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Design, Construction and Performance Test of a Solar Powered Prototype Vehicle

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Abstract

Solar power vehicle is the exciting issues to the transportation sector in the context of fossil energy crisis. A solar power prototype vehicle has been designed, constructed and performance test were carried out in this study. The vehicle is constructed using the locally available raw materials. The experimental investigation shows that the vehicle can run 1.87 km/h with load of 2 kg. The vehicle not requires conventional operating energy as it operates by rechargeable battery charged with the help of solar photovoltaic cell. If the automotive vehicles are design with the aid of solar energy instead of fossil fuel then energy crisis can be significantly solve globally and also in Bangladesh. This will also reduce the environment emissions in home and abroad.

Keywords: Solar energy, Prototype vehicle, Energy crisis.

1. Introduction

The demand of petroleum over the world will be driven by the motorization of passenger transport and the continuing growth of international trade. World motor vehicle ownership will increase more than 2 billion in 2030 compared to about one fourth today due to modernization, urbanization and other factors [1]. The vehicles are fossil based engine operation. There is substantial uncertainty about how much conventional oil remains in the world for future generation. There are varieties alternative resources already invented to run the engine instead of fossil fuel but still have limitations to use 100%. Besides, worldwide transportation fuel use is projected to double by 2050 despite significant energy efficiency gains [2]. So, reliable and renewable energy sources are important in the transportation sector to overcome the limitations. Solar energy is the renewable, pollution free energy and available over the world. Many technologies have been found to conversion/utilization of solar energy into useful energy in practice. But in transportation section the utilization of solar energy is poor. But solar can play an important role to minimize the dependent on fossil energy. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute sunlight. Active solar techniques include the use of photovoltaic panels and solar thermal collectors (with electrical or mechanical equipment) to convert sunlight into useful outputs. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air [3]. When sunlight (photons) strikes on PV cells, they excite electrons and allow them to flow, creating an electrical current. PV cells are made of semiconductor materials such as silicon and alloys of indium, gallium and nitrogen. Silicon is the most common material used and has an efficiency of 15-20% [4]. Design, construction and performance test of an automotive vehicle has been undertaken in this work with the help of PV cell and rechargeable batteries with an aim to reduce the use of fossil energy in the transportation sectors. The novelty of this work is the use of locally available raw materials and low cost system investigation. This construction will helps to make motor vehicle in practical with alternating energy sources and can reduce the energy demand in the context of energy crisis.

2. Design

A fixed small locally available solar panel considered in this work with available dimensions of 25 cm length, 18 cm width, 0.75 cm thickness and weight of 0.4 kg. The main parts used are plastic wheels, metallic gear, mild steel chassis, shafts, fittings, DC motor and battery. The dimension of the body is selected as per dimension of the solar panel used.

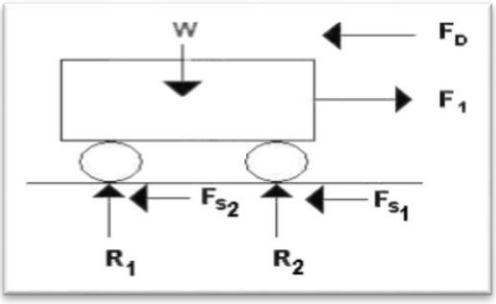

Fig. 1. Load balance of vehicle

Weight of the body with accessories 1.80 kg.
Total weight of the vehicle 2.20 kg.
From theory of load balance in dynamics [5-7]
$\sum R=R_1+R_2$
=>W=mg
=>W=R = 2.20*9.81 = 21.58 N
Friction force F_s
For Plastic and Concrete $\mu_R = 0.035$
Wheel radius r =3.10 cm
From theory of rolling friction [5-7]
$F_S=\mu_R*(\sum R/r)$
=0.035*(21.58/0.031)
= 24.36 N
Resisting force $F_R=Fs+F_D$
Since the drag force arise above 25 mph and its speed will not much higher so $F_D=0$
F_R=24.36N
Now, F_1 must be higher than F_R to run the vehicle.
Let, the value of F_1=24.46N

The Force Balance [5-7]
$\sum F = ma$
$F_1 - F_R$ =0.05481 N
=>24.46-24.36=2.20*a
=>Acceleration a = 0.045 m/s^2
Thrust for the vehicle =ma
=2.20*0.045kg.m/s^2
=0.099N
Power required for initial motion $P_{req}=F_1$*thrust
=> P_{req}= 24.46*0.099=2.42W
Now, $v^2 = u^2 + 2as$ [for 1 m]
=> $v^2 = 0 + 2*0.045*1$
=> v=0.30 m/s
Power required to keep the vehicle in motion
= F_t*v=0.0297W
So the vehicle require more than 2.42W continuously to run.
One DC motor considered to deliver the power.

Maximum Output Power by the Solar Panel is (8.85×0.52)=4.60W
A battery of 8.4V selected whose maximum power output 8.4*0.52=4.36W
The Maximum Input to the Motor by the Solar Panel with batteries is 4.60W (> 2.42W), which is Sufficient to Run the vehicle.

Maximum Load Carrying Capacity-

The available power = 4.60-2.42W= 2.18 W

$P_{req} = F_1 \times F$

or, $2.18 = 24.46 \times F$

or, F=0.089 N

therefore, F = ma

or, $0.089 = m \times 0.045$

or, m=1.98 kg

it is theoretical value of load

Again, speed $u = \frac{\pi DN}{60}$

Here , Diameter of wheel, D = 6.2 cm

Revolution of wheel, N= 422 rpm

Therefore, $U = \frac{\pi \times 0.062 \times 422}{60}$

$= 1.36\ ms^{-1} = 4.89\ kmh^{-1}$

The vehicle will run at the rate of 4.89 $kmh^{-1}$with a load of 2.00kg.

2. Construction

Mild steel material was chosen for the chassis due to high load carrying capacity. Four plastic wheels light in weight, small cast iron bevel gear arrangement, two transmitting shaft, one DC motor, necessary nuts/bolts and 8 volt battery were considered to construct the vehicle. Gear material chosen on the basis of wearing and mach inability property. Bevel gear can transmit power with high velocity ratio.

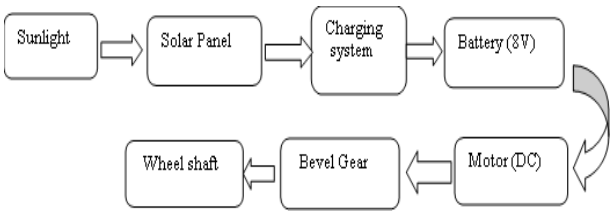

Fig. 2. Layout of vehicle construction

The motor fit with chassis at a suitable position connecting a shaft with pinion gear and mesh with bevel gear arrangement. The motor takes the power from the battery connected by wire. All the equipment arrange in a compact manner with the body. Charging system is basically electrical system. The rechargeable battery here used is rated at 8.0 volts and needs a charging voltage of around 8.0-8.4 volts to reach full capacity. Therefore to charge the batteries required 8.5 or 9 volt support 4W solar panel is available in the market. Note that all batteries charged at the same time should have the same capacity.

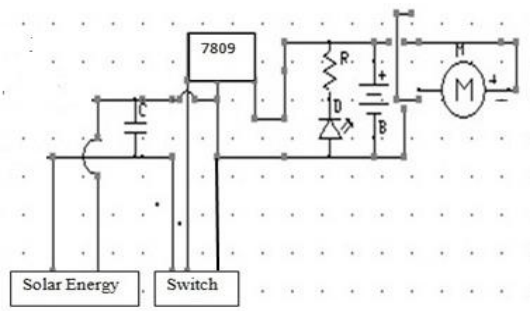

Fig. 3. Charging system

So, charging equipments were chosen according to the battery conditions. A polar capacitor, 7809 control regulating IC, diodes, kilo ohm resistors, LED, SPDT switches (single pole double throw) were considered for construction the charging system.

3. Results and discussion

The results and discussion of this study is described in the following subsection.

3.1 Charging performance

Figure 4 shows the variation of voltage of the solar panel with time of the day. From the figure it is seen that, the voltage increases with increasing time. The voltage is maximum of 8.85 V at 2.30 PM. The variation occurs due to the variation of solar intensity. Radiation intensity higher causes higher electron excitation on the panel and higher voltage. The charging system is designed with 8V, hence the performance is reasonable the charging system is well enough to charge the battery to run the vehicle.

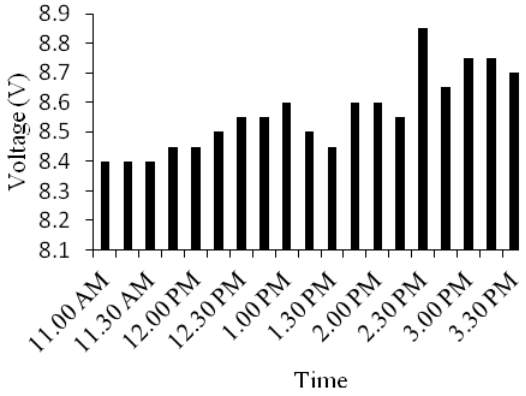

Fig. 4. Variation of voltage with time

Figure 5 illustrates the variation of current of solar panel with time of the day. The current of solar panel shows non uniform trends due to solar intensity variation over the day. It is seen that the current is increased for the same radiation intensity. The maximum current is found is 0.51A at 1 and 2 pm of the day which is reasonable to charge the battery.

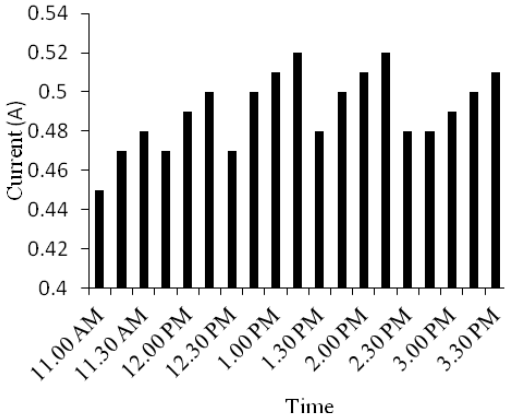

Fig. 5. Variation of current with time

Figure 6 shows the variation of power output using solar panel with time of the day. From the figure it is seen that the power output almost similar average of above 3.5W which is reasonable to run the vehicle constructed in this study. Though, the current and voltage are not shown in the same trends. This power constantly applies to the car through battery.

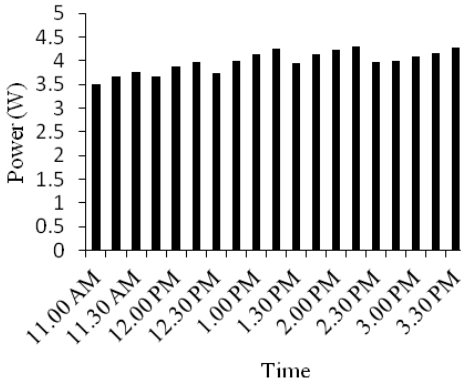

Fig. 6. Variation of power with time

3.2 Vehicle running performance

Figure 7 illustrates the variation of vehicle velocity with applied load. From the figure it is seen that, the Vehicle velocity decreases with increasing applied load. At the design load 2 kg the vehicle velocity is found to 1.87 km/h. The applied load should not increase too high and it considered near or below the design value to keep the equipment performance well. The experimental vehicle velocity (1.87 km/h) is deviate from the design vehicle velocity (4.89 km/h) due to the fact that the weight of the final vehicle was not in the range of design value. Few unnecessary materials were added in the vehicle system that makes the system heavy. After all the system is a prototype and the principle could be applied in the vehicle manufacturing sector in home and abroad using the solar panel.

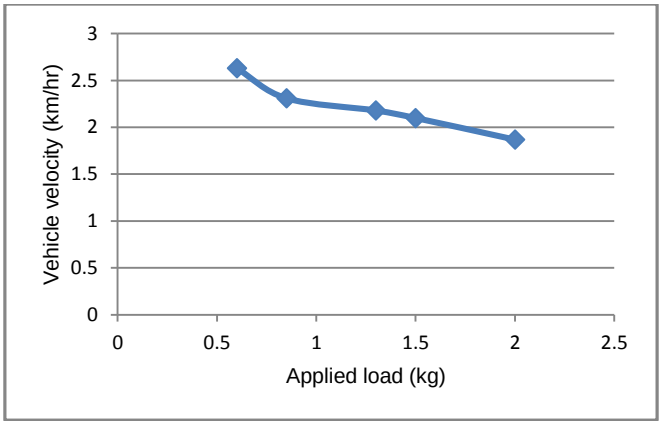

Fig.7. Variation of vehicle velocity with applied load

4. Conclusions

Design, construction and performance test of a solar powered prototype vehicle were conducted in this study. The results showed that the vehicle is successfully able to run near about 1.87 km/h for the applied load of 2 kg. The vehicle is constructed using locally available materials in Bangladesh. Hence, experimental performance is useful for future reference and for construction the heavy vehicle in the manufacture industry. This study is useful to encourage the manufacturer in home and abroad to reduce the energy crisis now and in future. It also helps to reduce the GHG emission in the atmosphere.

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