2018 8th International Conference on Education, Management, Computer and Society (EMCS 2018)

Design and Matching of Power system for pure electric vehicle

Shanshan Guo *
Electromechanical and vehicle department
Weifang university
Weifang,261061,China
lucy001478@163.com

Yousheng Liu
Electromechanical and vehicle department
Weifang university
Weifang,261061,China
liuys@wfu.edu.cn

Yun Liu
Electromechanical and vehicle department
Weifang university
Weifang,261061,China
wflyun@163.com

***Abstract*—The parameter design of pure electric vehicle power system is proposed, such as battery capacity, motor power and so on. A mathematical model of the performance parameters for each power subsystem of pure electric vehicles is established, and then the Advisor software is employed to simulate the total vehicle. The correctness and feasibility of the method are proved by simulation experiments. The final selection work and matching result are satisfied. The design performance index required by the manufacturer has greatly improved the efficiency of product development and shortened the R & D cycle.**

Keywords—Parameters Design, Matching, pure electric vehicle.

I. INTRODUCTION

Pure electric vehicle gradually entered people's daily life as a means of transportation[1-3]. In the past, the dynamic and economic evaluation of electric vehicles was obtained by the test road or bench test, but the parameters of the motor and power system matching and the main components varied. If each scheme was tested, it not only increased the cost, but also extended the R & D cycle[4-5]. Therefore, on the basis of the automobile theory and the structure calculation, the advisor simulation software is used to model the main parts of the electric vehicle, and the corresponding road conditions are simulated and simulated, so as to verify and analyze the best scheme [6].

II. STRUCTURE OF THE PURE ELECTRIC VEHICLE

The structure of the pure electric vehicle (PEV) is shown in Fig1.It includes: motor, battery, transmission, main reducer, Reduction gear and wheel[7].

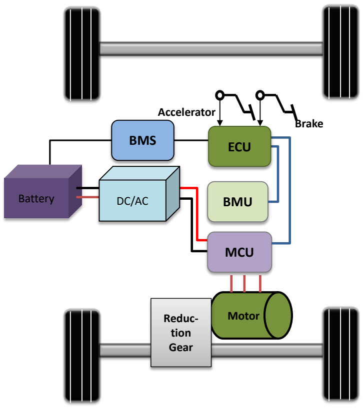

Fig.1. structure of the PEV

The performance of pure electric vehicles mainly focuses on power and economy. It mainly includes the maximum speed, the maximum climbing degree and acceleration time, etc. Meantime economics mainly focuses on the endurance mileage of pure electric vehicles. The basic parameters and performance requirements of pure electric vehicle are shows in table I and II.

TABLE I THE MAIN OF PURE ELECTRIC VEHICLE

Parameters	Value	Parameters	Value
Curb weight/kg	800	Windward area/m^2	2.05
Full load quality/kg	1000	Maximum transmission ratio	6.2
Drag coefficient	0.4	Transmission efficiency%	95
Rolling resistance coefficient	0.00095	Rolling radius/m	0.283

DOI: 10.25236/emcs.2018.131

TABLE II THE DESIGN PERFORMANCE OF PURE ELECTRIC VEHICLE

Design objectives	Value	Simulation value	Value
0~50km/h	5s	Gradient ability	≥15%
50-80km/h	6s	Maximum Speed	≥120km/h
0-100km/h	17s		

III. MATCHING OF PURE ELECTRIC VEHICLE DRIVE MOTORS

A. Selection of Peak Motor Power and Nominal Power of the Drive Motor

The motor should be always in a high efficiency range when matching the power of the drive motor to achieve higher energy conversion efficiency. Turning time is often in a high efficiency range to achieve higher energy conversion efficiency [3]. The nominal power of the driven motor must meet the requirement of the needed power at highest speed. maximum climbing power and maximum acceleration power[8].

$$P_e \geq \max\{P_u, P_i, P_a\} \tag{1}$$

$$P_u = \frac{1}{\eta_T}\left(\frac{mgf}{3600} v_{\max} + \frac{C_D A}{76140} v_{\max}^3\right) \tag{2}$$

$$P_i = \frac{v_i}{3600\eta_T}\left(mgf\cos\alpha_{\max} + \frac{C_D A}{21.15} v_i^2 + mg\sin\alpha_{\max}\right) \tag{3}$$

$$P_a = \left[\frac{\delta m}{2t_a}\left(\frac{v_b^2 + v_f^2}{3.6}\right) + \frac{2}{3} mgfv_f + \frac{2}{5} \times \frac{C_D A}{21.15} v_f^3\right] / 3600 \tag{4}$$

where, $v_{\max}$ is maximum speed, η_T is the mechanical efficiency of the transmission system, m is the quality of pure electric vehicle, kg, f is rolling resistance coefficient, CD is ir resistance coefficient; A is frontal area, $\alpha_{\max}$ is the maximum climbing degree, vi is climbing speed, vf is accelerated termination speed, t_a is acceleration time, g is gravitational acceleration.

The relationship between the peak power of the motor and the nominal power is

$$P_{e\max} = \lambda P_e \tag{5}$$

where, λ is overload coefficient of motor,the general value is 2~3.

B. Matching of the Maximum Speed and Nominal speed of the Drive Motor

The selection of rated speed (nb) and maximum speed (nmax) should be compatible with the torque and speed characteristics of the drive motor. The maximum speed of the drive motor should be selected in conjunction with the transmission and final gear ratio. Factors such as motor efficiency and continuous rotation characteristics should be determined[9]. The equations are calculated as:

$$n_{\max} = \frac{v_{\max} i}{0.377r} \tag{6}$$

$$n_b = \beta n_{\max} \tag{7}$$

where, β is the coefficient of expand the constant power zone for the motor, general value is 2～3.

C. Matching of the Maximum Torque for the Drive Motor

The maximum torque of motor Tmax should be determined according to the requirement of the starting torque and the maximum climbing degree αmax. Meantime, it should be determined by the maximum transmission ratio and the maximum climbing degree.

$$T_{\max} \geq \frac{1}{\eta_T} \frac{G(f\cos\alpha_{\max} + \sin\alpha_{\max})r}{i_{\max}} \tag{8}$$

where, r is the radius of the wheel; imax is the maximum transmission ratio.

D. Capacity Design of the Battery Pack

The choice of battery capacity mainly depends on the maximum output power and consumed energy to ensure requirements of the dynamic performance and driving miles for the electric vehicle.

The carrying energy of the battery must be greater than or equal to the maximum energy consumption of the electric vehicle to ensure the driving requirements of the electric vehicle. So the number of battery packs are calculated as:

$$n = \frac{P_{e\max}}{P_{b\max}\eta_e\eta_{ec}N} \tag{9}$$

where, ηe is the efficiency of the motor; ηec is the efficiency of the device motor control; N is the number of batteries contained in a single battery pack. The calculated results of the demand vehicle are shown in Table III.

TABLE III MAIN PARAMETERS.

	Motor		Battery
Peak motor power and	54Kw	Type	lithium ion
Nominal power	22.5Kw	voltage	3.6V
Nominal Speed	7000r/min	Capacity	120Ah
Maximum torque	100Nm	Number	12P42S

IV. VEHICLE DYNAMIC PERFORMANCE SIMULATION BASED ON ADVISOR

A. Selection of Main Parameters and Cycle Conditions of the Whole Vehicle

The vehicle simulation model includes sub-modules such as cycle conditions, vehicles, wheels, transmissions, final drives, drive motor systems, and energy sources. Each sub-module has a simulation module built in, and its parameter changes are controlled by the M function. The main parameters interface is shown in Fig.2. NEDC is used as the vehicle speed simulation of road cycle conditions as shown in Fig.3.

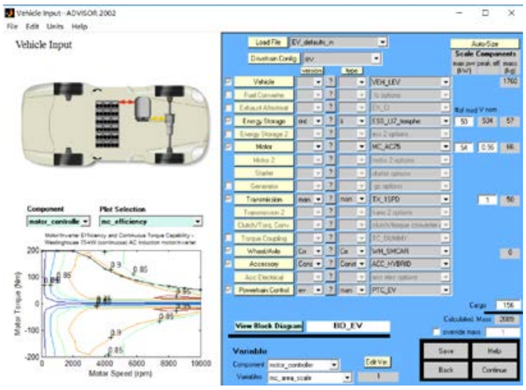

Fig.2. Main parameters of the whole vehicle

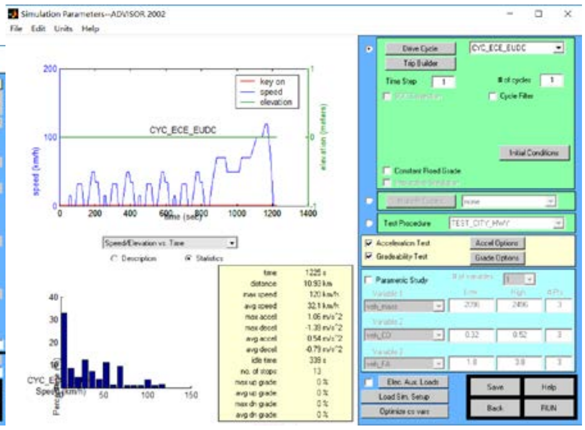

Fig.3. NEDC

The main simulation results are show in Fig4.Power: maximum speed is 122km/h, 0~50 km/h acceleration time is 4.5s, 50~80 km/h acceleration time is 4.9s, 0~100 km/h acceleration time is 14.8s maximum climbing speed is 20.1k/h, maximum climb slope is 18.6%.

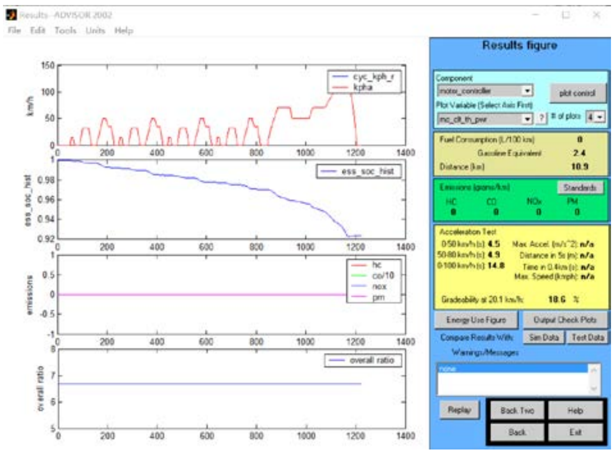

Fig 4. Simulation results

V. CONCLUSION

(i)The structural characteristics and requirements of the pure electric vehicle power system are analyzed.(ii)The parameters of the drive motor, transmission system, battery and so on are determined.(iii)A matching method of the power system in pure electric vehicles is proposed, which is also applicable to other models of cars.(iv) Using ADVISOR software, the feasibility of the design is verified to simulate the vehicle's dynamic performance.

ACKNOWLEDGEMENTS

This research was financially supported by Scientific research projects of universities in Shandong (J18kA012).

REFERENCES

[1] Gasworth S, Tankala T, Kancharla A, et al. Improved Battery Performance in Electric Vehicles via Reduced Glazing Thermal Conductivity[J]. SAE Technical Paper, 2011: 01-1341.

[2] M. Kamachi, H. Miyamoto, and Y. Sano. Development of Power Management System for Electric Vehicle 'i-Mi EV'. The 2010 International Power Electronics Conference.2949-2955.

[3] Shinsuke Nakazawa, NISSAN MOTOR CO., LTD. The Nissan LEAF electric powertrain[J]. 32. Internationales Wiener Motorensymposium 2011.

[4] Sato Y, Ishikawa S, Okubo T, et al. Development of High Response Motor and Inverter System for the Nissan LEAF Electric Vehicle[J]. SAE Technical Paper, 2011: 01-0350.

[5] Kawamura H, Ito K, Karikomi T, et al. Highly-Responsive Acceleration Control for the Nissan LEAF Electric Vehicle[J]. SAE Technical Paper, 2011: 01-0397.

[6] Freedom CAR.Freedom CAR Battery Test Manual for Power-Assist Hybrid Electric Vehicles. INEEL, October, 2003.

[7] Zhu Y, Hu H, Xu G, et al. Hardware-in-the-loop simulation of pure electric vehicle control system[C]//Informatics in Control, Automation and Robotics, 2009. CAR'09. International Asia Conference on. IEEE, 2009: 254-258.

[8] Battery Testing and Life Estimation in the US,Ira Bloom, US-China EV Initiative Workshop, Argonne National Laboratory ,August 4-5, 2011.

[9] Onda K, Ohshima T, Nakayama M, et al. Thermal behavior of small lithium-ion battery during rapid charge and discharge cycles[J]. Journal of power sources, 2006, 158(1): 535-542.