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CONSTRUCTION AND FEASIBILITY TEST OF A SOLAR POWERED BICYCLE IN BANGLADESH

Md. Tahjib Rafat[1,*], Pronob Deb Nath[2] and Md. Ashequl Haque[3]

[1]Engineer, MAN Energy Solutions Bangladesh Limited, Dhaka-1212, Bangladesh
[2]Undergraduate Student, Department of Mechanical Engineering, Khulna University of Engineering & Technology (KUET), Khulna-9203, Bangladesh
[3]Manager, MAN Energy Solutions Bangladesh Limited, Dhaka-1212, Bangladesh

[1, *]tahjib.rafat@gmail.com [2]pronobdebnathpartho@gmail.com [3]md.ashequl.haque@gmail.com

Abstract- *Solar energy is the most available renewable energy around us which we can use for different purpose in our daily life. Bicycle, is generally based on chain connected with crank gear and sprockets mechanism connected with rear wheel drive by human continuous rotating cyclic path of the crank. This exhausting process can be reduced by using motor or electric system. In this study, we used the solar energy concept and used it constructing a solar powered bicycle to generate power which is going to move the wheel using a high torque motor attached with the bicycle. In rainy days, cloudy days or during night it showed less performance using previously charged battery but overall, it could be very handy during sunny environment. Also, it was very cost friendly, environment friendly and feasible in our country. After construction of the bicycle, performance evaluation done for some days and also cost analysis carried out. Initial costing might be high but this solar powered bicycle comfortable for journey as it drives by solar and reduce humane effort.*

Keywords: Solar power, Bicycle, Construction, Cost Analysis, Feasibility.

1. INTRODUCTION

A solar powered bicycle is a vehicle which powered by using the solar energy during daylight. "Solar Vehicle" means a vehicle that used solar energy to power all or important necessary parts of a vehicle to move. Bicycle is a very common way of transportation in rural area especially for poor people. But it is difficult for people to cover a long distance by using this vehicle, as it requires hard work due to pedaling. That's why it is not much popular in cities compare to villages. But it can be used for covering long distance using solar power.

Solar power harnessed from sun's ray to earth is not only free but also renewable. Operation and maintenance cost are very low and has much flexibility to ride. But it is initially costly to build a solar powered bicycle. The bicycle will charge its self and no real maintenance is required during charging. Solar bicycle consists of battery, Solar Panel, Motor and Motor controller. This solar powered bicycle can be operated by manual labor and also by solar cell of the system. Solar powered bicycle would provide a reliable, clean, and environmentally friendly vehicle. Solar bicycle can move faster than traditional bicycle. It can be used for saving a lot of time and human effort. Even physically disable people can easily operate this vehicle. In this paper we design and build a solar powered bicycle which will allow riding in long-distance tours powered only by the sun and our muscles. This project is about to see how a solar powered bicycle can be made using easy-to-obtain parts [1]. The objective of this study is to study about solar cell and with its performance so that we can conversion a normal bicycle into solar power bicycle along with performance test of it.

2. LITERATURE REVIEW

Solar energy using technique with bicycle is very common technique all around the world. Different countries scientist, researcher has successfully construct and evaluation performance test on its.

Ignatius Maranga et al. design and test a solar power bicycle in Kenya which is feasible for off grid people in Nairobi [2]. Darshil G. Kothari et al. researched on hybrid bicycle and proposed and developed a system using solar technology, electric hub motor with high performance lithium-ion battery. It gives the bicycle sustainable power to ride long distance path from human pedaling & solar energy charging the battery [3]. Mr. Prashant Kadi & Mr.Shrirang Kulkarni published an article about hybrid powered electric bicycle. Using PMDC motor assisting with solar energy it was very cost friendly and suitable for rural and city area. He concludes that using it, 25 km can be easily traveled [4]. M. Reddi

Sankar et al. designed and development a solar assist bicycle fitted with motor which has ideal city ride about 40 km [5]. Graham S. Aikenhead application on board solar power system generation with Elora solar irradiance application with bicycle. Up to 30 km trip distance can be covered with 42% battery capacity [6]. Chung-Hsing Chao provided a strategy for solar powered bicycle with remote power management strategy. They monitor the solar powered energy system and analysis the effectiveness. Depending on charge system, it can travel about 36.4 km to 54.4 km. Proposed WSN far end technology is very feasible with solar power energy system, that what he concludes [7].

3. CONSTRUCTION

For completing the study, we need to construct a solar power bicycle and evaluate its performance. To do that, we need following equipment like solar panel, conventional bicycle, motor, battery, wheel, charge controller, wire and switch. Solar array of the solar panel collects solar energy and then convert it to electrical energy. After that the solar charger control the electrical energy and help to store inside battery. Electric motor uses this battery to drive the vehicle.
All the system specifications are as follow:

Table 1. Necessary system Specifications

Name	Remark
Solar Panel	20 W, 2.2 Kg, 443x420x25mm
Motor	250W, 24 V
Battery	12 Volt
Charging time	6-8 hour
Max Speed	34.8 km/hr
Frame	Steel
Wheels	R= 355x45 mm
Crank length	560 mm

The necessary steps of making a traditional bicycle into solar powered bicycle are given below: Firstly, the freewheel must be installed, then installing the motor was done. Then we attached the chain wheel to the shaft. After that we installed the solar panel and solar charger controller. After installing the battery, we established the electric connection. All the works are present in figure 1. Block diagram of electric connection are shown in figure 2.

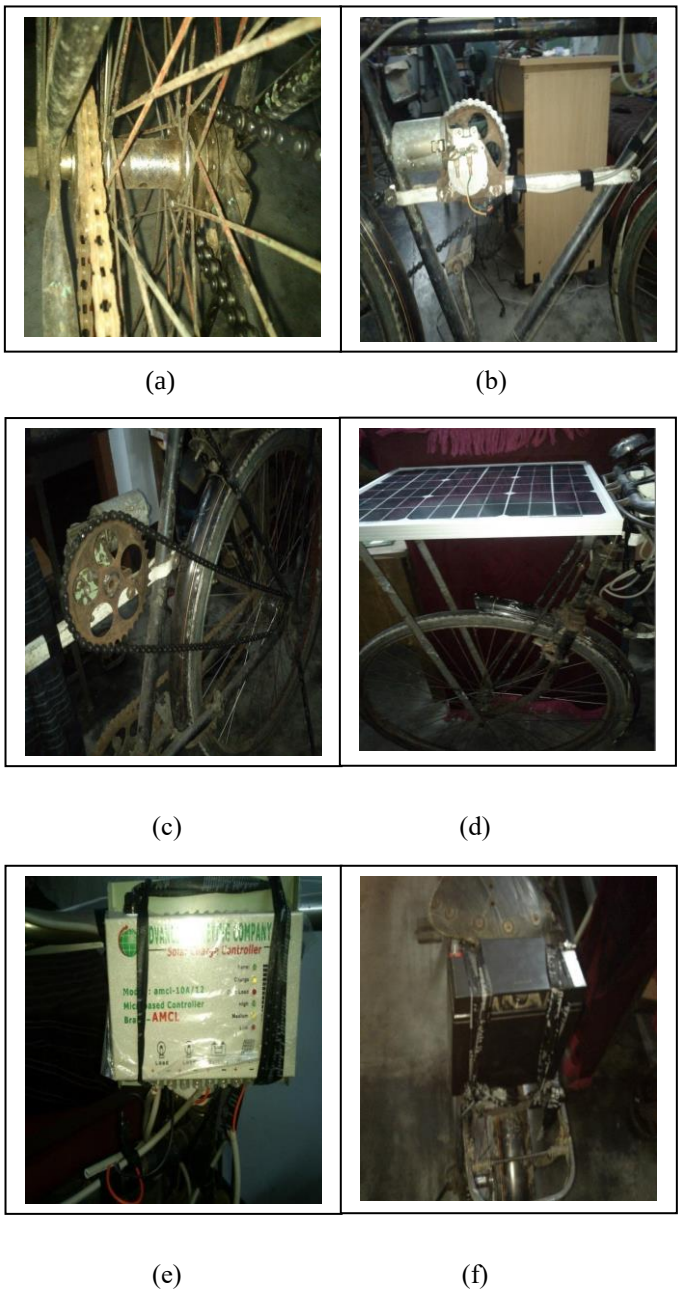


Figure 1. Construction process of making solar powered bicycle attachment of (a) free wheel (b) motor (c) chain wheel with shaft (d) solar panel (e) solar charger controller (f) battery

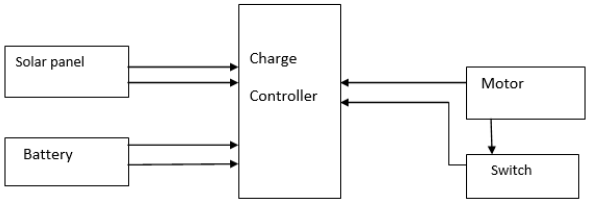


Figure 2. Block diagram of electric connection

4. RESULT AND DISCUSSION

All the experimental data was collected on 9 July, 2013 to 7 September, 2013 at Khulna University of Engineering and Technology (22.9006° N, 89.5024° E). Equations use for all the calculation are given follow:

Solar radiation efficiency, $\eta = \frac{Pm}{IA}$

Power factor = Average Power/ Rating Power

Average rpm of the wheel measured as 264.5 ≡ 27.69 rad/sec from calculated data. Average solar radiation about 683.8 W/m^2 and average power about 19.66 W at 9th of July from table 2. From table 3 we can see collected data from 25th August. 3rd September to 5th September collected data are given at from table 4 to table 6.

Table 2. 9 July, 2013 collected data from the bicycle

Time	Solar Radiation (W/m^2)	Voltage (V)	I (A)	Power (W)	Av. Power (W)
11.25	678	18.2	1.14	19.37	
11.35	680	18.5	1.18	19.92	
11.45	681	18.6	1.18	19.97	19.66
12.00	685	18.8	1.2	19.28	
12.10	695	19.01	1.24	19.79	

Table 3. 25 August, 2013 collected data from the bicycle

Time	Solar Radiation (W/m^2)	Voltage (V)	I (A)	Power (W)	Av. Power (W)
11.30	670	16.8	1.1	19.24	
11.40	673	18.01	1.12	19.26	
11.55	680	18.2	1.16	19.28	19.35
12.05	690	17.98	1.14	19.32	
12.15	687	17.99	1.12	19.33	

Table 4. 3 Sept, 2013 collected data from the bicycle

Time	Solar Radiation (W/m^2)	Voltage (V)	I (A)	Power (W)	Av. Power (W)
11.45	470	7.05	2.10	14.8	
12.10	495	8.7	2.16	15.98	
12.30	440	6.6	2.06	13.6	16.42
12.45	545	8.15	2.2	17.98	
13.00	587	8.8	2.24	19.72	

Table 5. 4 Sept, 2013 collected data from the bicycle

Time	Solar Radiation (W/m^2)	Voltage (V)	I (A)	Power (W)	Av. Power (W)
10.35	400	6.1	2.04	11.28	
11.00	410	5.9	2.08	12.28	
11.30	432	5.65	2.06	12.5	12.71
12.00	480	6.2	2.14	13.26	
12.15	503	6.55	2.18	14.23	

Table 6. 5 Sept, 2013 collected data from the bicycle

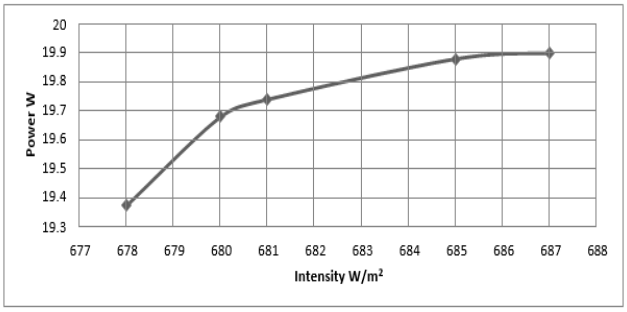
Time	Solar Radiation (W/m^2)	Voltage (V)	I (A)	Power (W)	Av. Power (W)
9.30	345	5.6	1.28	7.18	
10.00	330	4.30	1.65	7.09	
10.30	310	4.05	1.55	6.28	5.05
12.45	240	4.49	0.77	3.46	
13.00	139	1.8	0.7	1.26	

Average solar radiation and average power respectively from 25th August to 5th September were 679.4 W/m^2, 19.35 W; 507.4 W/m^2, 46.42 W; 445 W/m^2, 12.71 W; 272.8 W/m^2, 5.05 W. Efficiency and Power factor of the following days are given at table 7.

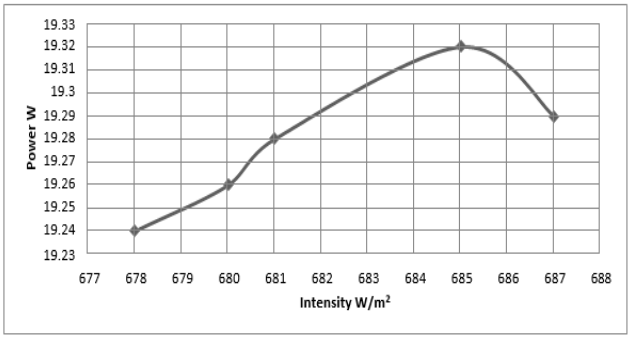
Table 7. Efficiency and Power factor from calculation

Date	Efficiency	Power Factor
09/07/2013	15.8	0.98
25/08/2013	15.66	0.96
03/09/2013	15.66	0.82
04/09/2013	15.7	0.63
05/09/2013	10.18	0.25

Power Vs Intensity graph are plotted in following figure for different date.



(a)



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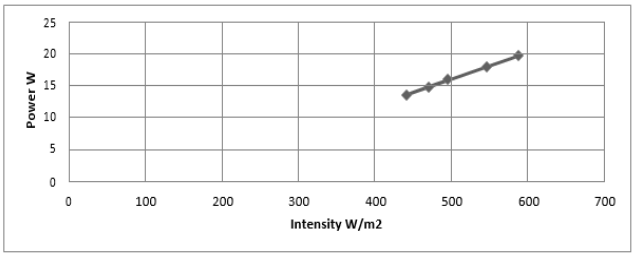

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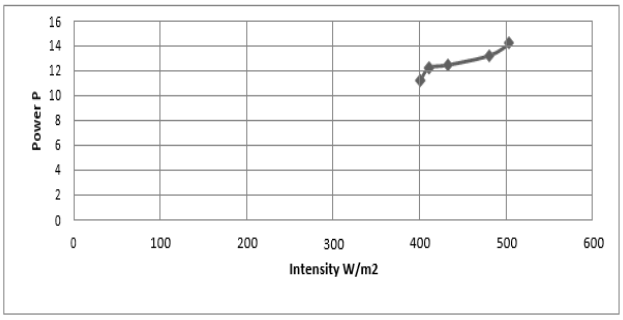

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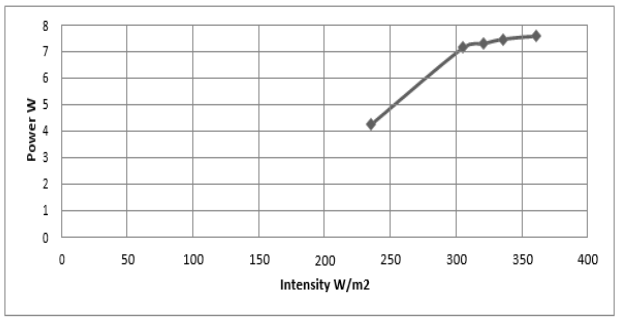

(e)

Figure 3. Power vs Intensity on (a) 9 July (b) 25 August (c) 3 September (d) 4 September (e) 5 September, 2013

Table 8. Cost analysis of the Solar powered bicycle

Item no	Name	Quantity	Price in Tk
1	Traditional bicycle	1 piece	2500
2	Motor	1 piece	15000
3	Chain Wheel	1 piece	180
4	Paddle Wheel	1 piece	150
5	Solar Panel	1 piece	2000
6	Charge controller	1 piece	700
7	Battery	1 piece	2500
8	Switch	1 piece	20
9	Electric Wire	1 piece	100
10	Flat, Triangular plate, etc	1 piece	250
	Total		23400

From the available data collected from July to September, we can see that solar radiation intensity depends on weather conditions. Also, highest intensity found around 700 W/m^2 in July and lowest about 140 W/m^2 in September. After completing the conversion, the calculated velocity is 35.35 km/hr. and the efficiency of solar cell is 15.74%. The required power of the motor is 250 Watts.

Designing an appropriate technology for solar powered bicycle is a huge challenge, especially when power is to be transmitted from the motor shaft to the rear wheel through chain and gear arrangement. For this there is a high friction loss for transmitting power from driver to driven shaft. And as the motor is to be placed on the bicycle the design become very complex due to lack of space. It also causes difficulty to balance the weight of the total bicycle. The total weight of the bicycle increased a lot for this arrangement so the load that can be carried by solar bicycle is less than traditional bicycle.

As the initial torque needed to start the bicycle is more than the power of motor, so rider needed to paddle first to overcome the higher initial torque. After overcoming initial torque, motor should be started.

Bicycle should be properly maintained and take care of the electric components, breaks, motor, battery for long lasting and durability. The battery should be change after a 3 or 4 year. Properly designed and constructed solar powered bicycle yields higher speed than a traditional bicycle. Due to high initial cost Solar powered bicycle may seemed to be infeasible in Bangladesh, but considering its durability and future maintenance it is definitely feasible in Bangladesh. Short to moderate distance can easily traveled using solar power bicycle, with the help of battery and using solar in daylight. Green and cleaner technology like solar power promote eco-friendly technology. Solar panels may seem quite expensive while purchasing for the first time, but in the long run it will save quite a great deal of money.

So solar powered vehicle can help greatly promoting healthy environment. In urban area traffic jam is one of the most encountered problem which causes a lot of waste of time. Solar powered bicycle can reduce the problem to some extent as it is fast and easy to operate. It is small in size and can be parked anywhere quite easily. So, in urban area it can be used to save money, time, and human effort. In rural area roads are narrow and zigzag, hence it is difficult to travel those paths by car or bus. That's why in rural area bicycle is widely used. But for travelling long distance along those require lots of human effort. As solar powered bicycle reduces human effort so it can be used widely. Construction and maintenance of solar powered bicycle is easy and do not require an expert. So, in short it can be said that solar powered bicycle is feasible in Bangladesh.

5. CONCLUSION

In Bangladesh, average bright sun light in summer season is about 7.6 hours a day, and during in the monsoon, season is about 4.7 hours. As, we are very densely populated country, we need sufficient supply of energy for our daily life. Solar power electric source can be is the only alternative source for energy. Solar powered bicycle would provide a reliable, clean, and environmentally friendly vehicle. The main obstacle is high initial costs. Solar powered bicycle can be used widely in rural area where people have to travel long distance. Solar powered bicycle is vehicle which can save

both time and human effort and bring comfortless in journey by bicycle. The initial constructing cost of a solar powered bicycle is high. And after the initial cost there is no need of resources (e.g. fuel) to run this as it runs by solar power. Solar powered bicycle is environment friendly vehicle as it uses renewable energy, hence no pollution due to burning of oil. It can be used for saving a lot of time and human effort. Even physically disable people can easily operate this vehicle

6. ACKOWLEDGEMENT

None.

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