ENE 302 – Energy Conversion Processes II

WEEK 12: LITHIUM ION BATTERIES

Li-ion batteries are the powerhouse for the digital electronic revolution in this modern mobile society, exclusively used in mobile phones and laptop computers. The success of commercial Li-ion batteries in the 1990s was not an overnight achievement, but a result of intensive research and contribution by many great scientists and engineers. Then much efforts have been put to further improve the performance of Li-ion batteries, achieved certain significant progress.

To meet the increasing demand for energy storage, particularly from increasingly popular electric vehicles, intensified research is required to develop next generation Li-ion batteries with dramatically improved performances, including improved specific energy and volumetric energy density, cyclability, charging rate, stability, cost and safety. There are still notable challenges in the development of next-generation Li-ion batteries. New battery concepts have to be further developed to go beyond Li-ion batteries in the future.

PROBLEM SETS

Problem 1: If the battery you want to buy is rated at 11.1 volts and 4,400 mAh per cell, find the watt-hour value of this battery.

Solution 1: Since a milliampere hour is one thousand of an ampere hour, divide 4,400 mAh by 1000 to get ampere hours (Ah).

4,400 mAh ÷ 1000 = 4.4 Ampere hours

To determine the watt hours in this battery, multiply 11.1 volts by 4.4 ampere hours:

11.1 V x 4.4 Ah = 48.8 Wh

Problem 2: Suppose It requires about 0.3 grams of lithium metal to produce 1 Ampere hour of power. If the battery you wish to buy is rated at 2,500 mAh per cell and contains 6 cells, find the amount of required lithium to make this battery.

Solution 2: Divide 2,500 mAh by 1,000 to get the rating in Ampere hours:

2,500 mAh ÷ 1,000 = 2.5 Ah

Multiply the Ah by 0.3 gm to determine the amount of Lithium in each cell:

2.5 x 0.3 gm = 0.75 grams of lithium in each cell

Multiply the amount of lithium in each cell by the number of cells in each battery:

0.75 grams/cell x 6 = 4.5 grams of lithium in the battery

Problem 3: A unit Li-ion cell has average discharge voltage of 3.9 V and a capacity of 5 Ah. Integrate as many Li-ion cell required for developing a battery module which can produce 120 V and 150 Ah.

Solution 3: We need to an overall voltage of 120 V. So a set of N batteries should be connected in series scheme. Where N is calculated as:

$$1.9\ V * N_{series} = 120\ V \text{ ----------> } N_{series} = \frac{120}{3.9} = 30.67 \sim 31$$

To get a capacity of 150 Ah we need to make a parallel connection of these series cell:

$$5\ Ah * N_{parallel} = 150\ Ah \text{ ----------> } N_{parallel} = 30$$

Therefore the total number of required batteries are:

$$N_{total} = N_{parallel} * N_{series} = 30 * 31 = 930 \text{ battery}$$

References:

1. http://www.gearseds.com/files/determining_battery_capacity3.pdf
2. http://images.fedex.com/us/services/pdf/LithiumBattery_JobAid.pdf
3. Nur Hazima Faezaa Ismail et al 2013 IOP Conf. Ser.: Mater. Sci. Eng. 53 012014
4. http://sustainable-nano.com/2013/10/15/how-do-lithium-ion-batteries-work/.