International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 7 Issue 1 Series I ǁ 2019 ǁ PP. 29-32

Design and Research of New Energy Dining Car Battery

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ABSTRACT: *People's requirements for fast-paced life and high-quality living standards have led to the improvement of our catering requirements and the emergence of mobile dining cars. But the traditional fast-food vehicle has many improvements, including the type of energy, conversion efficiency and so on, which have the space for improvement and optimization value.*
Based on the latest commercial catering car Datong E. V80, the power source and its distribution of the dining car are studied through entity investigation, analysis of its current status and feedback from actual users.
In the selection of new energy dining car power source, the battery design is carried out according to peak power, total energy consumption, specific energy, specific power, energy density, charging time and other parameters. For the traditional chemical batteries, the oldest batteries - lead-acid batteries, the most commonly used car batteries - lithium iron phosphate batteries, the least environmentally friendly batteries - nickel-chromium batteries, the smallest batteries - lithium batteries were compared, and their parameters were compared, and the performance of the batteries was analyzed under the operating conditions of dining cars.
In the new power source, the performance parameters, advantages and disadvantages of fuel cell, hydrogen-electric hybrid fuel cell, solar cell, flywheel battery and flywheel photovoltaic cell are compared. Finally, flywheel-photovoltaic cell is chosen as the power source of dining car. Because photovoltaic cell is greatly affected by weather, a set of spare batteries is added as the backup power source. The standby battery has stable selectivity and small size.
The power source selection of this new energy dining car is the most suitable power source system for dining car working conditions.
KEY WORDS: *catering car, new energy, power battery, flywheel-photovoltaic battery, hydrogen-electric hybrid fuel cell*

Date of Submission: 08-03-2019 Date of acceptance: 28-03-2019

I. SELECTION OF POWER SOURCE FOR NEW ENERGY DINING CAR

To study the power source of new energy dining car, we should first understand the characteristics of various power batteries, which directly determines whether they are suitable for use in dining car and automobile.Below is the structure of the dining car. The selected battery is the dining car battery.

Fig 1Photovoltaic panel shrinkage

Fig2Photovoltaic panel deployment status

1.1 Battery Brief Introduction

The most important core component of new energy vehicles is batteries. The development of batteries also restricts the development of electric vehicles. The storage methods of electric energy mainly include traditional chemical storage battery, superconducting storage, supercapacitor storage, flywheel storage and so on.

Batteries are mainly divided into three categories: chemical batteries, physical batteries and biological batteries. Chemical batteries are the most common batteries, which directly convert chemical energy into electrical energy. At present, most batteries are chemical batteries. Physical batteries refer to batteries made of physical principles, which can convert energy under normal temperature and pressure, such as solar cells, nuclear energy batteries and temperature difference batteries. Biological batteries refer to batteries made of biological enzymes, microorganisms, etc. Biological solar cells, microbial batteries.

II. PERFORMANCE INDICATORS OF COMMON POWER BATTERIES

Specific power of batteries, specific energy of batteries, charge/discharge ratio of batteries, capacity specifications of batteries, state of charge (SOC) of batteries and cycle life of batteries are the performance indicators of commonly used batteries. They are the main parameters of batteries [9]. The following is a brief introduction to it.

2.1 Charge/Discharge Ratio of Battery

C is commonly used to express the charging and discharging rate of batteries. The standard definition is 2-hour rate rated capacity and 2-hour rate discharge current, which is equal to 1/2 [1]. Expressed as

$$C = \frac{1}{C_n}$$

C——In the formula, the charge/discharge ratio of cell is calculated.

I ——Charge/Discharge Current of Battery (A);

C_n—— Rated capacity of batteries.

One of the most important performance parameters of power batteries is the battery charge/discharge ratio, especially the maximum charge/discharge ratio, which is not necessarily the same under different time limits. The maximum discharge rate represents the maximum current continuously emitted by the power battery in a certain period of time. The acceleration, climbing and overtaking performance of the vehicle depend on the maximum discharge rate. The maximum discharge rate is also related to the choice of electrical appliances used in dining cars, such as insurance, switch, maximum current of fuse, wire thickness, peak power of cookers, etc. The maximum charging rate represents the maximum current value that the power vehicle can sustain for a certain period of time. In the process of rapid charging, we should consider the maximum charging rate in order to obtain energy feedback, save charging time and protect battery balance.

2.2 Battery Capacity

Battery capacity generally refers to its rated capacity. It means that the power battery discharges at 20 +5 C with a current of 1 to reach the discharge stop voltage, and then charges to the termination voltage with a specified charger at 20 +5 C. After storing at the same ambient temperature for 1-5 hours, it discharges at a current of 1 to reach the discharge stop voltage and the energy released by the battery (Wh). From the voltage-capacity curve integral.

2.3 State of Charge (SOC) of Batteries

For secondary batteries used in electric vehicles, the residual capacity, terminal voltage and internal resistance of batteries will change at any time during the charging and discharging process. At present, the residual capacity of the battery is expressed and calculated by the state of charge of the battery. The performance, life and optimal control of energy distribution of the power battery are guaranteed by SOC, which is a very important parameter to characterize the power battery. The formula is expressed as follows:

$$soc = \frac{c_1}{c_n}$$

c_1— —In the model, the current remaining capacity of the battery (Ah)

c_n—— Battery rated capacity (Ah)

When the estimation of battery residual capacity is not required high or some simple conditions, SOC can be used to estimate the battery residual capacity, that is, to collect the battery terminal voltage to represent the residual capacity.

2.4 Charge/Discharge Cut-off Voltage

The lowest operating voltage of the battery is the discharge cut-off voltage, that is, when the battery discharges under certain discharge conditions specified by certain standards, the voltage of the battery gradually decreases, and when the battery no longer continues to discharge. Charge/discharge cut-off voltage is an important parameter to protect battery performance and life in order to prevent overcharging or discharging.

2.5 Battery Energy Density and Functional Density

The energy density and function density of batteries are closely related to the vehicle's continuous mileage, power performance, vehicle quality, space layout and so on. They are important parameters for battery development and battery selection of dining cars. The mass energy density of batteries is abbreviated as specific energy (W.h/kg), and the volume energy density is abbreviated as energy density (W.h/L). The power density of battery is defined as the energy output per unit mass or volume of power battery in a unit time. It is usually divided into specific power (W/kg) and power density (W/L).

2.6 Batteriescycle life

The power battery is discharged by 1 current DC at 20 +5 C until the discharge capacity reaches 80% of the rated capacity. The battery is charged to the termination voltage at the same temperature and is shelved in a standard environment for 1 hour. The number of cycles repeated in this step is called the cycle life of the battery. Experiments show that the cycle life of power batteries is affected by the cut-off voltage of battery charge and discharge, temperature, discharge rate, discharge depth (DOD), and SOC operating point of power batteries. One of the most important factors in the cost of batteries is the cycle life of batteries.

2.7 Comprehensive Analysis of Traditional Batteries

The advantages and disadvantages of lead-acid batteries, lithium-iron phosphate batteries, lithium-ion batteries, nickel-cadmium batteries, performance parameters, the degree of coincidence under operating conditions, cost and other issues are analyzed.

Table 1 Comparison of battery parameters

Battery type	Rated voltage (v)	Specific power (W/kg)	Energy density (W.h/L)	Specific energy (W.h/kg)	Cyclic life (secondary)
Lead acid battery	2.0	130	90	35	500
Lithium iron phosphate battery	3.2	90	10	120	2000
Nickel cadmium battery	12	170	94	55	500
Lithium ion battery	3.7	180	400	150	1000

It can be seen from the above table that the specific power and energy density of lithium-ion batteries are the largest and the occupancy volume is the smallest. They can be used as standby batteries for storing electric energy. Lithium iron phosphate battery has the longest service life, middle specific energy and power, and relatively stable performance. Therefore, it is the primary choice for many new energy automotive power sources.

Lead-acid battery has reliable performance and good reversibility of charge and discharge. Simple structure, low manufacturing cost, relatively mature technology, but the specific energy and specific power are worse than other batteries, so the energy storage and power per unit mass are less.

The lithium iron phosphate battery has high output efficiency and good high temperature performance. When the external temperature is 65 C, the internal temperature is as high as 95 C. The battery has good safety performance, long life and 500 cycles. Its discharge capacity is still more than 95%. It has small self-discharge. The self-discharge rate of the battery full of electricity at room temperature is about 2% in a month, and the charging time is short.

Nickel-cadmium batteries have low requirements for working environment, good low temperature performance, higher specific energy, specific power and energy density than lead-acid batteries.

Lithium ion batteries have large specific energy, small volume, high energy density, long cycle life, low self-discharge rate, wide allowable operating temperature range and no memory. Suitable for backup batteries. There are no harmful substances in lithium-ion batteries, which will not cause environmental pollution.

The above battery analysis is based on two parameters: maximum output protection power and total energy consumption. The following is a comparison of the weight, volume, life and cost of batteries under these two parameters:

Table 3.6 Battery parameters under working conditions of dining car

Battery type	Weight (kg)	Volume (L)	Life span (year)	Weight (kg)
Lead acid battery	1337	520	1.36	+
Lithium iron phosphate battery	390	1052	5.5	++++
Nickel cadmium battery	850.9	497.9	1.36	++
Lithium ion battery	312	117	2.74	+++

As can be seen from the table above, although the cost of lead-acid batteries is low, they have short life, large volume and high quality. The dining car needs to save space to leave a lot of room for the cooking utensils. Although lithium iron phosphate battery has a long life, its cost is not low, and its size is large, which is not in line with the original intention of the new energy dining car design. Nickel-cadmium batteries have short life and high quality. Heavy metal pollution will occur when heavy metal is used as electrode material, which does not meet the requirements of saving resources and protecting environment for new energy dining cars. Lithium-ion batteries have moderate mass and volume, but short life and high maintenance costs.

From the comprehensive analysis of batteries, each battery has its specific advantages and disadvantages. In order to make energy more efficient and energy-saving, a new type of power battery is considered.

ACKNOWLEDGEMENTS

This project is supported by National Natural Science Foundation of China (Grant No. 51606116).

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Yufei Gao Yun Guo" Design and Research of New Energy Dining Car Battery" International Journal of Research in Engineering and Science (IJRES), vol. 07, no. 1, 2019, pp. 29-32