UNIT-6

BATTERIES

CELL

In electrical engineering, a cell means a container, which contains some chemical substances which react with each other and a potential difference is created between the two terminals Anode and cathode and if these two terminals are joined externally by a wire, an electric current is passed through this wire, this is called a cell.

or

The word "Cell" means one unit or a combination of materials for converting chemical energy into electrical energy.

TYPES OF CELLS:

Cells are of two types 1) Primary cell and 2) Secondary cell

Primary cells: Primary cells are based on cell reactions which are not reversible. Once the cell reaction is complete, the cell is discharged and cannot be recharged again. Examples: Weston Cd Cell, Leclanche' cell (dry cell) etc.

Secondary Cells: Secondary cells (storage cells or Accumulators) are galvanic cells in which the cell reactions that produce the current can be reversed by applying an external source of current. These can be discharged and recharged many times until the electrode materials last. Examples: Lead-acid battery, Nickel-Cadmium battery, Ni Fe cells, etc.

DIFFERENCES BETWEEN PRIMARY CELL AND SECONDARY CELLS

Primary cell	Secondarycell
1. If recharged once, cannot be recharged.	1. If discharged, can be recharged.
2. For recharging, whole material is to be replaced.	2. It can be easily charged by giving supply.
3. These are light in weight.	3. These are Heavy in weight.
4. Mostly used for intermittent work with low current rate.	4. Can be used for conditions rating with heavy load currents.
5. Its life is low.	5. Its life is high.
6. For example, Daniel cell. Leclanche	

BATTERY

A "Battery" means a combination of the cells. Essentially cell consists of two dissimilar conducting electrodes (Cathode and Anode) immersed in a liquid called electrolyte. By using the energy released by chemical action, electrons are shifted from one electrode to another thereby creating potential difference between theelectrodes.

TYPES OF BATTERIES:

1. Lead - acid battery.
2. Alkaline - iron type: a) Nickel - iron type.
   b) Nickel - cadmium type.
3. Zinc - air battery.

LEAD ACID BATTERY CONSTRUCTION:

Parts of Lead acid battery

1. Container
2. Plate
3. Separators.
4. Cell cover.
5. Plate Connectors.
6. Cell Connectors.
7. Sealing Compound
8. Electrolyte.

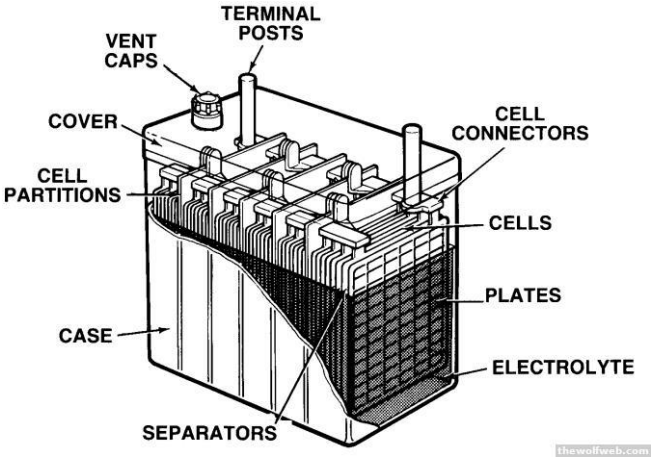

Fig.6.1: Parts of Lead Acid Battery

1. Container : The container of the lead acid battery is made of glass, lead lined wood, ebonite, the hard rubber of bituminous compound, ceramic materials or moulded plasticsand are seated at the top to avoid the discharge of electrolyte. At the bottom of the container, there are four ribs, on two of them rest the positive plate and the others supportthe negative plates.

2. Plate: Positive and Negative plates. These are of two types. (a) Plant type (b) Faure type.

Plant type: Plant are formed from pure load by repeated charge and discharge.

Faure type: plates are made by paste process. Active material is passed in lead made grids inthe form of pastes of red lead Pb3O4 on the +ve plates and paste of PbO in -ve plates. Theseplates are immersed in dilute H2SO4 . Electrolysis takes place when current passes. Red lead Pb3O4 is oxidised to lead peroxide PbO2 forming the positive plate and negative lithearge PbOis reducedto spongy lead.

3. Separators : The separators are thin sheets of non-conducting material made up of chemically treated leadwood, porous rubbers, or mats of glass fiber and are placed between the positive and negative to insulate them from each other. Separators are groovedvertically on one side and are smooth on the other side.

4. Cell covers:

These are obtained by moulding hard rubber and are used to cover the cell; there are vent- plugs in the cell cover for easy escape for gas formed in the cell during charge.

5. Plate connectors:

They are made of pure lead. Positive and negative plates are welded separately with it forming positive group and negative group post terminals. As up were extensions from eachconnecting bar from the terminal pole.

6. Cell Connectors:

Cells are connected in series to from battery. Plates in the selves are so arranged that thenegative terminal of one cell is closed to positive terminal of the next cell so. These adjustment terminal posts are then welded.

7. Ceiling Compound:

It is made from bitumen compound and is used to form on acid tight joint between the coverand containers, so that acid may not come out while cell is in use.

8. Electrolyte:

For Lead acid cell the electrolyte used in dilute solution of sulphuric acid.

WORKING PRINCIPLE OF LEAD ACID BATTERY

When the sulfuric acid dissolves, its molecules break up into positive hydrogen ions ($2H^+$) and sulphate negative ions ($SO4^{--}$) and move freely. If the two electrodes areimmersed in solutions and connected to DC supply then the hydrogen ions being positively charged and moved towards the electrodes

and connected to the negative terminal of the supply. The $SO4^{--}$ ions being negatively charged moved towards the electrodes connected to the positive terminal of the supply main (i.e., anode).

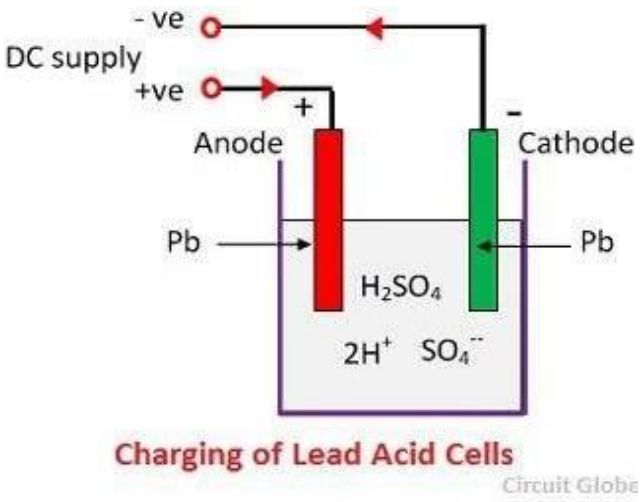

Fig.6.2: Charging of Lead Acid Cells

Each hydrogen ion takes one electron from the cathode, and each sulphates ions takes the two negative ions from the anodes and react with water and form sulfuric and hydrogen acid.

The oxygen, which produced from the above equation react with lead oxide and form lead peroxide ($PbO2$.) Thus, during charging the lead cathode remain as lead, but lead anode getsconverted into lead peroxide, chocolate in colour.

If the DC source of supply is disconnected and if the voltmeter connects between the electrodes, it will show the potential difference between them. If wire connects the electrodes, then current will flow from the positive plate to the negative plate through external circuit i.e. the cell is capable of supplying electrical energy.

CHARGING AND DISCHARGING OF LEAD ACID BATTERIES

CHEMICAL ACTION DURING DISCHARGING

When the cell is full discharge, then the anode is of lead peroxide ($PbO2$) and a cathode is of metallic sponge lead (Pb). When the electrodes are connected through a resistance, the cell discharge and electrons flow in a direction opposite to that during charging.

The hydrogen ions move to the anode and reaching the anodes receive one electron from the anode and become hydrogen atom. The hydrogen atom comes in contacts with a $PbO2$, so it attacks and forms lead sulphate ($PbSO4$), whitish in colour and water according to the chemical equation.

$$PbSO_4 + 2H = PbO + H_2O$$

$$PbO + H_2SO_4 = PbSO_4 + 2H_2O$$

$$\overline{PbO_2 + H_2SO_4 + 2H = PbSO_4 + 2H_2O}$$

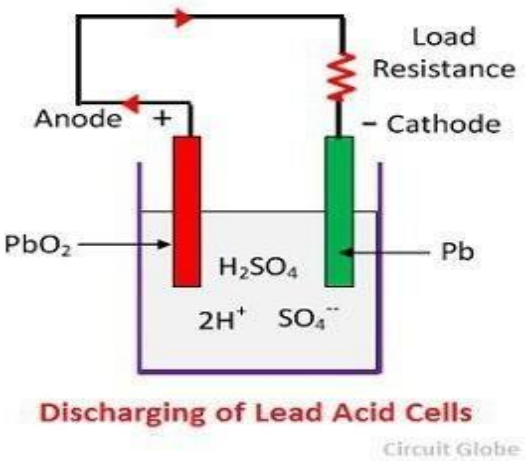

Fig.6.3: Discharging of Lead Acid Cells

The each sulphate ion ($SO4^{--}$) moves towards the cathode and reaching their gives up twoelectrons becomes radical SO4, attack the metallic lead cathode and form lead sulphate whitish in colour according to the chemical equation.

CHEMICAL ACTION DURING RECHARGING

For recharging, the anode and cathode are connected to the positive and the negative terminal of the DC supply mains. The molecules of the sulfuric acid break up into ions of $2H^{+}$ and $SO4^{--}$. The hydrogen ions being positively charged moved towards the cathodes and receive two electrons from there and form a hydrogen atom. The hydrogen atom reacts with lead sulphate cathode forming lead and sulfuric acid according to the chemical equation.

$$PbSO_4 + 2H_2O + 2H = PbSO_4 + 2H_2SO_4$$

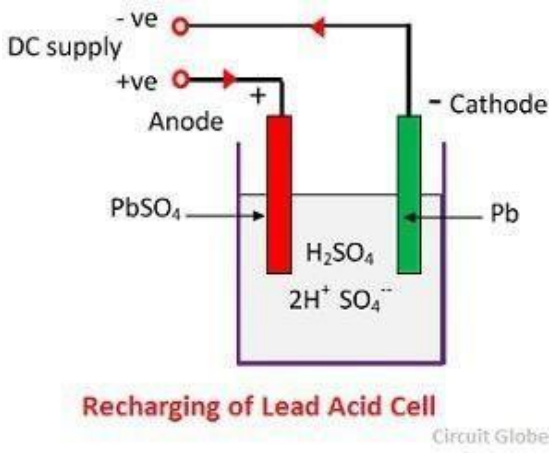

Fig.6.4: Recharging of Lead Acid Cell

$SO4^{--}$ ion moves to the anode, gives up its two additional electrons becomes radical SO4, react with the lead sulphate anode and form leads peroxide and lead sulphuric acid according to thechemical equation.

$$PbSO_4 + 2H = H_2SO_4 + Pb$$

The charging and discharging are represented by a single reversible equation given below.

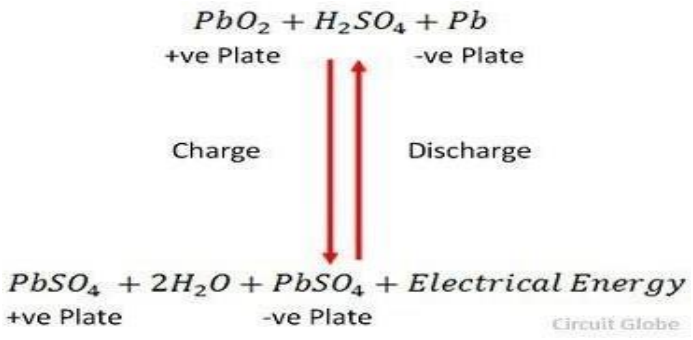

Fig.6.5: Charging & Discharging Equations

METHODS OF CHARGING LEAD ACID BATTERIES:

In general, There are two methods of charging batteries or Accumulators (the name accumulator, as it accumulates, means adds or stores the electrical energy) From d.c. supply there are two methods of charging a lead acid battery.

1. Constant current method.
2. Constant voltage method.
3. Trickle Charge Method

CONSTANT CURRENT METHOD

Constant current method of charging is usually adopted for initially charging the new batteries. According to this method charging current is kept constant throughout by adjusting the external resistance R. This method of charging is defective to the extent that it does not take into consideration the state of charge of the battery. Usually high, charging rate is required for fully discharged battery in the beginning and this rate of charging should go down as battery approaches its fully charged rate. This drawback is removed when we charge the battery according to constant voltage method.

CONSTANT VOLTAGE METHOD

In this method, charging voltage is held constant throughout the charging. Charging current in the beginning is high which however reduces as the back e.m.f. of the battery increases. This is the most common method of charging. The battery is charged till the cells are gassing freely and the specific gravity of the electrolyte and the terminal voltage of cells remain constant. The fully charged battery has fallowing indications.

Specific gravity of electrolyte :1260 to
1280 Voltage ofcell :2.1 volts

Where specific gravity can be determined by hydrometer and voltage by cell tester accurately.

TRICKLE CHARGE METHOD

When a storage battery is kept entirely as an emergency reserve, it is essential that it should be found fully charged and ready for service when an emergency arises. Due to open circuit losses and local action, the battery voltage falls(when it is idle for some time).Hence to keep it fresh, the battery is kept on trickle charge. The trickle charge is extremely a low rate charge and is applied to stand by batteries for compensating open circuit losses. The trickle charge current should be small.

APPLICATION OF LEAD-ACID CELL

Storage cells are these days used for a great variety and range of propose some which are summarized below:

(i) In central stations for supplying the whole load during light load periods also assist the generating plant during speak load periods for providing reserve emergency supply during periods of plant breakdown and finally to store energy at times when load is light for use at times when is at its peak value.

(ii) In Private generating plants both for industrial and domestic use, for much the same purpose as in central stations.

(iii) In sub-stations, they assist in maintaining the declared voltage by meeting a part of the demand and so reducing the load on and the voltage dropping feeder during peak - load periods.

(iv) As a power source for industrial and mining cell locomotives and for load vehicles, like cars and trucks.

(v) As a power source for submarines when submerged.

(vi) For petrol motor car starting and ignition etc.

(vii) As a Low - voltage supply for operating purpose in many different ways such as high- tension switch gear, automatic telephone exchange and repeater stations, broadcasting stations and wireless receiving sets.

CARE AND MAINTENANCE OF CELL

The Cells of vehicle cells must be inspected periodically, every week. The following points may be taken care of.

(i) The cell terminal should be clean and tight. The electrolyte may escape from the battery due to overfilling and cause the correction of the terminals. A loose connection at the terminals will result in a faulty starting and dischargedcell.

(ii) Remove vent plugs taking care that no flame is brought near the vents because the gas inside is highly inflammable.

(iii) In case the electrolyte level in the cell is not sufficient, top up with distilled water. If distilled water is not available sometime clean water may also be used.

(iv) Never let the cell remain in discharged condition, otherwise the plates will become sulphated.

(v) Cell electrolyte being remain in discharged condition, otherwise the plates

will become sulphated.

(vi) Do not bring any flame near the cell a highly explosive vapours coming out of the cell may get ignited accidentally.

(vii) To avoid accidental arcing always remove the negative ground cable first while disconnecting and cannot the same last while assembling.

(viii) Use proper protective clothing i.e. apron gloves and face shield while handling cells.

(ix) While marking cell connections take special care to observe proper polarities so that correct connections are made.

(x) Jump start cells only if permitted by the cell manufacturer. Some manufacturers specially prohibit jump start.

Short Answer Questions

1. Define cell.
2. Write the differences between primary and secondary cells.
3. Write the applications of Lead-Acid cell.
4. Explain care and maintenance of cell.

Long Answer Questions

1. Explain the parts of Lead-Acid battery with sketch.
2. Explain discharging and recharging of Lead-Acid battery.
3. Explain the methods of charging of Lead-Acid battery.