MELEX 963DS ELECTRIC VEHICLE DRIVING RANGE WITH PARTIAL CHARGE

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Abstract. A slow moving electric vehicle Melex 963DS is made for carrying up to 6 passengers. It is equipped with 8 six volt acid batteries and outer charger. With full charge, the vehicle has a range of approximately 64.91 km. In this study, partial charging regimes are studied. It is important to know the range from a half an hour and other partial charging modes, because there is no option to fill batteries like internal combustion engine with fuel and towing the vehicle can damage the electric motor. The experiments were carried out on a chassis dynamometer Mustang MD-1750 for road condition simulation and measuring the distance, REV logger for measuring the consumed energy from a charger and a data logger GRAPHTEC GL-220 for measuring the energy consumption from batteries. Melex was driven with maximal speed, Melex was stopped when the batteries reached voltage 40 V and a partial charge was done. After that, the vehicle was driven again in the same conditions. Each experiment was repeated 3 times. The vehicle on average managed 6.39 km with 30 min, 12.24 km with 1 h, 24.97 km with 2 h and 47.32 km with 4 h charge.

Keywords: partial charge, driving range, electric vehicle.

Introduction

Electric vehicles are getting more popular but still there are many unanswered questions. Despite, electric automobiles have been in use for over a century, their popularity has experienced few popularity and decline waves. Also the battery technology has improved over the last decade, but still it cannot satisfy the internal combustion engine users with driving range. The most popular electric vehicles in Latvia are bicycles, then slow moving vehicles and 12 electric automobiles [1]. This research is about a scenario when the electric vehicle has drained its batteries and needs a partial charge to reach the destination. There are 11 charging stations in Latvia that can charge 45 vehicles simultaneously [2]. Most stations are with free charging but paid parking space. This limits the driving range, but private house owners can charge their electric vehicle at home, an advantage compared to fuel users.

The test object Melex 963DS is a slow moving electric vehicle constructed to carry up to 6 passengers and is used for sightseeing tours in Sigulda, Latvia. Because of hilly environment batteries are drained faster and a charge is being done as soon as possible, to be able to continue tours all day long. The only reference point is an on-board battery gauge that shows energy left into the batteries. Because tours are performed in the Gauja National Park, Latvia, the electric vehicle is suited for work with no emission gasses, quiet operation, high torque and easy maintenance.

The charging mode can be described with: charging time (h), charging voltage (V), charging current (A), charging type (partial/full), charging phase (main/final) and consumed energy (kWh). This vehicle charging is done by an external charger that is connected to a standard household socket.

Materials and methods

The experiment object is a slow moving electric vehicle Melex 963DS which is made for carrying up to 6 passengers and is certified for road traffic (see Fig. 1). Specifications of the vehicle [3]:

- first registration 03.07. 2008.;
- 8 six volt acid batteries and external charger 48 V 30 A;
- maximal power 3.9 kW;
- maximal speed 8.9 m·s-1;
- mass equipped 762 kg;
- gross mass 1212 kg;
- direct drive transmission;
- length 3.66 m;
- width 1.335 m;
- wheel base 2.5 m;
- double A-frame with springs suspension;

- vehicle body- plastic.

Fig. 1. **Melex 963DS on a chassis dynamometer:** 1 – control platform, 2 – charger, 3 – REV logger, 4 – chassis dynamometer rolls, 5 – experiment object, 6 – straps

The Mustang MD-1750 chassis dynamometer consists of mechanical, electro-mechanical, and electronic modules, that simulate road loads to get repeatable and valid data for road simulation, performance, emission and driving cycle tests. The roller surface was dry; temperature in the laboratory was +18…+19 ºC. Specifications of the chassis dynamometer [4]:

- maximal power 1750 hp;
- maximal speed 100.56 $m \cdot s^{-1}$;
- roller diameter 1.27 m;
- face length 0.71 m;
- maximum absorption power: 294 kW;
- maximal load on rollers 4540 kg;
- Closed Loop Digital Controller with WindowsXP based software controls.

The automobile must be fixed on the chassis dynamometer with straps from front and back, to keep the automobile in place (see Fig. 1). Inertial rolling stand operates with the automobile driving wheels proportionally to the driving speed, imitating driving conditions. The air and rolling resistance sum must be entered in the chassis dynamometer control platform. The control platform also allows changing the vehicle mass and road grade. Because the wheel inner diameter was smaller than the chassis dynamometer inner track width, flanges were made to increase the width and fit on rollers.

REV logger (190-276 V, 20 mA-16 A, 5-3680 W, ±0.01 kWh) was used for total consumed energy measurement in a charge.

GRAPHTEC midi LOGGER GL220 was used to gather the data both when charging and driving. This device allows monitoring measurable values during experiments. Specifications of the data logger [5]:

- 10 analog input channels;
- built-in Flash memory (2 gigabytes);
- display size 4.3 inch TFT colour LCD (WQVGA: 480 x 272 dots);
- display formats - Waveform + Digital, Waveform, Calculation + Digital, Expanded digital;
- operating environment 0-45 ºC, 5-85 % RH;
- power source- AC adapter (100 to 240 V, 50/60 Hz), DC (8.5 to 24 V DC, max. 26.4 V);

- external dimensions (W×D×H) approx. 194 x 117 x 42 mm;
- weight approx. 520 g (Excluding AC adapter and battery pack).

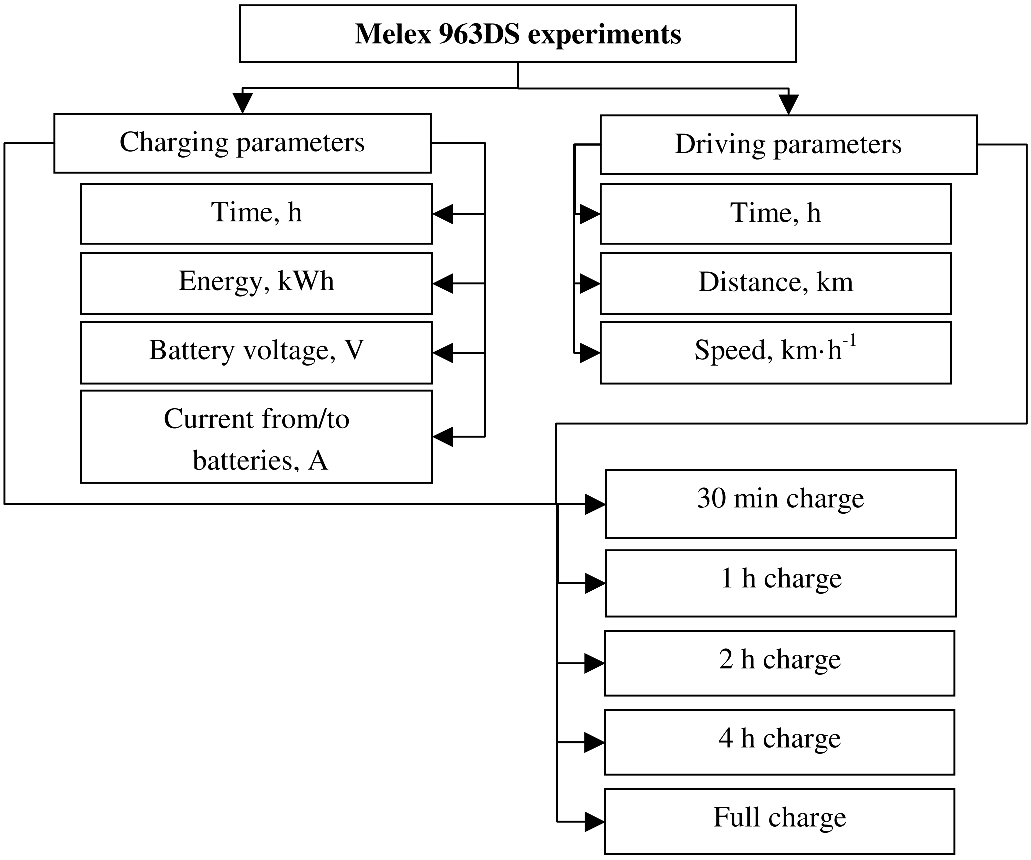

Fig. 2. **Block diagram of experiments**

Block diagram of the experiments is given in Fig. 2. At first the electric vehicle was placed on a chassis dynamometer, strapped, attached loggers and tested. Then a full charge was done. After that the vehicle was driven with maximal speed (fully pressed acceleration pedal), monitoring the battery voltage. When the battery voltage reached 40 V, the experiment was stopped, all data were saved in the loggers. Then a partial charge was done. After defined time, charging was stopped and the vehicle was driven again with maximal speed until the battery voltage reached 40 V. Each partial charge experiment was repeated 3 times. After that the vehicle was fully charged and left to sit for 24 hours. Then the next partial charge regime was carried out. The experiments were carried out with the lights switched on- mandatory in Latvia all year long. Partial charge was always done after draining batteries with voltage 40 V, this value was obtained in on-road experiments.

Results and discussion

The experiment results are summarized in Table 1. All partial charging points have linear relevance.

The charging characteristics for a full charge are shown in Fig. 3. Drained batteries without load have 43.88 V, maximal voltage was 61.86 V. The current at the start was 34.49 A and was slowly decreasing until reaching the lowest value 8.76 A. The current does not increase gradually at the start, like for the electric automobile Fiat Fiorino [6], even contrariwise – the first 11 minutes the current is noticeably higher, but the average power output 769 W (charger power 1440 W) is not enough for overloading household electricity connection.

The characteristics for a drive with fully charged batteries are shown in Fig. 4. Voltage drop is noticeable at the end of the drive and has a similar tendency as speed in Fig. 5 (both charts are for the same drive). Maximal voltage at start is 50.9 V. Maximal current from batteries was 104.54 A at the start and lowest 31.2 A at the end. Average current was 47.96 A. At the same point when the voltage starts to drop, the current values become discursive, what can be described as vehicle attempts to maintain maximal speed.

Table 1

Experiment results for Melex 963DS

Charge type	Distance, km	Consumed energy, kWh	Drive time	Battery voltage before experiments, V
Full charge	65.00	9.90	2h 17min	50.90
	62.42	10.37	2h 13min	51.09
	67.31	10.12	2h 32min	50.90
Average	**64.91**	**10.13**	**2h 21min**	**50.96**
30 min charge	8.14	0.72	19min	50.40
	5.80	0.71	14min	49.80
	5.23	0.71	13min	49.50
Average	**6.39**	**0.71**	**15min**	**49.90**
1h charge	14.37	1.39	32min	50.20
	11.23	1.29	27min	49.80
	11.12	1.26	26min	49.92
Average	**12.24**	**1.31**	**28min**	**49.97**
2h charge	26.72	2.58	58min	51.00
	25.20	2.58	59min	50.80
	22.99	2.67	53min	50.90
Average	**24.97**	**2.61**	**57min**	**50.90**
4h charge	51.13	4.93	1h 53min	51,00
	47.16	5.03	1h 44min	51,20
	43.67	4.86	1h 39min	50,88
Average	**47.32**	**4.94**	**1h 45min**	**51.03**

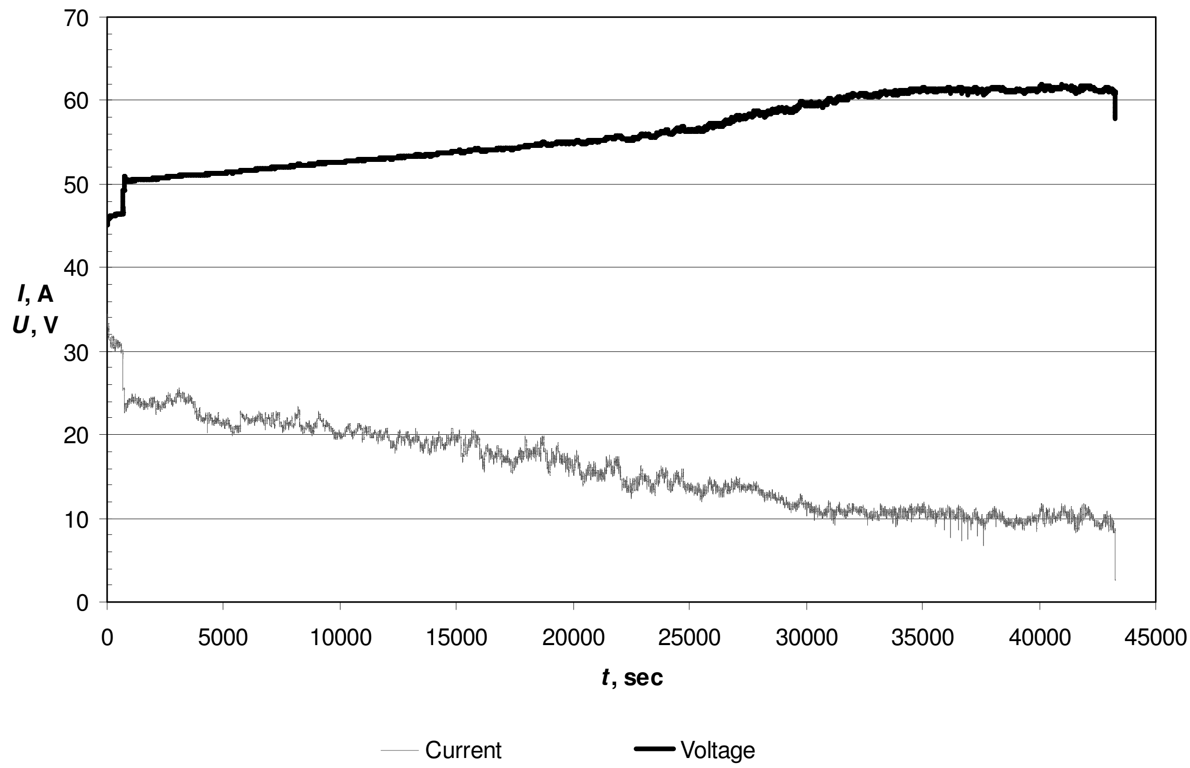

Fig. 3. **Characteristics for a full charge**

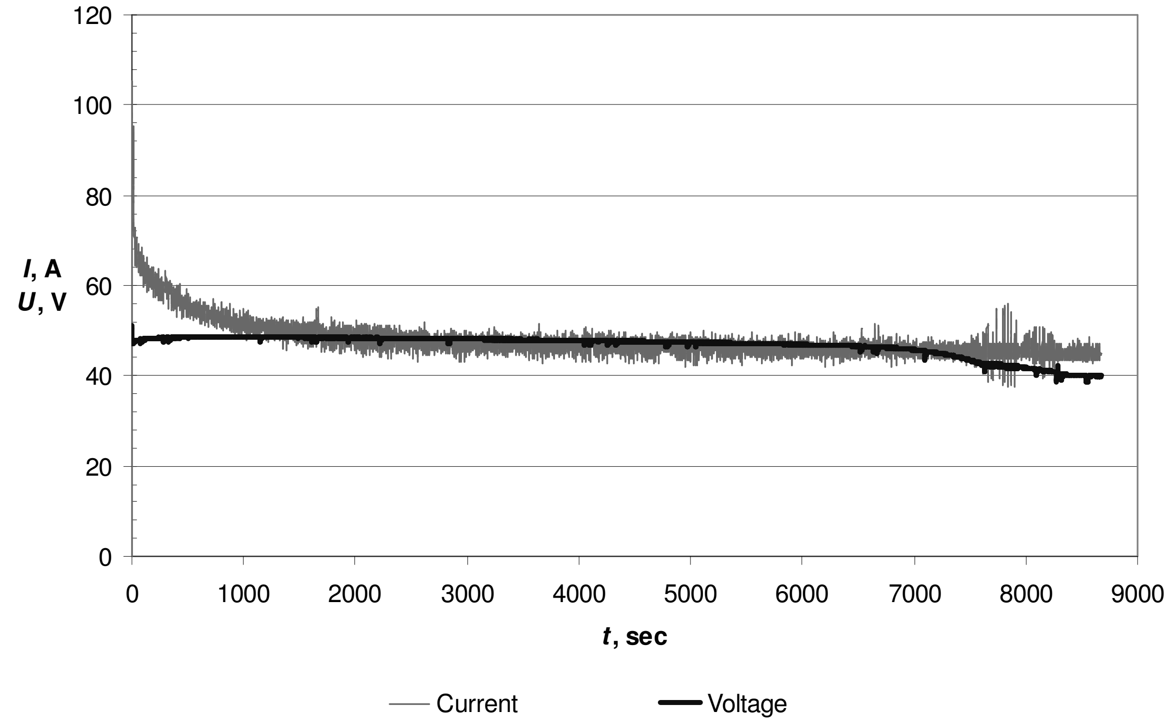

Fig. 4. **Characteristics for a drive with charged batteries**

Fig. 5 shows the screen from a chassis dynamometer control platform program for a full charge drive. The chart line for speed shows the maximal value of 8.06 $m \cdot s^{-1}$, speed at the end is 6.67 $m \cdot s^{-1}$. These speed characteristics are the same for all drives, also with partial charge. The graph also shows steady regime – there are no spikes.

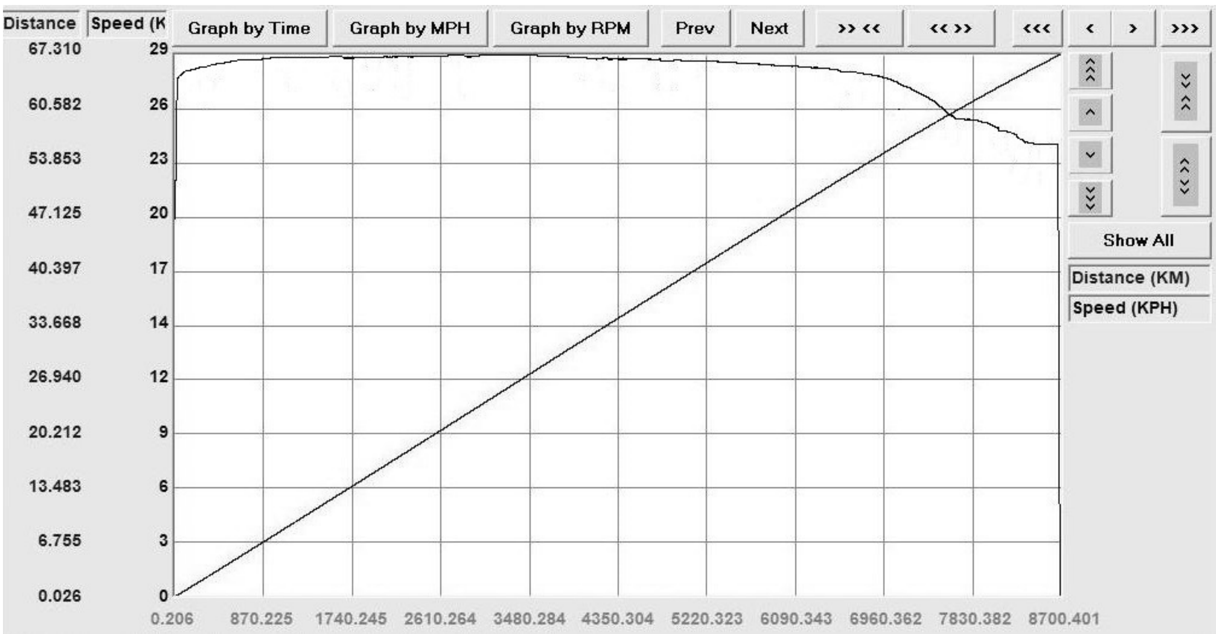

Fig. 5. **Mustang Dynamometer PowerDynePC screen**

Compared to other full driving range experiments on a chassis dynamometer [7] with Melex 963DS, the values differ because of the battery state: previous tests were done with batteries before utilization, but this experiment with new batteries, also the level of discharge differs.

By the international standard IEC61851-1 for electrical connectors and charging modes for electric vehicles that has introduced 4 charging modes [8], Melex 963DS charging regime complies with charging mode 1 – slow charging from a household socket.

Conclusions

1. Full battery charge takes around 11 hours, 10.13 kWh and costs 1.58 euro. Full charge gives driving range of 64.91±2.82 km.
2. For Melex 963DS 30 min charge after batteries have been drained, gives driving range of 6.39±1.78 km or 10 % of full range.
3. For Melex 963DS 1h charge after batteries have been drained, gives driving range of 12.24±2.13 km or 19 % of full range.
4. For Melex 963DS 2h charge after batteries have been drained, gives driving range of 24.97±2.17 km or 38 % of full range.
5. For Melex 963DS 4h charge after batteries have been drained, gives driving range of 47.32±2.31 km or 73 % of full range.
6. Onboard battery gage shows empty batteries even after 4 hour charge that gives 73 % of full driving range.
7. Without battery resting and normalizing, each partial charge gives less driving range, for 30 min and 1 h charge around 20 % decrease, and for 2 h and 4 h – 10 % decrease.
8. Obtained driving ranges on a chassis dynamometer are bigger than on-road values, because of constant load and speed regime that rarely can be achieved in on-road conditions.

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