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Development of a Lithium-Ion – Supercapacitor Hybrid Battery for Electric Forklifts

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Extended Abstract

Forklifts are widely used to transport loads in many facilities. Although the power of forklifts with internal combustion engine is quite sufficient, it is impossible to operate them in indoor environments such as factories and warehouses. For this reason, electric forklifts are used in indoor environments.

For many years, lead acid batteries have been used as energy storage units in electric forklifts. While heavy lead acid batteries have a positive feature in terms of stability, the requirement of keeping spare batteries for each forklift is a must due to their slow charging phenomena. In addition, other disadvantages of lead acid batteries are that they need regular maintenance, have a low depth of discharge (DoD) and have a low cycle life [1]. This has made Li batteries more favorable. In parallel to the developments in general transportation applications, the usage of lithium-ion batteries in forklifts is spreading [2].

Despite the above advantages, lithium batteries are sensitive to excessive current pulses. For this reason, it is recommended to add supercapacitors to compensate the overcurrent pulses. Supercapacitors can supply very large current for a short time with cycle life up to 1,000,000 [3]. Thus, in this study a hybrid storage system is proposed. Thanks to the hybrid battery and an optimized energy management system, the high power pulses that exerted on the lithium-ion battery are cropped by the supercapacitor, and the peak current on the lithium-ion battery is decreased. The reduction of the pulse currents in lithium-ion batteries will have a positive effect on their State of Health (SoH) and State of Charge (SoC), the efficiency and the cost by reducing the battery capacity to lower levels.

This study is on the design of a forklift battery with a Lithium Iron Phosphate (LFP) battery and Supercapacitor (SC). The measurements were made to obtain the load profile of an actively used forklift. The pulse currents during acceleration and regenerative braking were measured, and the necessity for adding a supercapacitor is justified. In addition, supercapacitor was tested. 10 kW power can be supplied for 10 seconds until its voltage is half of its rated voltage.

The hybrid battery system of this study includes 80-volt LFP battery and 54-volt 166F supercapacitor. While the lithium-ion battery feeds the 80-volt DC bus, the 54-volt supercapacitor is connected to the DC bus via a bidirectional DC/DC converter. In order to operate this hybrid system efficiently a battery management and control system is developed. This system is not only control the power sharing between battery and super capacitor but also keep the Li battery in best operational condition. It is ensured that the batteries cell voltage, current and temperature limits are not exceeded. Thus, it will be possible to extend the life of the lithium-ion battery without sacrificing the performance capabilities of the forklift.

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