SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF AUTOMOBILE ENGINEEIRNG

19AUT202 – HYBRID ELECTRIC AND FUEL CELL VEHICLE

II YEAR / III SEM

UNIT - 2 – ENERGY STORAGE SYSTEM

TOPIC – Battery Characterization

PRESENTATION OUTLINE

The following battery characteristics must be taken into consideration when selecting a battery:

Type
Voltage
Discharge curve
Capacity
Energy density
Specific energy density
Power density
Temperature dependence
Service life
Physical requirements
Charge/discharge cycle
Cycle life
Cost
Ability to deep discharge
Application requirements

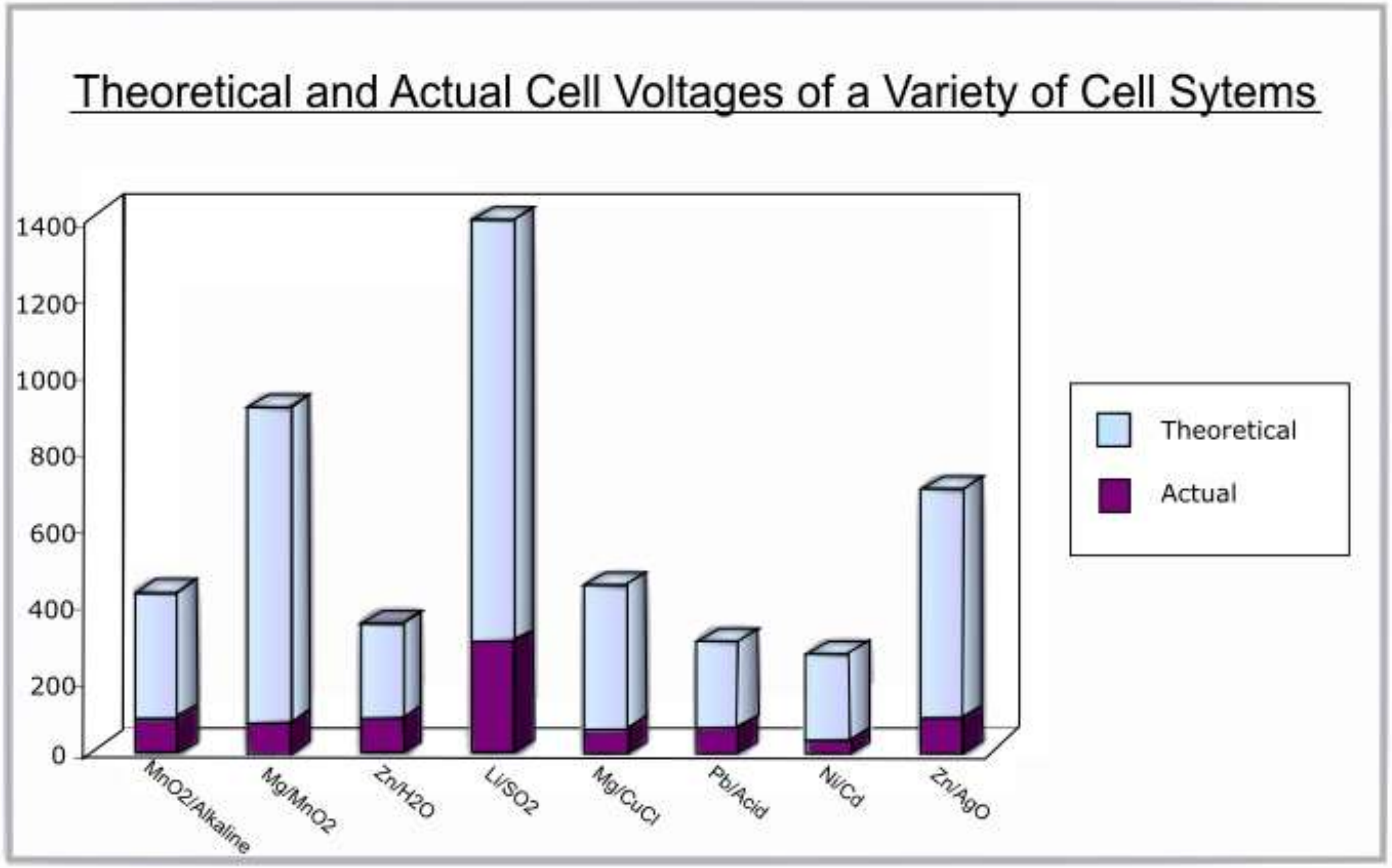
Voltage

The theoretical standard cell voltage can be determined from the electrochemical series using Eo values:

Eo (cathodic) – Eo (anodic) = Eo (cell)

The actual voltage produce will always be lower than the theoretical voltage due to polarisation and the resistance losses (IR drop) of the battery and is dependent upon the load current and the internal impedance of the cell

Typical values of voltage range from **1.2 V for a Ni/Cd battery to 3.7 V for a Li/ion battery**.


Theoretical and Actual Cell Voltages of a Variety of Cell Sytems
1400
1200
1000
800
600
400
200
0
MnO2/Alkaline
Mg/MnO2
Zn/H2O
Li/SO2
Mg/CuCl
Pb/Acid
Ni/Cd
Zn/AgO
Theoretical
Actual

Discharge Curve

- The discharge curve is a **plot of voltage against percentage of capacity discharged**. A flat discharge curve is desirable as this means that the voltage remains constant as the battery is used up.

Capacity

- The theoretical capacity of a battery is the **quantity of electricity involved in the electro-chemical reaction.** It is denoted Q and is given by:
- $Q=xnF$

where x = number of moles of reaction, n = number of electrons transferred per mole of reaction and F = Faraday's constant

The capacity is usually given in terms of mass, not the number of moles:

- $Q=nFMr$

where Mr = Molecular Mass. This gives the capacity in units of Ampere-hours per gram (Ah/g).

Energy density

- The energy density is the **energy that can be derived per unit volume of the weight of the cell**.

Specific energy density

- The specific energy density is the energy that can be derived per unit weight of the cell (or sometimes per unit weight of the active electrode material).
- It is the product of the specific capacity and the operating voltage in one full discharge cycle.
- Both the current and the voltage may vary within a discharge cycle and thus the specific energy derived is calculated by integrating the product of current and voltage over time.
- The discharge time is related to the maximum and minimum voltage threshold and is dependent upon the state of availability of the active materials and/or the avoidance of an irreversible state for a rechargeable battery.

Power density

- The power density is the power that can be derived per unit weight of the cell (W/kg).

Temperature dependence

- The rate of the reaction in the cell will be temperature dependant according to theories of kinetics.
- The internal resistance also varies with temperature; low temperatures give higher internal resistance.
- At very low temperatures the electrolyte may freeze giving a lower voltage as ion movement is impeded. At very high temperatures the chemicals may decompose, or there may be enough energy available to activate unwanted, reversible reactions, reducing the capacity.

Service life

- The battery cycle life for a rechargeable battery is defined as the number of charge/recharge cycles a secondary battery can perform before its capacity falls to 80% of what it originally was. **This is typically between 500 and 1200 cycles**.
- The battery shelf life is the time a battery can be stored inactive before its capacity falls to 80%. The reduction in capacity with time is caused by the depletion of the active materials by undesired reactions within the cell.
- Batteries can also be subjected to premature death by:
- Over-charging
- Over-discharging
- Short circuiting
- Drawing more current than it was designed to produce
- Subjecting to extreme temperatures
- Subjecting to physical shock or vibrations

Physical requirements

This includes the geometry of the cell, its size, weight and shape and the location of the terminals.

Charge/Discharge cycle

There are many aspects of the cycle that need consideration, such as:

Voltage necessary to charge

Time necessary to charge

Availability of charging source

Potential safety hazards during charge/discharge

Cycle life

The cycle life of a rechargeable battery is the number of discharge/charge cycles it can undergo before its capacity falls to 80%.

Cost

- This includes the initial cost of the battery itself as well as the cost of charging and maintaining the battery.

Ability to deep discharge

- There is a logarithmic relationship between the depth of discharge and the life of a battery, thus the life of a battery can be significantly increased if it is not fully discharged; for example, a mobile phone battery will last 5-6 times longer if it is only discharged 80% before recharging.

- Special deep discharge batteries are available for applications where this might be necessary.
  - Nickel Cadmium

Application requirements

The battery must be sufficient for the intended application.
This means that it must be able to produce the right current with the right voltage.
It must have sufficient capacity, energy and power.
It should also not exceed the requirements of the application by too much, since this is likely to result in unnecessary cost;
it must give sufficient performance for the lowest possible price.