Temperature Estimation of Power Battery Based on Back Propagation Neural Network

Haiying Wang[1] , Yang Liu[1], Guoxing Zheng[2] and Gechen Li[3]

[1] Automation College, Harbin University of Science&Technology, 52 Xuefu Road Nangang District, Harbin, 150080
[2] Production Engineering Research Institute of Daqing Oil Field Co. Ltd., Daqing, 163000
[3] CENS Energy-Tech Co. Ltd. , Hangzhou, China

Abstract. With the growing of environmental pollution and energy consumption, the applications of renewable energy increasingly gained people's attention. Power Batteries which have great prospects in renewable energy field are one of the focuses of attention. Rechargeable batteries are widely used in many electrical systems to store and deliver energy. However, there is a wide variety of Power Batteries and they have different weak Points. In order to use batteries more efficiently, their response to various operating conditions must be understood. Knowing the battery temperature variation in electric vehicles (EVs) is very important issue. Temperature depends on ambient temperature, charging current and charging time. Recently neural networks have been successful used for power system applications. In the literature, there are many neural networks for power system applications. However, Back Propagation (BP) has demonstrated better capabilities. This paper presents neural network for temperature estimation of power batteries. The main contribution of this paper is consideration of non-uniform temperature field and the temperature effect in batteries. In addition, the results of estimation and actual measured values are compared, proving the feasibility and accuracy of the method.

Keywords: Power batteries; Neural Network; BP

1 Introduction

As the original main energy storage for hybrid electric vehicle, power battery is the most key parts of hybrid electric vehicles[1]. The battery available capacity refers to the quantity of electricity that can be delivered at a certain discharged current and temperature before reaching the specified cutoff voltage[2]. Knowing the temperature in electric vehicles (EVs) is very important issue. The temperature increase depends on the charging temperature and current for different kinds of battery[3-5]. For Ni-MH battery temperature variation directly affect the performance and battery life issues, we study on Ni-MH battery charging temperature distribution of storage. To achieve the level of practicality and industrialization, one of the important issues that must be resolved in the process of charging and discharging battery is non-uniform temperature field.

It has been proved and discussed by experts that the performance of the battery in charging, discharging and recycling state may suffer significant degradation with the increasing temperature. So the temperature control may act as a crucial role of the performance of the power battery, which may also affect the economic and applicability of the power battery. Then, the battery thermal effects have gradually become the hot issues in the battery application fields.

The neural network can be widely applied in prediction field in a short time for its great generalization ability[6]. Neural network toolbox is one of the toolboxes developed in the Matlab environment, which is applied to establish typical transformation function and conduct design, study, test and simulation of network[7] based on artificial neural network principle with using the Matlab language. For a variety of network models, neural network toolbox integrates a variety of learning algorithms to provide users with great convenience.

Domestic and foreign researchers have achieved a lot of useful exploration in predicting and simulating different battery power systems using neural networks. At present, the more common and relatively mature application is of the prediction of the remaining capacity of the batteries, the state of charge (SOC), the state of health (SOH) and cracking extent of the battery[9-10]with Matlab.

As is described above, this paper has achieved the prediction of the thermal effects of nickel-hydrogen battery using the BP neural network.
are acceptable.

2 Acquisition and Processing of Experimental Data

In order to make accurate prediction of the surface temperature of the battery with BP neural network, a large number of experimental data should be acquired, and tested. The acquisition of experimental data is to conduct thermal measurements for some kind of nickel-metal hydride battery:

Firstly in constant temperature environment, conduct charging and discharging recycling experiment with different magnification and measure the surface temperature of the recorded cell；Secondly with different temperature degrees, conduct charging and discharging recycling experiments with constant magnification and measure the surface temperature of the recorded cell as well.

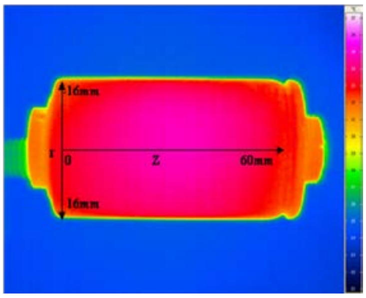

Fig. 1. The surface temperature distribution map after the 1200min charging is shown.

Conclusions can be drawn from the details that the experiment data increased along with the charging time in the charging magnification of 1C/3C/5C, with the environment temperature of -10°C / 0°C / 10°C / 20°C / 40°C, the surface temperature of the battery is listed below respectively.

3 Establish, Test and Examine the Neural Network

The surface temperature is a function of ambient temperature, charging current and charging time when charging. Relationships are represented as:

$$T = f(Tamt, I, t) \tag{1}$$

There must be correspond surface temperature values after given a set of values of environmental temperature, charging current and charging time.

4 Analyze the Testing Result and Predict the Temperature

4.1 Matlab provides function used for further analysis on the results of network training

The function *postreg* has analyzed the relationship between the network output and target value using linear regression which also the changing rate of network output to that of target output relatively, which evaluates the results of network training as well.

$$[m, b, r] = postreg(zongyuce\_outputs, Tnew) \tag{2}$$

We can get the parameters below:

m=0.9962; b=0.0011; r=0.9982

4.2 Analysis of the results

Conduct prediction of testing samples and normalization of the output values using BP network and make analysis on the performance of the network by comparison. Then restore the network output as the surface temperature of the battery with the analysis of the error.

Table 1. Analysis of the results.

Test conditions (C / ℃/ s)	Measured temperature values(℃)	Estimated temperature values(℃)	Relative error
1 / -10 /1500	-7.98	-8.94	0.12
1 / 10 /2010	15.31	13.32	0.13
1 / 20 /2520	24.18	26.43	0.093
1 / 30 /3000	35.17	40.44	0.15

3 / 0 /1000	12.24	11.06	0.096
3 / 20 /1100	30.95	28.47	0.08
3 / 40 /1300	58.19	63.36	0.089
5 / -10 /700	39.96	36.32	0.091
5 / 10 /800	54.77	48.75	0.11
5 / 30 /750	57.29	62.78	0.096

5 Conclusion

Many aspects should be taken into consideration when predicting the temperature of the battery, such as the difference in charging environment, charging magnification which may reduce human interference, and thus more objective indeed. However, as for difference of the heat production mechanism of different types of power battery, there may be some impact caused by material factors in the design of neural network structure, which determines the fact that the impact factors suitable for nonlinear problems should be taken into consideration. In addition, a variety of practical problems in the application should also be seriously considered, and increase the capacity of training samples, improve the network structure can be conducted to improve the accuracy of the prediction which ensures the satisfactory prediction results.

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