Chapter 12: Primary & Secondary Batteries

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Abstract

The chapter has been dedicated to primary and secondary batteries, their chemistry, design and industrial applications. Primary batteries. These are nonrechargeable batteries, e.g. alkaline and zinc-carbon cells, which produce electrical energy through spontaneous chemical reactions and are applied in household equipment. Rhodomelus and Joerges (2001) also add that rechargeable secondary batteries like lead-acid, nickel-cadmium, and lithium-ion batteries may be used as long-term energy storage in vehicles, portable electronics, and renewable energy systems. The battery parts, along with operating principle, energy density, efficiency and cycle life have been covered in the chapter with a focus on the parameters that influence performance and life cycle. It focuses on industrial applications, particularly to electric automobiles, grid storage and consumer electronics, where the battery capacity and reliability are critical. Thermal stability, capacity fading and environmental impact issue is also addressed and the way of enhancing the safety and efficiency of the battery. By the use of the theory and practical examples, the chapter offers students a comprehensive understanding of the storage of electrochemical energy, design and technological development. The study of batteries spans over the fundamental electrochemistry and the applied engineering disciplines, preparing students to be employed in the research of energy storage, electronics, automobile manufacturing, and sustainable technology.

Keywords: Primary batteries, Secondary batteries, Lead-acid, Lithium-ion, Energy density, Rechargeable, Industrial applications

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12.1.Introduction

Electrochemical devices which store chemical energy and directly translate the same into electrical energy are known as batteries. Contrary to mechanical generators, batteries do not have any moving parts thus are small and effective and reliable sources of electricity. They are critical to the present-day society in providing energy to a wide range of uses, both small and portable like mobile phones, calculators, laptops, and large scale systems such as electric vehicles, renewable energy storage plants, backup power systems, and industrial equipment. There are two general types of batteries, based on their rechargeability. Primary batteries are non-rechargeable electrochemical batteries whereby the chemical reactions are irreversible. When active materials get exhausted, the battery cannot be used anymore and it has to be discarded. These batteries are appreciated due to their simplicity, low prices, and a long shelf life, which makes them appropriate with low power consumption and medium power consumption devices. Usual ones are zinc carbon and alkaline batteries. On the contrary, in secondary batteries, the system is rechargeable with the electrochemical reactions being in a reversible state. With the provision of an external source of electrical energy, the initial chemical composition of the electrodes can be reinstated and the battery can be subjected to numerous charge/discharge cycles. Lithium-ion and lead-acid batteries are common secondary batteries as they are very efficient, reliable and can be applied in high-energy and powerful applications. The analysis of batteries is highly significant regarding the energy storage technology, sustainable development, and the integration of renewable energy sources. The practical utility of a battery is determined by key performance parameters that include: cell potential, energy density, internal resistance, cycle life, charging efficiency and temperature stability. An in-depth knowledge of the fundamental chemical principles, electrode materials, electrolyte dynamics and reacting mechanisms is

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