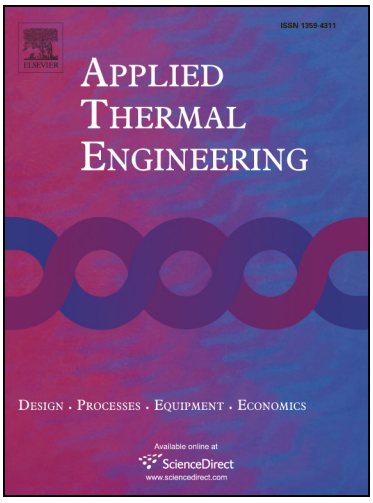

Phase-change materials (PCM) for automotive applications: a review.

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Phase-change materials (PCM) for automotive applications: a review.

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Abstract

In this paper, an extensive review of a battery thermal management systems (BTMSs) such as phase-change materials (PCMs) in the state of art is proposed. Nowadays, PCMs are particularly attractive and chosen as one of the most interesting cooling system in terms of high-energy storage density. In addition, they are less bulky, complex and expensive than traditional cooling methods such as forced-air cooling or liquid cooling. Nonetheless, the integration of PCMs in a battery application calls for an analysis that will enable the researcher to proposed optimized BTMSs. Indeed, due to the lack of literature in this domain, the paper proposed to review all the existing studies on battery applications involving PCMs. Numerical analysis description, heat transfer theory along with the classification of the existing components for PCMs are also presented. This paper is based on previous reviews to help to update the thin number of references, which is considered by the authors as the major contribution.

Keywords: Phase-change material, automotive application, cooling system, battery system.

1. Introduction

Dwindling natural resources and global climate change are currently two of the most important challenges in the world. They affects drastically our way of living, thinking and working to make more eco-friendly changes. In this regard, fingers have been pointed toward automobile manufacturers because the current way of transport with the internal combustion engine (ICE) has to innovate even more related to a clean environment [1]. Thus, under the pressure of energy shortage and environment pollution, hybrid vehicles (HEVs) and electric vehicles (EVs) have emerged as the first step and make nowadays the transition possible to the fully electrification of the automotive sector in the future [2, 3, 4, 5]. However, EVs and HEVs meet today still some restrictions related to autonomy [6], price [7], charge time [8] , local charge possibilities [9], lifetime battery [10], comfort aspects related to the cabin [11],... The majority of the problems are related to the battery system, which is the most crucial and expensive component of BEVs [12]. Accordingly, one crucial aspect for the market penetration is the improvement of the power performance and lifetime of the battery system. To help the market penetration, large-scale battery system and endurable high-current rate are required to improve the power and/or the energy embedded in EVs/HEVs.

Nonetheless, at high-current levels, these batteries produce much heat during operation such as quick acceleration, long-discharge cycles or rapid charge [13, 14, 15]. Then, the safety risks, overheating,and explosions become critical as they increase with the amount of thermal energy contained within the battery or whole system [16, 17]. In a less drastic way, uneven temperature distribute reduces the battery or pack's cycle life excessively [18, 19]. In brief, the batteries must operate between certain boundaries for optimal performance, lifetime and safety considerations. Therefore, a battery thermal management system (BTMS) as part of the whole battery management system (BMS) needs to be implemented to maintain the operation temperature of the batteries between those limited boundaries. Depending on the application area and the type of battery, cooling and/or heating are/is required to work in the right temperature operation range. Two traditional BTMSs have been extensively investigated for automotive applications:

1. Forced air cooling [20, 21, 22, 23]

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