Battery matching of load isolated electric vehicle based on operating mode energy consumption

Cuiping Song[1,a], Hongxin Zhang [2,b *],Huaixian Yin[3,c],Tiezhu Zhang[4,d]

[1]Mechanical and Electronic Engineering College, QingDao University, Qingdao 266071, China

[2]Scientific Research Office, QingDao University, Qingdao 266071, China

[a]974860185@qq.com, [b]qduzhx@126.com,[c]qdzhangtz@163.com,[d]yhx6279010@163.com,

Key words: load isolated pure electric vehicle (LIPEV); NEDC cycle; energy consumption; power battery

Abstract: This paper introduces the load isolation type pure electric driving (LIPED) system, and according to the performance requirements of the vehicle. Based on the NEDC cycle, the energy consumption and the maximum demand of a light truck are calculated, and the parameters matching of power battery is carried out according to the working condition and the dynamic requirements.

Introduction

Introduction to LIPED system. Load isolated pure electric driving system referred to as LIPED system. The system distinguishes the concept of energy and power from the car, matching the rated power of the internal combustion engine based on the average power demand. The internal combustion engine and load isolation, and the operating state of the internal combustion engine is not affected by the load, to ensure that the internal combustion engine works in the optimal steady state conditions or the steady state region, reducing the fuel consumption rate. The battery pack is only used as the energy conversion device with two or more groups to charge and discharge, in order to avoid the battery over charge, over discharge or over temperature and other issues. The power output module matches the load power requirements, effectively restoring the braking energy, greatly reducing the engine power rating.

Research on automobile energy consumption based on operating mode

Vehicle parameters and performance indicators. This topic selects a certain type of car produced by a company as the research object, model parameters are shown in table 1.

Tab.1model parameters

Technical parameters	Company	Parameter values
Body length / width / height	mm	4610×1554×1835
Wheelbase	mm	2750
Full load mass	kg	1890
Air drag coefficient	-	0.6
Frontal area	m^2	2.7
Transmission efficiency	-	0.92
Wheel rolling radius	mm	330
Rolling resistance coefficient	-	0.02
The depth of discharge.	-	0.7
Transmission ratio	-	6

Analysis of energy consumption parameters of power system

Selection of target operating mode selection. The vehicle driving cycle diagram can be used to indicate the driving state of the vehicle on the road [1]. This paper adopts the new European cyclic operation mode [2] (NEDC), which is applied in the world. This cycle is composed of two parts, the operating cycle of the urban area and the suburbs, and the total length is 1180s. The urban operation cycle consists of four small urban operation cycle units, each cycle unit testing time is 195s, including idle, start, acceleration and deceleration parking and other stages, the maximum speed of 18.35km/h, the average speed of 1.042m/s², the maximum acceleration is 50km/h, the average acceleration is 0.599m/s². On the outskirts of the operating cycle time is 400s, the maximum speed is 62km/h, the average speed is 120km/h, the maximum acceleration is 0.833m/s², the average acceleration is 0.354m/s². From the test duration, the highest speed and the speed of three aspects, the actual operating conditions of the urban vehicle operation are considered. NEDC operating mode is shown in Figure 1.

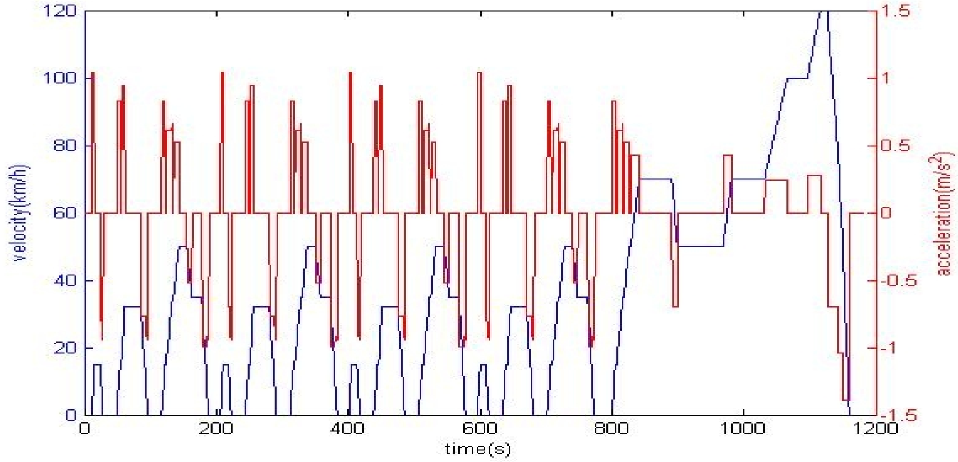

Fig. 1 speed and acceleration diagram of NEDC cycle

Calculation of total energy consumption and average power of power system. When the vehicle is driving on the target, the instantaneous power demand of the power system can be determined by formula (1).

$$P_{cyc\_t} = \frac{1}{3600h_t} \cdot \left(\frac{C_D \cdot A v_t^2}{21.15} + mgf + md \cdot \frac{v_t - v_{t-1}}{3.6dt} \right) v_t \qquad (1)$$

Type, M --Vehicle quality; h_t --Total efficiency of transmission system; f --Rolling resistance coefficient; C_D -- Air drag coefficient; A -- Vehicle frontal area; v_t -Instantaneous speed of time t in the target state; v_{t-1} -- Instantaneous speed of time t-1 in the target state; P_{cyc_t} --The instantaneous power demand of the power system when driving on the target; dt -- Sampling period.

According to the basic parameters of the vehicle and the upper type, the vehicle driving power demand time course is obtained. The maximum power demand is 75kW, as shown in Figure 2.

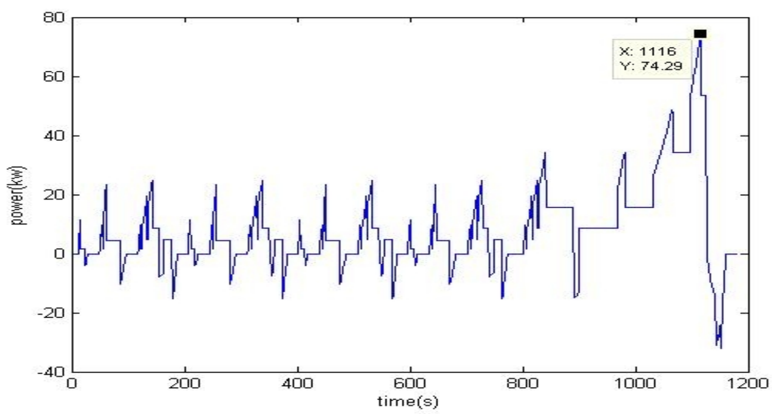

Fig. 2 NEDC operating speed and power curve diagram

Matching of power battery pack based on working condition energy consumption

The matching of energy storage device is a key technology of LIPED-EV, which is also the key to determine the quality of the power system. We use two groups of batteries to switch, in turn, can avoid the battery pack output without interruption condition of the single energy storage battery, such as over charge, over temperature, etc. And the two groups of energy storage battery pack to achieve a shallow filling and shallow charge, greatly improving the service life of the battery pack. The lithium iron phosphate battery has the advantages of high energy density, low cost, long service life [3-4], so it is the first choice of LIPED-EV energy storage device.

The power battery pack needs to meet the power requirements and energy requirements of the power system, power battery set the output power should be no less than the maximum power of the motor, the capacity should meet the requirements of the vehicle mileage in a charge and discharge cycle of energy [5-6].

Battery capacity matching. Choosing the right capacity is very important for the power battery pack. The greater the capacity, the greater the maximum current, the greater the electric power can be stored, but the total mass of the vehicle will increase, the power and the economy will fall [7]. Capacity selection is too small, power battery pack can not meet the power needs of the power system and the demand of energy, easy to lead to the battery pack over charge and over discharge, this is not allowed.

According to the analysis of the energy consumption of the target, the capacity of the power battery is mainly determined by the energy consumption, as shown in formula (2).

$$Q_{NEDC} = \frac{1}{3.6}\int_0^{t_e} P_{cyc_t}(t)\,dt \tag{2}$$

Type, t_e --The time course of NEDC cycle, is 1180s.

If the battery pack is switched on each of the two cycles, the power battery pack capacity is shown as follows

$$Q_b \geq \frac{2 \cdot Q_{NEDC}}{(SOC_{max} - SOC_{min}) \cdot h_b \cdot h_m \cdot U_b} \tag{3}$$

Type, Q_b --The energy needed to provide the power battery pack; Q_{NEDC} --The energy requirement of the vehicle in the NEDC cycle; SOC_{max} --- The power battery pack allows work caps; SOC_{min} -- The power battery pack allows the working floor; h_b --The work efficiency of the battery is 0.9; h_m -- The work efficiency of the motor is 0.9; C -- Power battery pack capacity; U_b --Power battery pack.

Dogger [8] et al studied the relationship between the depth of the battery discharge and the number of cycles, and pointed out that the depth of the discharge decreased with the extension of the battery life. We took SOC_{max} to 90% and SOC_{min} to 20%.

Battery power matching. The power of the battery pack depends on the power of the motor, and the power of the drive motor depends on the power demand of the vehicle. The battery pack power should be able to meet the needs of the car's power. As shown in formula (4).

$$P_{b\_max} \geq \frac{P_{max}}{h_b h_{m\_max}} \tag{4}$$

Type, P_{b_max} --Maximum power of power battery pack; h_{m_max} --The efficiency of the maximum power point of the motor is 0.9.

$$P_{b\_max} = U_b \cdot I_b \tag{5}$$

Type, U_b --Working voltage of power battery. Appropriately increasing its value, it can reduce the operating current, improve the system efficiency and battery life; I_b --maximum allowable operating current of the power battery pack.

$$I_b = k \cdot I_c \tag{6}$$

When the discharge rate is 1C, C and I_c are equal, in order to facilitate the discussion, the theoretical equivalent current is defined as the battery's capacity current. The numerical calculations by Q_b and P_{b_max} discharge rate was 9C. Considering the current and voltage of the battery pack, the parameters of the battery pack are determined.

Consider the current and voltage of the battery pack, and determine the parameters of the battery pack as shown in Table 2.

Tab.2 battery pack parameter list

Battery type	Voltage（v）	Capacity(Ah)	Maximum permissible discharge rate
Lithium iron phosphate battery	100	54	9C

Conclusion

(1) The NEDC cycling condition is more consistent with the actual operating conditions of the urban traffic in our country, which can calculate the total energy requirement of the vehicle more accurately.

(2) The parameters matching of power battery is carried out according to the working condition and the dynamic requirements. The battery can play the biggest role while avoiding the problem of over charging, over discharge, greatly improving the battery life.

(3) Based on the energy consumption of the battery capacity, the battery capacity matching is more in line with the actual energy consumption, which provides a strong theoretical support for the design of the next LIPED-EV.

Acknowledgements

Thanks to the financial support from the national high tech research project (No.2014AA052303), the Shandong provincial science and technology development project (No.2014GGX103044) and the Qingdao strategic emerging industry development program (14-8-1-2-gx).

Reference

[1] Guodong Wang, Xianghua Liu. Numerical simulation of temperature field of hot strip [J]. Metal forming process, 1998, (1): 39-42. In Chinese

[2] Fuxing Zhang. Study on the driving cycle of urban vehicles [D]. Wuhan University of Technology, 2005. In Chinese

[3] Xiaohua Zeng. Energy saving mechanism and parameter design method of hybrid electric bus for [D]. Jilin: Jilin University, 2006. In Chinese

[4] Yueyuan Wei, Wenzhang Zhang. Study on the matching and optimization of power system for fuel cell hybrid electric vehicle [J]. Automotive engineering, 2008, 30 (10): 918-922. In Chinese

[5] Hongpeng Li. Dynamic simulation of the starting process of automobile engine [J]. Journal of Chongqing University: Natural Science

Edition, 2005, 28 (6): 4-8. In Chinese
[6] Xuezhe Wei, Zechang Sun. Parameter identification and state estimation of Li ion battery [J]. Journal of Tongji University: Natural Science edition, 2008, 36 (2): 231-235. In Chinese
[7] Reza Langari, Jong-Seob Won. Intelligent Energy Management Agent for a Parallel Hybrid Vehicle-part I: System Architecutre and Design of the Driving Situation Identification Process [J]. IEEE Transactions on Vehcular Technology, 2005, 54(3): 925-934.
[8] Dogger J D，Roossien Nieuwenhout F D J．Characterization of li-ion batteries for intelligent management of distributed grid-connected storage[J]．IEEE Transactions on Energy Conversion，26(1)：256-263．