 MJ/m^2-day. The average intensity of solar radiation value across all areas of the daily per year is 18.2 MJ/m^2-day. For the comparison of intensity of solar radiation value with data from other countries, see Fig 1. Thailand has a high potential for solar energy. The solar energy depends upon the intensity of solar radiation value during the year. The change in solar radiation value is during 16-22 MJ/m^2-day. It begins in January and its peak is in April. Then, it gradually reduces to a minimum in December. In middle and north-east area of Thailand is the radiation in the range of 1,350-1,400 KWh/m^2-year; see Fig 2. This value can be used to produce energy.

Generally, in these two methods can produce electricity from sunlight. (1) Solar energy conversion into electricity directly uses the solar cells. (2) Power generation uses solar heat to heat water or gas. The steam or hot gas is used to turbine generator. In this it's required high technology and complex system. The first investment is very high.[5]

2.2 Solar Vehicle

The electrical vehicle that runs on solar energy is a two wheel drive and can be used for shuttle and short distances. Sunlight is the main source of energy for the vehicle. Energy from Sunlight is captured by the solar panels and is converted to electrical energy. The electrical energy is charged to the batteries and used to run motor. The shaft of the motor is connected to the rear wheel of the solar vehicle through chain sprocket; see Fig 3.[6]

The solar bicycle team from the UNITEN research the energy of the solar bicycle is supplied by the battery, which is connected to the solar panels. HP48G calculator is used to handle the energy management of the solar bicycle due to its portability and computer-like capabilities.[7] The concept of a hybrid electric car assisted by solar panels appears more realistic.[8]

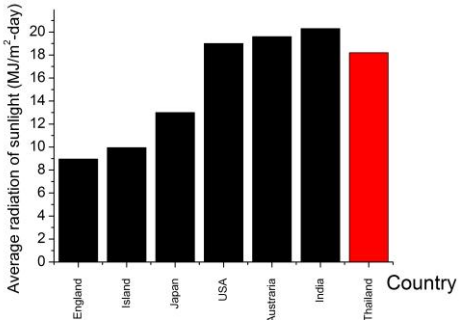

Fig. 1. The average daily intensity of solar radiation on the others country

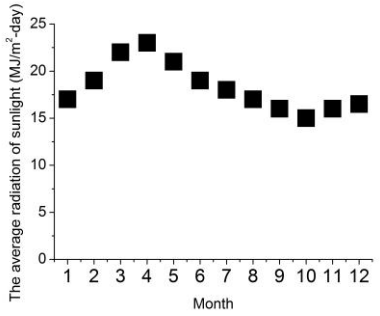

Fig. 2. The daily average intensity of solar radiation for monthly in all areas of Thailand

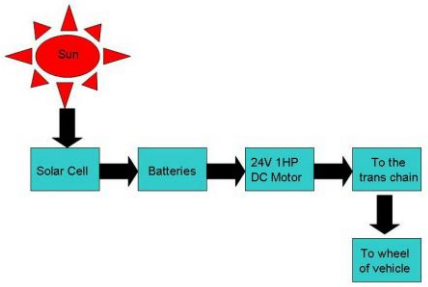

Fig. 3. Basic block Diagram Representation of Solar vehicle

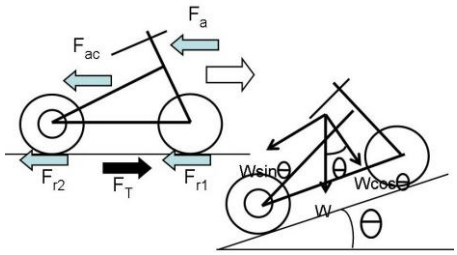

Fig. 4. The force component of bicycle

Components of the solar bicycle that:

1. Solar Cell
2. Battery
3. The charging controller
4. The DC Motor
5. Standard bicycle

3. Design and Installation

3.1 Design

The design of the solar cycle was determining the force required to drive the bicycle. In accordance with this equation; see Fig 4.

The total force running. $F_T = F_r + F_a + F_{ac} + F_c$ (1)

1. Rolling force(F_r *)* $F_r = \mu_r W$ (2)

2. Aerodynamics force(F_a *)* $F_a = (12.96 \rho C_d A v^2)/2$ (3)

3. Acceleration force(F_{ac} *)* $F_{ac} = (W + W_r)(a/g)$ (4)

4. Climbing force(F_c *)* $F_c = W\sin\theta$ (5)

Solar cycle design is to find a position for installation the 2 panels solar cell and a position for installation the others controls system device. It can drive the bicycle; see Fig 5.

3.2 Installation

The installation for solar bicycle is installing 2 solar cell panels each of which is 12 V, 0.29 - 0.49 A and setup the controller of the electronic charging of 24 V into the control system device box. Then, install two battery charging of 12 V 12 Ah in the same area of the controller device and setup the controller DC power supply and electronic throttle lever. Next, setup the DC motor driver of 350 W 24 V into gear driver of the bicycle so that the battery charging was connected in series. It was the power supply source of the motor driver. The bike weighs 100 kg and has one seat; see Fig 6.

4. Experimental and Methods

4.1 Experimental

The experiment on the solar cell charging into the batteries is from 09.00 am – 04.00 pm., recording the voltage and current. Experiment the movement of the bicycle when the rider. The bicycle weighs 70 kg and the rider weighs 57 kg. Then, test how the bike runs.

4.2 Methods

The methods of testing the solar bicycle are follows. When the batteries are fully charged with solar energy, setup the measuring device, distance measuring equipment, speed measuring equipment, voltage meter and current meter. Measure the length of the road. Test the way the solar bicycle drives and twists the throttle until the speed of 5 km/hr. Test again as driving at velocity of 10, 15, 20 and 23 km/hr. The maximum speed is 23 km/hr.

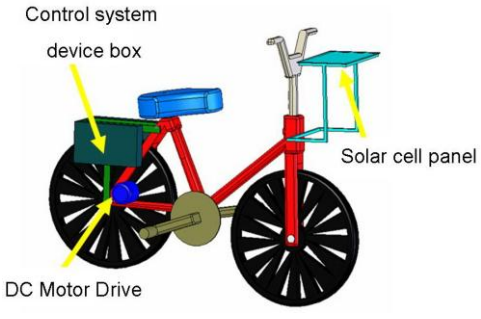

Fig. 5. The design of solar bicycle

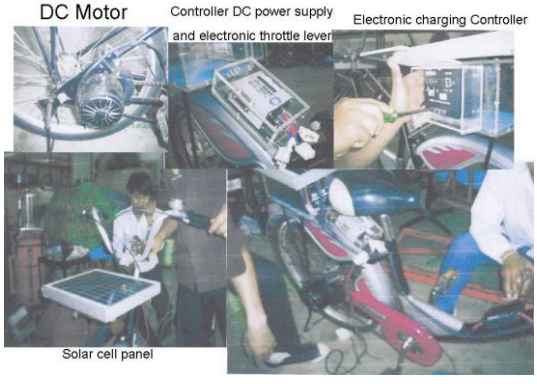

Fig. 6. The installation of solar bicycle

5. Results and Conclusion

5.1 Results

1. The charging batteries

From the experiment, the batteries charged by the solar cells were setup on the bicycle in the outdoor park. Measure the average charging per hour from 09.00am - 04.00 pm each day. The result shows in table 1.

From the table shows that at the period of time at 09.00am – 01.00 pm., the value of voltage has higher value charging from the solar cells than from batteries set. The value of voltage is between of 26.79 – 27.24 V. In 01.00 – 02.00 pm the voltage charging of the solar cell is the maximum value of 27.26 V and will decline thereafter until 04.00pm with the voltage value of 26.86 V. The average voltage value of the solar cell is 27.04 V. Also, it was found found that the current charging of the solar cell is the same as the voltage. In 09.00 - 12.00 am the current has higher value charging from the solar cells. The current value is between 0.30 – 0.35 A. The period of time 12.00am - 01.00pm the current charging of the solar cell is the maximum value of 0.45 A. and will decline thereafter until 04.00pm at 0.29 A. The average current value of the solar cell is 0.36 A.

The electric power of the solar cell charging has an average value of 7.79 W. In 09.00 - 12.00 am., the value of power has higher value charging. The values of the power charging of the solar cell between 8.04 – 9.46 W and during 12.00 am - 01.00 pm are at the maximum value of 12.26 W. The power maximum size is 12.26 W and will begin to decline after 04.00pm; see Fig 7. The average power value is 9.81 W.

2. The solar bicycle driving

From the experiment, the solar bicycle driven from batteries was tested its drive on the road. Measure the average value driving. The result shows in table 2.

From the table, the parameter value for solar bicycle driving per velocity is shown. The voltage value has lower from batteries to motor drive. The voltage value is between of 26.85 – 25.78 V. It is found that the voltage will decrease when the velocity increases. The velocity is 5 km/hr, the voltage is 26.85 V, the maximum velocity is 23 km/hr, and the voltage is 25.78 V. It is found that the current use of the motor drive is different from the voltage. In the velocity of 5 km/hr, the current is 1.00 A. And the current increases when the velocity increases. The current value is between 1.00 – 5.80 A. The electric power of the motor drive has an average value between of 26.85 – 149.52 W. The value of power has higher value when the velocity was increase; see Fig 8.

3. The coefficient of the rolling resistance

From the experimental, it is found that the coefficient of the rolling resistance is 0.03 when the rolling force is 4 kg, and the total weight is 127 kg.

4. The energy efficiency

From the experimental, it is found that the energy efficiency is 42.72% when the maximum energy consumption is 149.52 W and the power of motor drive is 350 W.

5.2 Conclusion

The design and setting up of a solar bicycle consist of (1) solar cell of 12 V, 0.29 - 0.49 A of 2 panels, (2)the controller of the electronic charging of 24 V, (3) the Controller DC power supply and electronic throttle lever, (4)the DC motor driver of 350 W 24 V, (5)the 2 batteries charging of 12 V 12 Ah connected in series that was the power supply source of the motor driver and (6) the bike weight of 70 kg and one seat. The solar bicycle is designed as same as a standard bicycle that can be installed the devices. Installation of solar cells is in the

position to receive the most sunlight. When the sunlight falls on the solar cell, the solar cells will change into system. The solar energy is used in the electrical direct current. Then the electrical energy is sent to the charging controller and charged to the batteries. The solar bicycle used by twisting the throttle lever is connected to the control power. The controller DC supply controls the power from the battery to the motor driver. The motor driver is connected to a driven gear of the bicycle. The speed of the rotation motor or the speed of the bicycle is based on twisting the throttle in the desired position and velocity. From the experiment in the energy consumption of the solar bicycle, it is found that the voltage measured at the solar cell poles is at the average of 27.04 V. The direct current measured from solar cells to batteries charging average is 0.36 A. And the voltage measured at the battery poles is at maximum average of 25.78 V. The direct current of the power supply measured from the battery to the motor is at maximum average of 5.80 A. And the energy consumption of the battery power supply to the motor driver is 149.52 W at the maximum speed of the bicycle of 23 km/hr. And the value electrical charging average daily of the solar bicycle is found during to 09.00 – 10.00 pm average of 8.30 - 9.46 W. It increases during to 12.00 pm - 01.00 am at the average of 12.26 W, which has the highest average value every day. And it will begin to decline during 01.00 - 04.00 am at the average of 11.72 - 7.79 W, respectively. It is found that the power supply to the motor driver is based on the speed of a bicycle or twisting the throttle lever. The energy consumption average is 26.55 – 149.52 W at the average velocity of 5 – 23 km/hr, respectively. Using a bicycle that weighs 57 kg, the coefficient of the rolling resistance is 0.03. The energy efficiency is 42.72 %. The total time to a full charging of the batteries is about 4 hours and 45 minutes. The solar bicycle can drive continuously about of 2 hours per one time of charging. The solar bicycle can be recharged.

Table 1. The average charging into batteries from the solar cells panel

Time(hr)	V(V)	I(A)	P(W)
09.00-10.00am	26.79	0.30	8.04
10.00-11.00am	26.93	0.32	8.62
11.00-12.00am	27.02	0.35	9.46
12.00am-01.00pm	27.24	0.45	12.26
01.00-02.00pm	27.26	0.43	11.72
02.00-03.00pm	27.18	0.40	10.87
03.00-04.00pm	26.86	0.29	7.79
Average	27.04	0.36	9.81

Table 2. The average solar bicycle driving

Velocity(m/s)	V(V)	I(A)	P(W)
5	26.85	1.00	26.85
10	26.65	1.67	44.51
15	26.42	2.20	58.12
20	26.20	3.87	101.39
23	25.78	5.80	149.52

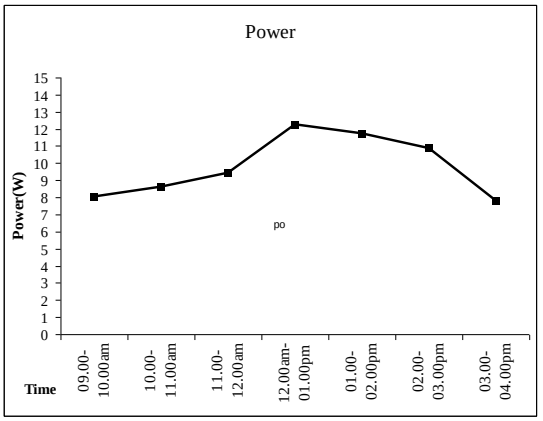

Fig. 7. The power value charging from the solar cells to batteries set per day

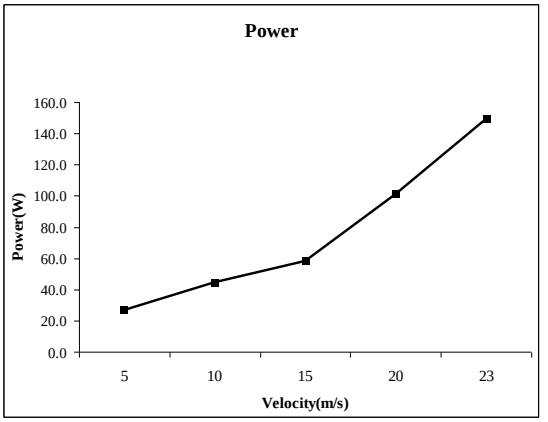

Fig. 8. The power value charging from the solar cells to batteries set per day

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