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STUDY OF CONSTRUCTION AND ANALYSIS OF A VEHICLE USING SOLAR ENERGY WITH SOLAR TRACKING SYSTEM

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Abstract: **Environment awareness has developed progressively worldwide over the last 40 years. Engineers in all disciplines have a particular obligation towards the integration of development and the environment leading towards sustainable future development. The future engineers are required to be trained in decision making and to act environmentally sensitive and responsible manner. It is essential for them to obtain the knowledge on new environment friendly technologies e.g. renewable energy technology. Solar energy is a renewable energy source that converts the sun's heat and light into energy. Not only is the sun, a source of heat and light, it's a source of electricity too. Solar cells, also called photovoltaic cells, are used to convert sunlight to electricity. This electricity is sufficient enough to drive a motor attached to a car as well as to drive the car. Besides, Fuel cell is a steady flow system where the fuel is only hydrogen. In modern age to prevent the deficiency of fuel solar energy and fuel cell technology are widely used. The purpose of this research is to construct and analyze the shape of a fully road worthy vehicle operating under nothing but the power of the sun, fuel cell and to construct a solar car. My challenge will be to construct a vehicle that travels as fast and straight as possible. This project provides a chance to explore the aerodynamically ideal vehicle. Little attention has to be paid to practicality. This results a very streamlined, highly aerodynamically efficient car that is stable and safe. Here solar tracker is used to track the sun light through five positions of the sun with respect to vehicle.**

Keywords**: Solar car, solar tracker, Photovoltaic cell, Renewable energy, Vehicle aerodynamic**.

1. INTRODUCTION

As standard of living improved the world population day by day, we should think about the renewable sources of energy because the traditional sources such as coal, petroleum, gas limited in stock. The wood and the biomass age ended in about 1880. At this point the coal became the primary fuel until 1940 [1]. Now petroleum acts as the primary fuel but it is time to seek a replacement for it. The scientists of the world are looking for renewable source of energy for last two decades. Renewable energy source that comes from natural energy sources from natural environment Sun, Wind, Water, Geothermal are the common forms of renewable energy. In Bangladesh the only means of fuel used for the road vehicle is petroleum i.e. diesel, octane, petrol etc. But after the 'Middle-East' crisis the price of the petroleum is rising in an alarming rate. Now a day's natural compressed gas is considered as the alternative but its implementation is very limited.

Only some vehicles are converted into CNG and also there are a few refueling stations. Bangladesh is a country where 60% people lives below poverty line. In a country like it is very hard to find out people having personal vehicle. So, rickshaw is the common vehicle in our country to travel from one place to another place. Previously the rickshaw drivers used to run their rickshaw by paddling. It was too hard and also humiliating. With the blessings of technology those days are gone by. Now most of the rickshaws got motor driver and battery to run them. We simply called them auto rickshaw or battery rickshaw. But the system developed there is not so good. Cause a huge amount of electricity is needed there to charge it. Therefore, Photovoltaic cell and fuel cell are used to charge the battery. This system will reduce the consumption of electricity from household and also reduce load shedding.

2. MATERIAL AND METHODOLOGY

The weight of the vehicle is a very important design consideration. Since the vehicle is probably acceleration most of run, the weight is more important that if the vehicle is traveling at a constant speed. Also the weight is a direct multiplier on rolling resistance. Twice the weight means twice the rolling resistance for the same wheels, tires and bearing. So use lightweight materials, built up construction, or other lightening techniques.

2.1 Material used in solar vehicle:

2.1.1 Composite:

Because weight is a retarding force, solar vehicles are constructed of lightweight, state-of-the art materials, known as composites [2]. Composite materials are extremely lightweight and very strong; however, the manufacturing process is very detailed and labor intensive. Kevlar can be used as the fabric with a Nomex honeycomb spacer, which gives a better strength to weight ratio.

2.1.2 Carbon fiber fabric:

Carbon fiber is usually the preferred material since it offers a better strength to weight ratio than Kevlar. The fabric itself is very strong during axial loading but flexes under torsion and is brittle under shear [2].

2.1.3 Honeycomb spacer:

Honeycomb spacer provides structural rigidity in those directions. The combination of the two is often referred to as a composite sandwich. There are many types of honeycomb spacers. When choosing the correct spacer, examining the spacer’s properties is crucial [2]. A spacer’s properties is dependent upon the material of which it is constructed and the spacer’s geometry. Different densities, cell size, and spacer thickness provide different properties for flex, buckling, shear, bending etc.

2.1.4 Composite sandwich:

The last variable for the construction of a composite sandwich is the resign and adhesive that is used [2]. The choice of resign and adhesive does not affect the properties of the finished composite, it affects the fabrication process. Different resigns and adhesives have different cure times and temperatures, and perform differently during various operating conditions. The success of manufacturing a composite is dependent upon correctly choosing a fabric, spacer, resin, and adhesive. In this case I used aluminum sheet of 0.5 mm and plastic wood of 2 mm. For the chassis I used plastic wood because if I used aluminum sheet, as this sheet is very thin, creates vibrations. I used angle bar measuring 1” and flat bar 1” of aluminum.

2.2 Basic Body Design:

The race regulations of the body set certain limits to the body design; the maximum height, length and width of the body as well as the minimum height of 1 m. Along with the other regulations the design has converged to three basic shapes shown in Figure 1; unified aero body and panel, separate cab and panel, catamaran shapes. These are only basic shapes that might have to be complemented with features that might have negative effects to the aerodynamic performance of the vehicle. The one that can have the most impact is the rear-view mirrors. It adds to the drag; the retarding force acting on

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the vehicle. Therefore techniques like fiber optics and cameras are used to see the rear without adding drag increasing features on the body.

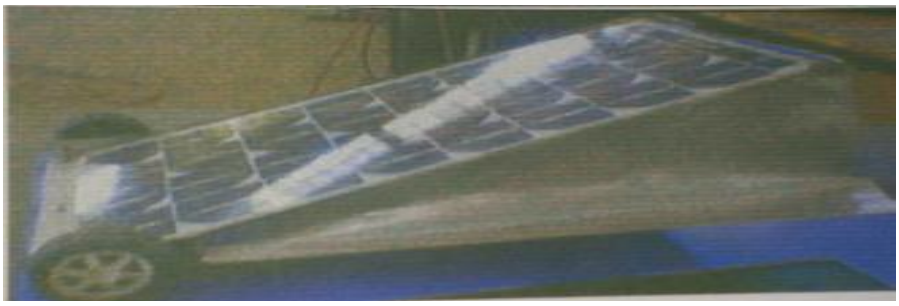

Fig.1. Body of car

2.2.1 Unified aero body and panel:

This body shape is the dominating one; it has the advantage of the solar panel fully integrated in the body, creating a single aerodynamic body, with a minimal parasitic drag. It also has a small frontal area which governs for a low C_D*A value.

2.2.2 Separate cab and panel:

This shape enables a lightweight construction of a low cost and simple construction. The disadvantages are its aerodynamic characteristics; it has a low efficiency due to the open wheel suspension and is very sensitive to crosswinds. The tilting panel has a large advantage; the solar panels can face the sun even when the sun is near the horizon on the side of the vehicle.

2.2.3 Catamaran shapes:

Trade-offs between aerodynamics, power collection and the driver's compartment has to be made when designing the body [3]. The catamaran shape is a good compromise; it has a low frontal area and the catamaran shape also gives good possibilities to have a rather low drag coefficient. The solar panels can be placed on the back array of the car; which has a large area facing the sun from many angles.

2.3 Airfoil Shaped:

The profile of the body differs a bit from the competing cars, but they all have a basic airfoil shape. The most efficient airfoil is the NACA 4418 [4] shown in Figure 2; it is optimized to achieve lami8nar flow, minimized separation, without the unwanted lift. It has the thickness to cord ratio of 17 and the maximum thickness at 27% after of the leading edge. To optimize the body shape in the other directions it should from the top consist of two top surfaces, of NACA 4424, on each side. To minimize vortices and separation in crosswinds sharp0 corners in the front should be avoided. Putting all this together a teardrop like shape is created, with a minimum drag and no lift force. The disadvantage with this shape is the lack of are to use for the solar panels.

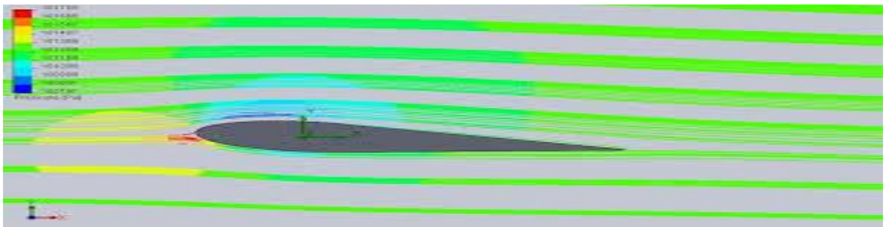

Fig.2. Airfoil of a car [5]

2.4 Aerodynamic:

Solar powered vehicles have a similar amount of energy available compared to the conventional, internal combustion engine powered passenger vehicles, and therefore, solar aerodynamic drag must be reduced to a very low level in order to

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have the same performance as conventional vehicles. Aerodynamic drag is non-linear with speed. At very low speeds, below 10 mph, it doesn't have too much effect, but as speed increases to more than 30 mph, aero drag gets important [6]. The magnitude of drag depends on the frontal are of vehicle, i.e. maximum cross section looking at the car from the front, multiplied again by the coefficient of aero drag, which depends on car shape, multiplied again by the velocity squared. A poorly designed shape might have a coefficient of 0.5 and a very good shape might be as low as 0.012. So we can see that the drag could range over 4 to 1. Be sure the underbody is smooth, too, not open like a regular car. As a comparison, the Honda 96 "Dream" solar car requires only 1.62 kW to cruise at 100 km/h, while a conventional vehicle with a C_d value of 0.32 requires as much as 13.52 kW. The solar car requires only 12% of driving force for a conventional vehicle, and the difference is even greater at higher speeds. Running resistance consists of rolling resistance dictated by weight and tire factors and aerodynamic drag resulting from the body shape. From aerodynamic needs, the design goal is to minimize drag while not creating lift or down force. But since the vehicles are lightweight and have a relative large area, they will be very susceptible to instability in crosswinds and have to be designed for crosswind stability.

2.5 Chassis:

For the construction of chassis I preferred angle bar (1") and flat bar (1") of aluminum shown in Figure 3. Because it is light in weight but has good tensile and brittleness.

2.6 Transmission System:

The simplest type of transmission is direct drive, which means the motor is connected directly to the axle of driven wheel. Direct drives are not common in vehicles; one of the few vehicles that use direct drive is a unicycle. It is most important to choice the best gear ratio [7]. First I must find the speed at which the motor gives the most power. Then I try to keep the motor turning at approximately that speed as my experiment gear ratios. It helps if it is built in such a way that I can change the gear ratios easily as you experiment. Gears can be particularly wasteful if they are not precision made. Some form of belt drive may be best, but I have to be sure that belt does not slip and that is not overly tight. The drive ratio is important. It may be that different ratios are best for different sun conditions. Therefore, a solar tracking device is needed to track the sun to provide useful electricity. The power produced from the solar panel is limited and sometimes not sufficient. As a result, I have to select such a transmission system where the driven pulley is smaller and the driving pulley is large compared with the driven. In my transmission driven pulley is 1.2 cm and driving pulley diameter is 12 cm.

2.7 Solar System:

Sunlight is an excellent energy source. The Sun's energy can be used to heat and cool buildings, generate electricity and operate communication and navigation systems [8]. With the cost and demand on fossil fuels, solar powered cars may become more and more popular. Solar power is population free and inexhaustible. Solar vehicles convert the sun's energy directly into electricity. Electric vehicles have their energy stored in a battery. Since electric and solar vehicles do not directly burn fuel, there are few harmful emissions produced. Solar panel is used as the source of power. Sunlight strikes the solar cells and the light is converted to electricity on an atomic level. The basic building block of a solar system is the photovoltaic cell. [Photon= light; voltaic= electric]. The amount of electrical power delivered by the cell depends on its size and efficiency. These cells are thin silicon layers with a positively charged impurity. The parent silicon layer is negatively charged.

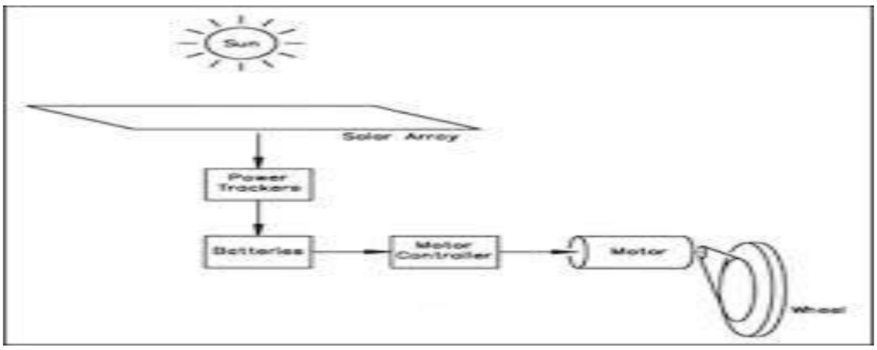

Fig.3. Solar system [8]

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2.8 Solar Tracker:

A solar tracker is a device that orients a payload toward the sun. In flat-panel photovoltaic (PV) applications, trackers are used to minimize the angle of incidence between the incoming sunlight and a photovoltaic panel [9]. This increases the amount of energy produced from a fixed amount of installed power generating capacity. The optics in concentrated solar applications accepts the direct component of sunlight light and therefore must be oriented appropriately to collect energy. Tracking systems are found in all concentrator applications because such systems do not produce energy unless pointed at the sun.

Table 1. Direct power lost (%) due to misalignment (angle *i*) [9]

Angle	0^0	15^0	30^0	45^0	60^0	75^0	90^0
Lost	0	3.4%	13.4%	30%	50%	75%	100%

3. RESULT AND DISCUSSION

After completing the fabrication we have to collect some data in order to analysis the system. So in a sunny day we started to take some date.

3.1 Data Collection:

We started to collect the data at the beginning of December month. As it was winter we started to take data from 10 am and after two hours each. The data is given below:

Table: 2. Voltage and current floe rate available from the solar panel

Time period	**10 am**	**12 pm**	**2.30 pm**	**Average**
Voltage (volt)	16.32	17.12	16.95	16.8
Current (A)	0.67	0.71	0.701	0.7

Table: 3. Motor specification

Speed (rpm)	**Power (watt)**	**Current (amp)**	**Voltage (volt)**
3000	3	0.6	12

Table:4. Transmission specification

Rear wheel (cm)	**Driving pulley (cm)**	**Driven pulley (cm)**
14	12	12

Table: 5. Velocity calculation

Time	**Track length (m)**	**Time taken (s)**	**Velocity (m/s)**	**Average**
10 am	10	10.309	0.97	
12 pm	10	9.61	1.07	1.01
2.30 pm	10	10.101	0.99	

3.2 Solar Panel power and velocity analysis:

For solar cell array, we can calculate the power output, *P*. The panel is rated at 16.76 Volts, 0.688 Amps.

Then, the calculation is, P (watts) = I (amps) • V (volts).

= 0.688 amps • 16.76 volts.

= 11.531 Watts.

My solar panel has 32 individual cells connected to one another in series. Their combined area is about 32 cells × 0.05m × 0.05 m = 0.08m^2. Multiplying the area by 150W/m^2 we get power 150× 0.08 = 12W.

For velocity analysis we know that, t = $\sqrt[3]{4m(d)^2/P}$ = $\sqrt[3]{4(3.10)(10)^2}/12$ = 4.69 sec.

Where, m= 3.10 Kg, d= 10m, P = 12W.

On race day we got that the actual time is much more than this which is just above two times. The average velocity is 1.01 m/s.

3.3 Summary of Result:

Result obtained from this experiment is the actual velocity, theoretical velocity, transmission efficiency, solar power available from the solar car. The summary of the results are given below:

- The actual velocity of the car is 1.01m/s.
- The theoretical velocity of solar car is 4.08m/s.
- The transmission efficiency is 45.5%.
- Solar power available actually is 11.531W.
- Solar power available is 12W.

3.4 Discussion of the Result:

The difference between the actual value and the theoretical value for the velocity is due to the over weight of the car. As all the parts we collected from the local scrap market and the parts we made was not precious enough, the efficiency of the transmission system is not sufficient enough. This is enough reason for low velocity. Battery was integrated in the car as a result the battery could recharged from solar panel which energy could be used to run at night. In addition, Bangladesh is a poor country. The people of the Santmartain, Sandip use solar electricity and it is a popular system in that area. Solar car, if establish in our country, will also popular in our country as it has no running cost. It is environment friendly also.

4. CONCLUSION

Solar energy is one of the effective renewable energy. It is free and a source of ultimate energy. It has no environmental pollution. In our country we have lot of scope to use solar energy. Ours is one with a tropical weather. Latitude of Bangladesh is 24º00´ north of the Equator and Longitude of Bangladesh is 90º00´ East of Greenwich. So the sunlight is prior at our country. That's why we should put on more interest at solar energy. This project was taken as a prototype of using this solar energy a form of renewable energy. Solar Electrical Vehicles is adding convex solar cells to the roof of hybrid electric vehicles.

There are limits to using photovoltaic (PV) cells for vehicles: [10]

- ***Power density:*** Power from a solar array is limited by the size of the vehicle and area that can be exposed to sunlight. This can also be overcome by adding a flatbed and connecting it to the car and this gives more area for panels for powering the car. While energy can be accumulated in batteries to lower peak demand on the array and provide

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operation in sunless conditions, the battery adds weight and cost to the vehicle. The power limit can be mitigated by use of conventional electric cars supplied by solar (or other) power, recharging from the electrical grid.

- ***Cost:*** While sunlight is free, the creation of PV cells to capture that sunlight is expensive. Costs for solar panels are steadily declining (22% cost reduction per doubling of production volume).

REFERENCES

[1] Harrison Steve, Faculty advisor, solar vehicle project, Queen's University

[2] Sven Johan, Holmberg Erik, Nilsson Andreas and Ahmed Shamim, "Aerodynamic Design of Solar Cars", in the course road vehicle aerodynamic, MTF235

[3] Xie J, Bradon CJ and JJ, Fighting urban transport air pollution for local and global good: The case of two strokes engine three-wheelers in Dhaka. Paper presented at the Consultative meeting on integrated approach to vehicular air pollution control in Dhaka held by World Bank and department of Environment, Government of Bangladesh April 26-27, 1998

[4] Perry Ross and Gardner Ian, "Model Solar Car Mathematical Simulation," version 1 (0/02/02)

[5] Pardun Richard R., Aerospace Engineering, "Aerodynamic of solar car."

[6] Bedwinek Andrew, "junior solar sprint", NREL/BK-820-30830, revised (8/23/01)

[7] Holly Krisztina and Madhani Akhil, "An introduction to building a model solar car"

[8] Haehnel Robert, Inside tips on parts and construction of solar car", NREL/BK-820-30827, revised (8/23/01)

[9] Antonio L. Lugue; Viacheslav: M.Andreev (2007), concentrator photovoltaics. Springer verlag, ISBN: 978-3-540-68796-2

[10] Ignacio Luque-Heredia etal, "The Sun Tracker in Concentrator Photovoltaics" in Cristobal, A.B. Martí, A. and Luque, A. Next Generation Photovoltaics, Springer Verlag, 2012 [ISBN 978-3642233692]