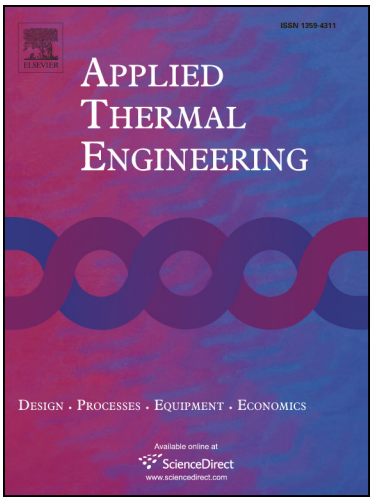


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# A forced gas cooling circle packaging with liquid cooling plate for the thermal management of Li-ion batteries under space environment

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**Abstract**

Large temperature difference in power cells will lead to a lot of reliability issues such as the reducing of life cycle and the decreasing of energy conversion efficiency. This paper presents an integrated cooling method combing the forced internal gas cooling circle and a liquid cooling plate to overcome the thermal issue for Li-ion space batteries. Models of the Li-ion battery packaging with the integrated cooling components have been established. Numerical investigations have been conducted focusing on the impacts of flow field characteristics with different assembly structures, turbulence intensity of the gas circle, and the liquid cooling conditions on the temperature control performance of the integrated cooling approach using computational fluid dynamics method. Compared with the traditional vacuum packaged cooling way, the maximum temperature and the general temperature difference of the space battery cells with total 576W heat generation can be decreased by 3.45K and 3.88K respectively, meanwhile, the temperature uniformity and the temperature control effectiveness can be increased by 2.42 times and 2.61 times respectively. The numerical results support that this novel thermal management method can improve the performance and reliability of the space battery system quite well.

**Keywords:** Thermal management, Li-ion battery, spacecraft, liquid cooling, gas cooling, numerical investigation.

## 1. Introduction

Energy storage battery has been regarded as an essential component for the power supply of communications satellites, the International Space Station, and interstellar vehicles for deep space exploration [1-5]. The state-of-the-art Li-ion battery has caught the attentions of the researchers greatly due to its merits of environmental friendliness, long cycle life, high power-weight ratio [6-7], large operating and storage temperature ranges (-30℃~+60℃) [8-11] and so on. The operating performance of the Li-ion battery is dependent largely on its temperature level. Single cells are usually connected in series to power the electric equipment with high discharging and changing rates [12], which may lead to high heat generation rates inside the battery and give rise to the occurrence of thermal runaway, potentially lowering the performance of the battery and causing