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Design and Development of a Public Waste Battery Diagnostic Device

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Abstract

In this study, design of an intuitive internal resistance diagnostic device is to diagnose the residual capacity and aging of the battery regardless of the model and the internal protocol of the waste battery through the method of measuring the internal resistance of a waste battery. In this paper, charging and discharging were continuously performed with 2A charging and 5A discharging in order to secure data on impedance changes that may occur in the charging and discharging process of various methods. As a result of the final experiment, it was confirmed that the impedance change occurred during charging and discharging, and the amount of change increased as the charging/discharging C-rate increased. In addition, it was confirmed that the waste battery aged or abnormal cell had a large change in the impedance value.

Keywords: *IIRDM, Waste battery, Internal impedance, DC-IR*

1. INTRODUCTION

The share of the transport sector and the road sector in global carbon dioxide emissions is increasing from 22.5% and 16.5% in 2008 to 24.0% and 17.9% in 2015, respectively, in 2017, the International Atomic Energy Agency (IAE) announced [1]. Accordingly, major countries are implementing eco-friendly vehicles, especially electric vehicles, and new and renewable energy policies in order to reduce carbon dioxide emissions in the transportation sector and demand is continuously increasing. The use of lithium-ion batteries, which are most commonly used as power sources for electric vehicles and renewable energy, is increasing. Lithium-ion batteries are receiving a lot of attention as energy conservation and an eco-friendly alternative energy source of the future. In particular, it is widely used in hybrid vehicle applications. In addition, problems in the treatment and utilization of waste batteries used as power sources for electric vehicles and new and renewable energy, and waste batteries caused by accidents and breakdowns are occurring, and the collection and storage of discharged waste batteries is growing in importance [2].

Since internal impedance of battery is a factor that can know information about the current battery state and dynamic characteristics, various methods for modeling the internal impedance have been studied [3]. In particular, the internal resistance of a battery is closely related to the main factors representing performance such as capacity, efficiency, and lifespan. In addition, since the measurement of the internal resistance component can be included in the performance measurement of the battery at regular intervals, it is required

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to accurately measure the internal resistance of the battery.

There are a number of methods for measuring internal resistance so far, among them, Direct Current-Internal Resistance (DC-IR) measurement method that can measure internal resistance in a relatively simple way without additional equipment is widely used. has been used [4]. However, Electrochemical Impedance Spectroscopy (EIS) is used to measure and model the internal impedance of a battery cell. Based on this, the existing DC-IR measurement method has limitations. In addition, currently, various models of electric vehicles are being released, the operating methods of batteries used are standardized, and most of the companies producing batteries keep their internal protocols secret. There is a problem that the exact internal state of the battery cannot be accurately checked. Because of this, it is difficult to manage and store waste batteries, so a diagnostic technique that can check the internal state regardless of various types of waste batteries is needed.

Therefore, in this study, the design of a diagnostic device capable of intuitively diagnosing internal resistance and a method of measuring the internal resistance of a waste battery are used to diagnose remaining capacity and aging of the battery regardless of the internal protocol and model of the waste battery. Intuitive internal resistance diagnostic device to be developed constructs an external impedance measurement circuit for each cell of waste battery and measures standard variation through the switching circuit stage and confirms high-precision internal resistance value of waste battery can do.

2. DIAGNOSIS OF WASTE BATTERIES USING INTUITIVE INTERNAL RESISTANE MEASUREMENT

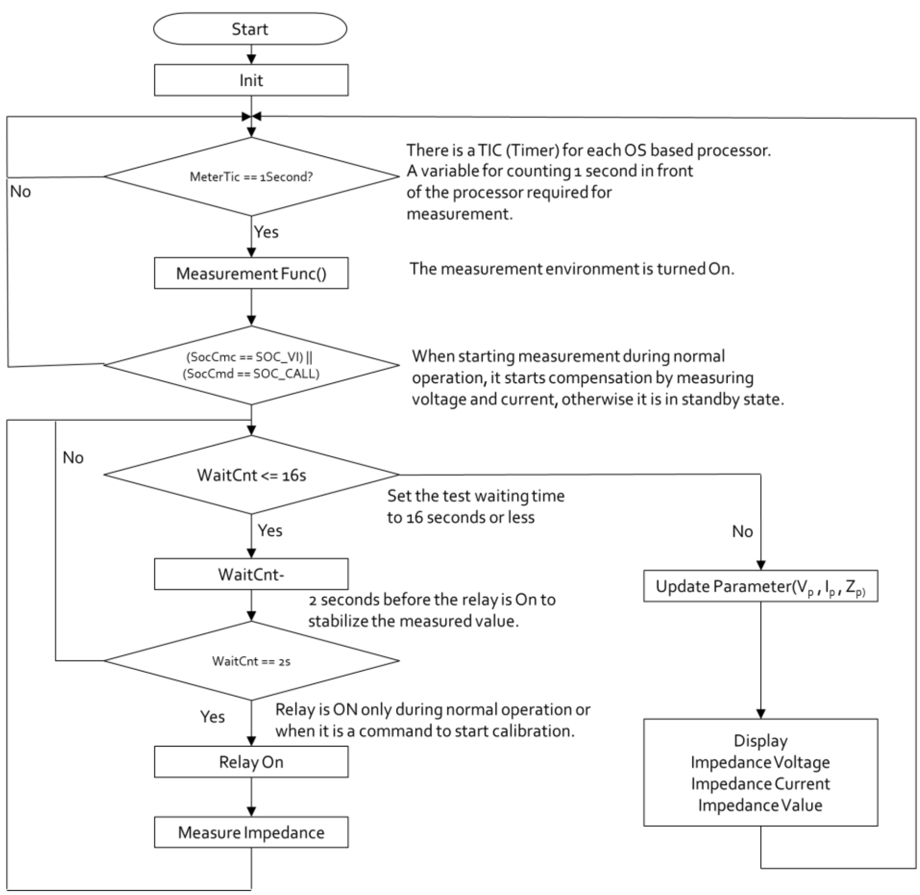

Figure 1. Process of waste battery diagnosis using intuitive internal resistance measurement

In this research paper, for storage of lithium-ion batteries used in electric vehicles and renewable energy, measurement of residual capacity and aging degree inside waste batteries.

Through intuitive internal resistance measurement of the state of a waste battery, it is possible to diagnose the remaining capacity and aging of the battery regardless of the manufacturer and type of battery [8].

The following figure 1 is a figure showing the process of waste battery diagnosis using intuitive internal resistance measurement. Explaining the process of diagnosing waste batteries using intuitive internal resistance measurement is as follows. First, *MeterTic == 1Second?* TIC (Timer) exists for each processor based on OS and is a variable for counting 1 second in the front stage of the process required for measurement. *Measurement Func()* function turns on the measurement environment, and *(SocCmc == SOC_VI) || (SocCmd == SOC_CALL)* starts measurement during normal operation and starts calibration through voltage and current measurement, and the rest is in the standby state. *WaitCnt <= 16s sets* the test waiting time to 16 seconds or less. When *WaitCnt == 2s*, it is in the standby state for the relay contact, and if it is not connected, it is in the test standby state again.

Intuitive internal resistance diagnostic machine applying this process configures an external impedance measuring circuit for each cell of a waste battery and measures the standard deviation through the switching circuit stage to infer the internal resistance of the battery with high precision. and the health of the battery can be checked.

The intuitive internal resistance diagnostic device can measure up to 64 cells with each cell, and is designed to measure intuitive cell data through various connectors and pin types regardless of battery manufacturers. In addition, it is possible to measure both lithium-based batteries and can be applied to flow batteries and solid-state batteries (SSB).

3. DESIGN OF WASTE BATTERY DIAGNOSIS MACHINE

The design of the battery diagnostic device was designed as shown in Figure 2. The operation method of the battery diagnostic device uses a relay, and it is possible to measure sequentially from Cell No. 1 to 64 Cells by the Real Time Operation System (RTOS) method. It is designed so that the measured value can be checked through the LED of the battery diagnostic device, the cell can be checked with the naked eye, and the measured voltage, current, and internal resistance value can be checked through the LCD.

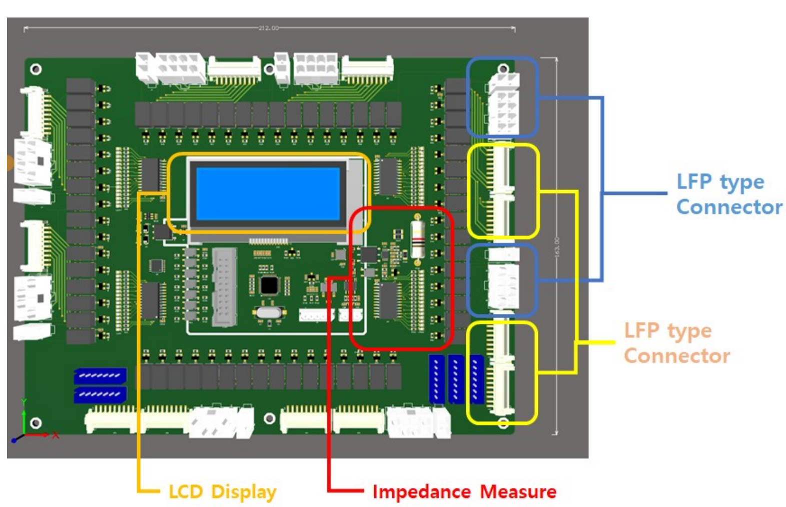

Figure 2. Internal design model of battery diagnostic device

Figure 3 is a battery diagnosis module device implemented according to the internal design of the battery diagnostic device in Figure 2.

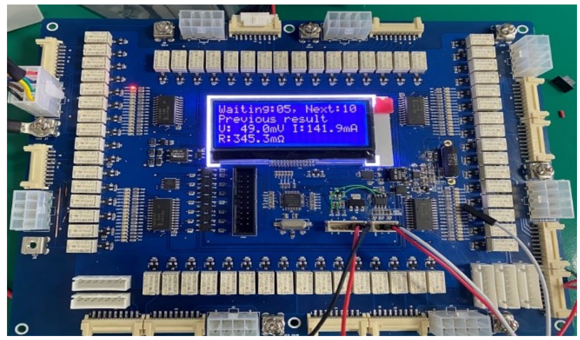

Figure 3. Battery diagnostic module device

3.1 Lithium 8-cell waste battery test to check impedance change

In this experiment, an 8-cell waste battery is connected to the battery diagnostic module device shown in Figure 3 and the internal impedance value is measured through external impedance. As for the measured contents, the impedance data of the 8-cell waste battery in Figure 4 is extracted and the measured impedance value is checked for each cell as shown in the Excel table.

TimeTa	CH9_R	CH10_R	CH11_R	CH12_R	CH13_R	CH14_R	CH15_R	CH16_R	VC1	VC2	VC7	VC8	PackI
#####	281.1	191.4	206	200.9	288.7	223	234.6	227.5	3.339	3.347	3.339	3.343	0
#####	293.3	191.8	205.4	200.6	294.1	223.7	234.8	227.2	3.342	3.345	3.341	3.343	0
#####	265.5	191.6	205.6	201.1	260.2	223.2	234.5	227.1	3.424	3.371	3.365	3.412	0.703
#####	264.8	192.2	205.7	201.3	259.7	224.1	234	227.8	3.452	3.4	3.397	3.439	0.712
#####	264.3	192.5	206.1	200.8	261.6	223.8	234.3	227.1	3.446	3.406	3.404	3.434	0.756
#####	264.5	192.4	206.4	201.2	263.9	223.2	234.3	227.1	3.453	3.409	3.415	3.439	0.721
#####	264.5	192.2	205.9	201.7	265.4	223.9	234	226.7	3.475	3.416	3.446	3.46	0.712
#####	264.2	191.7	206	201.1	305.4	223.1	232.1	227	3.533	3.45	3.827	3.515	0.695
#####	263.4	191.5	206.1	201.4	263.8	224.1	231.6	226.9	3.535	3.451	3.851	3.516	0.756
#####	263.8	191.6	205.9	200.7	261.1	223.7	232.1	226.8	3.437	3.409	3.847	3.439	0
#####	263.9	191.9	205.9	200.8	275.1	223.5	231.8	226.4	3.44	3.412	3.892	3.444	0
#####	263.1	191.6	205.5	200.4	272.8	222.8	231.9	226.8	3.436	3.406	3.827	3.437	0
#####	263.7	191.6	206.2	201.1	275.7	223.5	231.6	227	3.433	3.404	3.8	3.434	0
#####	263.8	191.7	205.7	201.3	275.2	223.2	231.5	226.4	3.431	3.403	3.777	3.433	0
#####	264.2	191.4	205.5	200.8	275.8	223.6	231.4	226.7	3.427	3.399	3.761	3.432	0
#####	264.2	191.6	205.3	200.6	276.5	223.1	231.6	228.7	3.427	3.4	3.749	3.432	0
#####	261.1	191.5	205.4	200.5	276	223.5	231.2	226.3	3.433	3.403	3.845	3.438	0
#####	260.5	191.5	205.1	200.7	276.9	223.3	231.8	226.4	3.433	3.402	3.815	3.437	0
#####	260.9	191.6	205.8	200.5	285.8	222.9	231.6	227.3	3.437	3.404	3.87	3.439	0
#####	260.7	191.4	205.4	201	285.9	223.5	231.2	226.8	3.436	3.403	3.846	3.438	0
#####	260.3	191.9	205.3	200.8	285.1	223.2	231.5	226.4	3.433	3.403	3.828	3.437	0
#####	260.3	191.5	205.7	200.5	284.9	223.1	231.7	226.4	3.433	3.403	3.811	3.436	0
#####	261.1	191.5	205.3	200.8	285.5	223.3	231.3	226.9	3.433	3.403	3.797	3.436	0
#####	260.7	191.5	205.7	201	286.5	223.1	231.8	226.6	3.433	3.403	3.784	3.436	0
#####	260.5	191.6	205.8	200.4	286	222.7	231.6	226.7	3.431	3.402	3.772	3.434	0
#####	260.9	192	205.7	201.1	275.3	223.3	231.4	226.8	3.438	3.403	3.872	3.443	0
#####	260.6	191.2	205.4	200.7	275	223.4	231.7	227.1	3.436	3.403	3.847	3.44	0

Battery Cell Impedance Data(8Cell) Cell Voltage

Figure 4. Impedance value measured for each cell using the battery diagnostic module device

In addition, through continuous testing in the form of a cycle that repeats charging and discharging, the impedance changing for each cell can be checked, and if the internal separator is damaged, a large impedance change can be confirmed during the cycle.

Figure 5. Change of impedance value measured for each cell using battery diagnostic module device

The experiment in Figure 5 was conducted as a process of continuously extracting charge/discharge data with 2A for charging and 5A for discharging in order to secure data on impedance changes that may occur during the charging/discharging process of various methods. As a result of the impedance measurement, it was confirmed that the change in impedance occurred during charging and discharging, and the amount of change increased as the charging and discharging C-rate increased. In addition, it was confirmed that the aged or abnormal cell moved with a larger change in impedance.

4. CONCLUSION

In this study, we designed and developed a system that can check the internal state of a battery through an intuitive impedance measurement method regardless of the types of batteries produced by manufacturers.

The experiment using the developed device in conducted as a process of continuously extracting charge/discharge data with 2A for charging and 5A for discharging in order to secure data on impedance changes that may occur during the charging/discharging process of various methods. As a result of the impedance measurement, it was confirmed that the change in impedance occurred during charging and discharging, and the amount of change increased as the charging and discharging C-rate increased. In addition, it was confirmed that the aged or abnormal cell moved with a larger change in impedance.

As a result of this study, regardless of the battery manufacturer and type, such as lithium ion and lithium iron phosphate, it was possible to check the usage status according to the impedance change value, and it was possible to confirm the possibility similar to that of a waste electric vehicle battery.

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