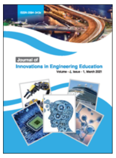

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Battery performance evaluation of solar assistive electric vehicle

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Abstract

Solar-powered electric vehicles have great opportunities on obtaining a clean, self-sufficient, inexhaustible, and free source of energy that could get better from the energy crisis in the automobile industry. Any means that could generate electricity in both running and static conditions not only lessen the charging time but also help in efficient battery performance. Accordingly, solar-powered vehicle solves many problems related to the environment and is the best pollution-free method. This project focuses on the charging and discharging pattern of the battery of an electric trike with and without solar assistance. This article provides a detailed comparison of battery performance between a solar-assisted trike and a pure electric trike. This experiment mainly incorporates charging assisted with help of a solar panel mounted on top of an electric vehicle.

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1. Introduction

Solar energy uses rays of sunlight to produce electric energy by the photovoltaic effect. The photovoltaic cell is made of semiconductors, mostly silicon which absorbs energy from sunlight and converts it into electric current which is then stored in a battery. Solar cars, driven by electric motor use DC current from a battery to propel the l vehicle. A Three-wheeler vehicle is more reliable as it has lesser rolling resistance which gives greater mileage and has less aerodynamic drag than four-wheeled vehicles. On the basis of structure, the three-wheeler is categorized into two types viz. tadpole and delta configuration. An electric trike is generally powered by a BLDC hub motor which is controlled by a motor controller.

2. Literature Review

Renewable energy generation system optimization and EV charging-related research are hot topics in the past few years, however, existing research on the topic of combining renewable energy systems and EV charging systems from the aspect of technology, economy, and actual application are relatively rare. In good sunny conditions, the full-charged endurance of solar electric vehicles could be increased by about 35% substantially compared with no PV panels. The conclusion of this paper was that SEV was driven using a dual-mode of PV and battery hybrid. It can be achieved PV-driven and battery-driven independently and had been tested to drive on roads, achieved an average distance of 135 km traveling by one charge on good sunny days and the efficiency is about 15 km/kWh while it is varied depending on road conditions and weather condition [1]. The reverse trike with two wheels at the front and one at the rear and has a 40-watt photovoltaic panel above the rider which charges the onboard 12V/80Ah dry cell battery. The batteries were charged from a solar panel and through the battery, power was transmitted to drive the dc motor. From this paper, it was found that it can travel 70 km maximum distance within one full charge, with a maximum speed of 30 km/h without creating any air or sound pollution. The batteries were

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automatically charged with the help of solar PV during rest conditions [2]. The vehicle was so designed to have a good mileage of 30-40 km/hr. on the free road and the charging could be done on both stationary and running conditions with the maximum load-carrying capacity of 2.5 quintals on full load conditions [3].

3. Methodology

A modified solar-assisted trike is designed and tested for this. In this experiment, the trike was placed in a sunny place and turned in the south direction. The voltage increment in each battery was noted at an equal interval of time. Finally, the total time required to charge the trike was noted. Then, the electric trike was run in a round circle of 266 m. Considering 5 rounds of that circle as 1 trip, the voltage decrement in each battery voltage was noted in each trip i.e., 1.33 km until the battery voltage dropped to some specific value. The halt time for measuring voltage was 1.5 min after each trip. The same procedure was repeated after the installation of the solar system in an electric trike. The testing was done at two different average speeds of about 20 km/hr. and 30km/hr. for comparison. After completion of the experiment, we found the result, which was tabulated below. The battery pack is discharged to the depth of discharge of 75%. The tools used for this experiment are a multimeter, measuring tape, and stopwatch.

4. Result and Analysis

Actual Evaluation of battery performance is measured in the Section, where Performance is evaluated in terms of each battery pack voltage with distance traveled by the electric trike and Solar Assistive electric trike. Two solar panels connected in series each having 220W capacity are used to charge four lead-acid batteries connected in series each having 12V 20Ah capacity. The 1000W wheel hub motor is used to drive the trike. The acquired data and graph charts show that the charging pattern of the solar assistive electric trike is different according to time variances. This happens due to the difference in intensity of the sun at a different times on the testing day. It is also found that the individual battery voltage in the battery pack doesn't have the same value at the same time. The acquired graph and data show that the battery voltage of each pack, SOC decreases linearly with the increment of distance traveled. During the average velocity of 20 km/hr. and keeping DOD 75%, the electric trike runs 17.29 km without solar PV and runs 21.28 km with the solar assistive system. When the velocity was increased to 30km/hr. the solar assistive electric trike runs only 19.95 km keeping all other values constant.

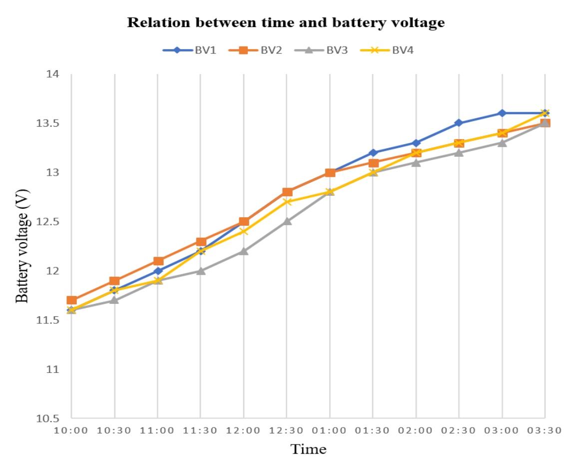

Figure 1: Battery voltage change with respect to clock time with solar charging only.

After noting the charging pattern of the battery by solar energy on a sunny day in August, we found that the

Table 1: Voltage decrement with electric trike (20km/hr.)

Distance (km)	BV1 (V)	BV2 (V)	BV3 (V)	BV4 (V)	Total volatge(V)	SOC (%)
0	13.58	13.56	13.45	13.49	54.08	97.1429
1.33	13.43	13.49	13.26	13.2	53.38	90.8929
2.66	13.31	13.32	13.01	13.02	52.66	84.4643
3.99	13.05	13.06	12.84	12.85	51.8	76.7857
5.32	12.88	12.89	12.69	12.67	51.13	70.8036
6.65	12.73	12.72	12.53	12.52	50.5	65.1786
7.98	12.59	12.61	12.52	12.5	50.22	62.6786
9.31	12.45	12.46	12.38	12.36	49.65	57.5893
10.64	12.3	12.32	12.23	12.25	49.1	52.6786
11.97	12.14	12.16	12.08	12.09	48.47	47.0536
13.3	11.99	11.98	11.93	11.95	47.85	41.5179
14.63	11.89	11.89	11.82	11.81	47.41	37.5893
15.96	11.73	11.74	11.69	11.71	46.87	32.7679
17.29	11.58	11.57	11.51	11.52	46.18	26.6071

Table 2: Voltage decrement with electric trike (20km/hr.)

Distance (km)	BV1 (V)	BV2 (V)	BV3 (V)	BV4 (V)	Total volatge(V)	SOC (%)
0	13.59	13.58	13.53	13.48	54.18	98.0357
1.33	13.45	13.46	13.41	13.35	53.67	93.4821
2.66	13.34	13.32	13.29	13.19	53.14	88.75
3.99	13.22	13.18	13.17	13.08	52.65	84.375
5.32	13.03	13.08	13.06	12.98	52.15	79.9107
6.65	12.91	12.94	12.91	12.87	51.63	75.2679
7.98	12.75	12.77	12.79	12.75	51.06	70.1786
9.31	12.63	12.63	12.68	12.65	50.59	65.9821
10.64	12.56	12.51	12.55	12.51	50.13	61.875
11.97	12.39	12.37	12.44	12.39	49.59	57.0536
13.3	12.28	12.24	12.3	12.25	49.07	52.4107
14.63	12.14	12.16	12.21	12.17	48.68	48.9286
15.96	12.01	12.04	12.05	12.02	48.12	43.9286
17.29	11.88	11.95	11.99	11.88	47.7	40.1786
18.62	11.79	11.77	11.88	11.75	47.19	35.625
19.95	11.66	11.64	11.73	11.64	46.67	30.9821

Table 3: Voltage decrement with solar assistive electric trike (30km/hr.)

Distance (km)	BV1 (V)	BV2 (V)	BV3 (V)	BV4 (V)	Total volatge(V)	SOC (%)
0	13.58	13.55	13.51	13.46	54.1	97.3214
1.33	13.44	13.41	13.38	13.33	53.56	92.5
2.66	13.3	13.28	13.24	13.2	53.02	87.6786
3.99	13.17	13.28	13.24	13.2	52.47	82.7679
5.32	13.03	13.02	12.97	12.94	51.96	78.2143
6.65	12.91	12.86	12.83	12.81	51.41	73.3036
7.98	12.76	12.74	12.7	12.67	50.87	68.4821
9.31	12.64	12.6	12.56	12.54	50.34	63.75
10.64	12.49	12.46	12.42	12.4	49.77	58.6607
11.97	12.33	12.32	12.29	12.33	49.27	54.1964
13.3	12.21	12.19	12.16	12.2	48.76	49.6429
14.63	12.08	12.05	12.02	12.06	48.21	44.7321
15.96	11.95	11.92	11.88	11.94	47.69	40.0893
17.29	11.81	11.78	11.75	11.8	47.14	35.1786
18.62	11.67	11.64	11.61	11.66	46.58	30.1786
19.95	11.55	11.55	11.55	11.54	46.19	26.6964

battery is not equally charging all time. Initially, from 10 A.M to 11:30 A.M, the battery voltage is increasing at one rate. From 11:30A.M to 2:00 P.M the battery voltage is increasing faster than earlier. From 2:00 P.M onward the voltage increment pattern also decreases. This is due to the difference in intensity of the sun at a different time on the testing day. From the experiment, it is also found that the individual battery voltage in the battery pack doesn't have the same value at the same time. Here BV1, BV2, BV3, and BV4 represent the battery voltages of the first, second, third, and fourth battery respectively. Figure2, figure3, and figure4 show the graph between voltage decrement and range of the trike at different speeds and conditions, and variation of pattern is due to more current required when the load of the solar panel is added on the trike and due to less interaction time between solar radiation and solar PV in comparison without using a solar panel.

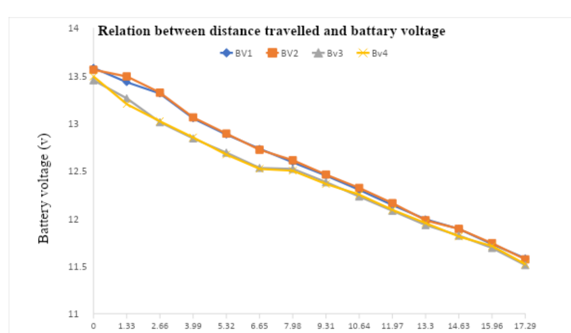

Figure 2: Battery voltage decrement with distance travelled without solar PV at 20km/hr.

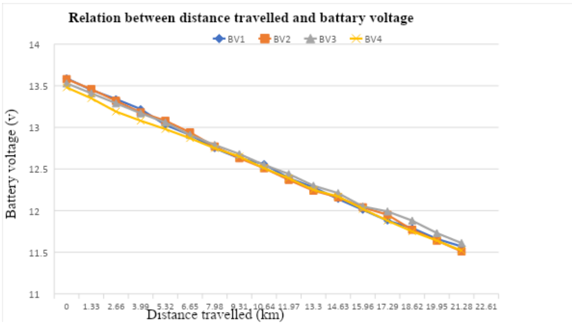

Figure 3: Battery voltage decrement with distance traveled with solar PV at a speed of 20km/hr

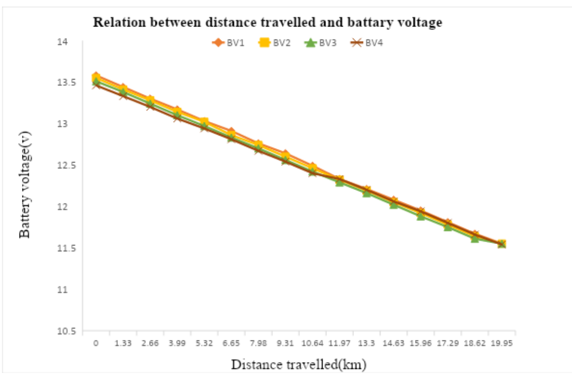

Figure 4: Battery voltage decrement with distance traveled with solar PV at a speed of 30km/hr.

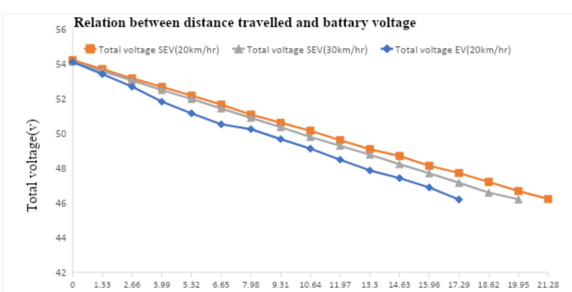

Figure 5: Total battery voltage decrement over distance traveled

5. Conclusion and recommendation and limitations

After analyzing the data obtained from the experiment and graph, the charging assisted by the solar trike is obtained. At the average speed of 20 km/hr. and keeping the depth of discharge 75% we found that the electric trike which was normally running 17.29 km per full charge; it runs 21.28 km with the solar assistive system. When the velocity was increased to 30km/hr. the solar assistive electric trike runs only 19.95 km keeping all other values constant. The trike runs about 3.9 km and 2.6 km more with an assistive system at 20km/hr. and 30km/hr because when the trike run at a higher speed the contact time between solar PV and solar radiation decreases. For the range of 17km distance its range increased by 23% and 15% at 20km/hr. and 30km/hr. speed respectively. The BMS system can be used for increasing battery performance. The limitations of the project are: Variation of data may arise in different weather conditions. Insolation of Solar radiation alters on directional change of the vehicle. Due to the low torque of the motor, it is not so favorable for the inclined road. We will not do the complete analysis and calculation of the steering and suspension system.

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Conflict of interest

No conflict of interest

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