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Real time thermal monitoring of lithium batteries with fiber sensors and thermocouples: A comparative study

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ABSTRACT

This work shows a comparative study between the thermocouples and fiber sensors response for the monitoring of temperature variations occurring in three different locations of a lithium battery. The battery is submitted to constant current charge and different discharge rates, under normal and abusive operating conditions.

For this specific application, the results show that the fiber Bragg grating sensors have better resolution and a rise time 28.2 % lower than the K- type thermocouples, making them a better choice for the real time monitoring of the battery surface temperature as well as a useful tool for failure detection and an optimized management in batteries.

Keywords:

Fiber sensors; Thermocouples; Temperature monitoring; Lithium batteries; Abusive conditions.

1. Introduction

Nowadays, due to the strong decrease of the worldwide petroleum resources and the present environment pollution, significant research has been carried out on the development of lithium ion batteries (LiB) as alternative energy power supplies [1, 2]. The traditional LiB are extensively used in portable electronic equipment, such as notebook computers, mobile phones and electric vehicles due to its high energy density, high voltage and low self-discharge rate [3, 4].

The primary challenge in designing a scaled up LiB system is to guarantee safety under normal and abuse operating conditions. Thermal management of batteries is critical in achieving better lifetime performance and safety of the batteries. Besides, the heat generated in a battery must be controlled in order to improve lifecycle reliability and prevent failure. The LiB operation out of the adequate range of temperatures can cause their rapid degradation and reduction of the available discharge energy [5]. When carried out under abnormal conditions, they are largely exothermic, causing fast temperature increase [2]. The effective control and management of battery charge and discharge by battery management systems (BMS) is essential for good performance. In order to develop a sufficient thermal management strategy, it is essential to monitor the thermal gradient in the battery during all operating states for an accurate online diagnostic analysis. Current BMS rely on monitoring conventional external parameters such as voltage, current and external temperature.

Most of the previous works were focused on monitoring temperature using thermocouples (TC) attached to the surface of batteries, in strategic locations. The TC have the advantages of small dimensions, self-powered and ease of handling [7, 8]. Recent works have proposed the use of optical fiber sensors as an alternative method,

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