



FABRICATION AND IMPLEMENTATION OF SOLAR WINDOWS FOR RESIDENTIAL APPLICATIONS

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Abstract

Solar energy means all the energy that reaches the earth from the sun. It provides daylight, makes the earth hot and is the source of energy for plants to grow. Solar energy is also put to two types of use to help our lives directly: solar heating and solar electricity. Solar electricity is the technology of converting sunlight directly into electricity. It is based on photo-voltaic or solar modules, which are very reliable and do not require any fuel or servicing. Solar electric systems are suitable for plenty of sun and are ideal when there is no main electricity. Our objective is to design and develop a solar electric system normally "SOLAR WINDOWS". Window integrated photovoltaics (WIPV) are an important application of future solar energy development in the residences. The incorporation of solar panels into windows must not only maintain indoor natural lighting but also generate electrical power at the same time. In our continuing effort to improve the design of diffusion solar windows, a more fundamental and efficient uncoated solar panel and coated solar panel is to be fabricated. In this work, a well-established ASAP ray-tracing model for a diffusive solar cell window is implemented to validate the outperformance of uncoated solar window structure over coated solar window structure. For this project the conversion of the solar energy is done by the solar panel. The control mechanism carries the LDR sensor, Control unit, inverter, battery charge controller and LED Indication.

KEYWORDS : Solar energy, renewable energy, photovoltaic method, alumina resin mixture, solar windows.

1. Introduction

Man has needed and used energy at an increasing rate for its sustenance and well being ever since he came on the earth a few million years ago. Primitive man required energy primarily in the form of food. He derived this by eating plants or animals, which he hunted. Subsequently he discovered fire and his energy needs increased as he started to make use of wood and other biomass to supply the energy needs for cooking as well as agriculture. He added a new dimension to the use of energy by domesticating and training animals to work for him. With further demand for energy, man began to use the wind for sailing ships and for driving windmills, and the force of falling water to turn water wheels. Till this time, it would not be wrong to say that the sun was supplying all the energy needs of man either directly or indirectly and that man was using only renewable sources of energy.

METHODS OF UTILISATION OF SOLAR ENERGY

1. DIRECT METHOD
 - a. Photovoltaic Method
 - b. Thermal Method

2. INDIRECT METHOD

- a. Water Power Method
- b. Wind Power Method
- c. BioMass Method
- d. Wave Energy Method
- e. Ocean Power Method

DIRECT METHOD OF UTILIZATION OF SOLAR ENERGY:

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photo-voltaic cells. Sunshine is incident on Solar cells, in this system of energy Conversion that is direct conversion of solar radiation into electricity. In the stage of conversion into thermodynamic form is absent. The photo-voltaic effect is defined as the generation of an electromotive force as a result of the absorption of ionizing radiation. Energy conversion devices, which are used to convert sunlight to electricity by use of the photo-voltaic effect, are called solar cells. In recent years photo-voltaic power generation has been receiving considerable attention as one of the more promising energy alternatives. The reason for this rising interest lies in PV's direct conversion of sunlight to electricity, the non polluting nature of the widespread area of PV generation has been hampered by economic factors. Here to force the low cost of conventional energy sunlight has obviated the development of a broad-based PV technology. At the present time, PV generation can be justified only for special situations mostly for remote sites where utility lines on other conventional means of furnishing energy may be prohibitively expensive and is one of the most attractive non-conventional energy sources of proven reliability from the micro to the Mega-watt level.

Like other energy system this system also has some disadvantages

- (1) Distributed nature of solar energy,
- (2) Absence of energy storage,
- (3) Relatively high capital cost.

PHOTOVOLTAIC METHOD

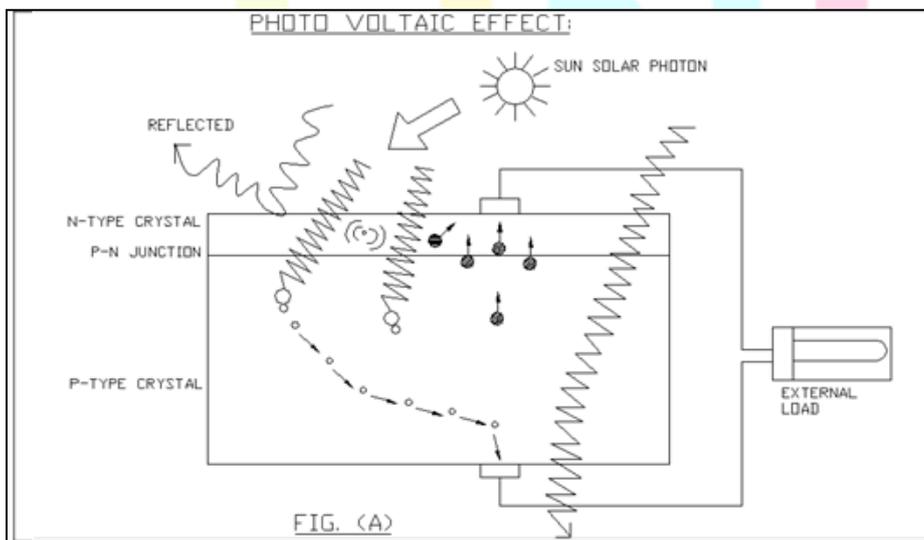
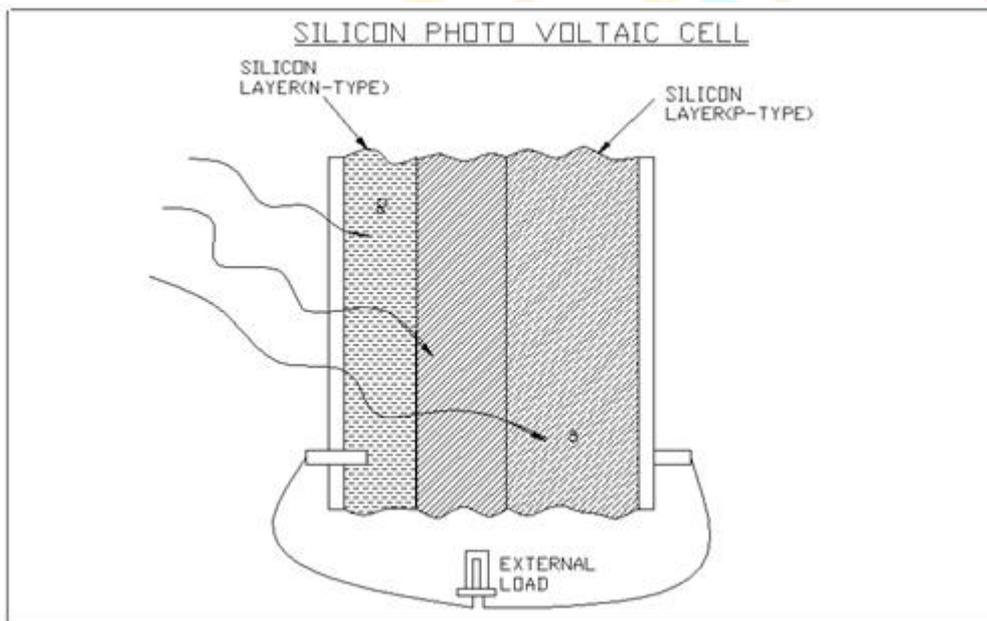
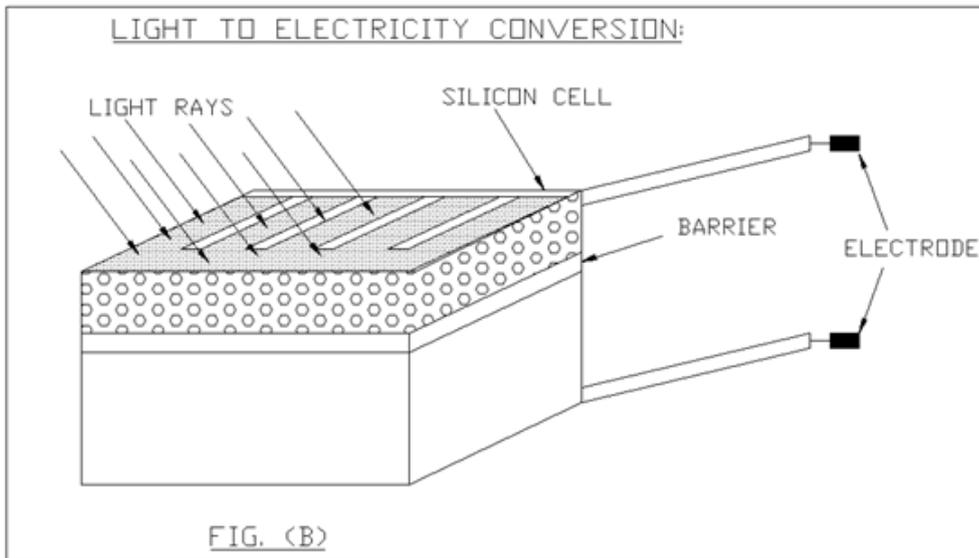
PHOTOVOLTAIC PRINCIPLES:

The photo-voltaic effect can be observed in nature in a variety of materials that have shown that the best performance in sunlight is the semiconductors as stated above. When photons from the sun are absorbed in a semiconductor, that create free electrons with higher energies than the created there must be an electric field to induce these higher energy electrons to flow out of the semiconductor to do useful work. A junction of materials, which have different electrical properties, provides the electric field in most solar cells.

To obtain a useful power output from photon interaction in a semiconductor, three processes are required.

- 1) The photon has to be absorbed in the active part of the material and result in electrons being excited to a higher energy potential.
- 2) electron hole charge carriers created by the absorption must be physically separated and moved to the edge of the cell.

3) The charge carriers must be removed from the cell and delivered to useful load before they lose extra potential.



For completing the above processes a solar cell consists of:-

(a) Semiconductor in which electron hole pairs are created by absorption of incident solar radiation.

- (b) Region containing a drift field for charge separation
- (c) Charge collecting fronts and back electrodes.

The photo-voltaic effect can be described easily for p-n junctions in a semiconductor. In an intrinsic semiconductor such as silicon, each one of the four valence electrons of the material atom is tied in a chemical bond, and there are no free electrons at absolute zero. If a piece of such a material is doped on one side by a five valence electron material, such as arsenic or phosphorus, there will be an excess of electrons in that side, becoming an n-type semiconductor. The excess electrons will be practically free to move in the semiconductor lattice. When a three valence electron material, such as boron dopes the other side of the same piece, there will be deficiency of electrons leading to a p-type semiconductor. This deficiency is expressed in terms of excess of holes free to move in the lattice. Such a piece of semiconductor with one side of the p-type and the other, of the n-type is called a p-n junction. In this junction after the photons are absorbed, the free electrons of the n-side will tend to flow to the p-side, and the holes of the p-side will tend to flow to the n-region to compensate for their respective deficiencies. This diffusion will create an electric field from the n-region to the p-region. This field will increase until it reaches equilibrium for V , the sum of the diffusion potentials for holes and electrons.

2. Methods and Materials

COATING ON SOLAR PANEL.

Alumina

PROPERTIES OF ALUMINA

Aluminium oxide is a chemical compound of aluminium and oxygen with the chemical formula Al_2O_3 . It is the most commonly occurring of several aluminium oxides, and specifically identified as aluminium(III) oxide. It is commonly called alumina, and may also be called aloxide, aloxite, or alundum depending on particular forms or applications. It commonly occurs in its crystalline polymorphic phase $\alpha-Al_2O_3$, in which it comprises the mineral corundum, varieties of which form the precious gemstones ruby and sapphire. Al_2O_3 is significant in its use to produce aluminium metal, as an abrasive owing to its hardness, and as a refractory material owing to its high melting point

Al_2O_3 is an electrical insulator but has a relatively high thermal conductivity ($30 \text{ Wm}^{-1}\text{K}^{-1}$ [3]) for a ceramic material. Aluminum oxide is insoluble in water. In its most commonly occurring crystalline form, called corundum or α -aluminium oxide, its hardness makes it suitable for use as an abrasive and as a component in cutting tools.

Aluminium oxide is responsible for the resistance of metallic aluminium to weathering. Metallic aluminium is very reactive with atmospheric oxygen, and a thin passivation layer of aluminium oxide (4 nm thickness) forms on any exposed aluminium surface. This layer protects the metal from further oxidation. The thickness and properties of this oxide layer can be enhanced using a process called anodising. A number of alloys, such as aluminium bronzes, exploit this property by including a proportion of aluminium in the alloy to enhance corrosion resistance. The aluminium oxide generated by anodising is typically amorphous, but discharge assisted oxidation processes such as plasma electrolytic oxidation result in a significant proportion of crystalline aluminium oxide in the coating, enhancing its hardness.

RESIN

Material selection

RESIN MATRIX

The resins that are used in fibre reinforced composites are sometimes referred to as ‘polymers’. All polymers exhibit an important common property in that they are composed of long chain-like molecules consisting of many simple repeating units. Man-made polymers are generally called ‘synthetic resins’ or simply ‘resins’. Polymers can be classified under two types, ‘thermoplastic’ and ‘thermosetting’, according to the effect of heat on their properties.

Although there are many different types of resin in use in the composite industry, the majority of structural parts are made with three main types, namely polyester, vinylester and epoxy.

POLYESTER RESINS

Polyester resins are the most widely used resin systems, particularly in the marine industry. By far the majority of dinghies, yachts and work-boats built in composites make use of this resin system. Polyester resins such as these are of the ‘unsaturated’ type. Unsaturated polyester resin is a thermoset, capable of being cured from a liquid or solid state when subject to the right conditions. An unsaturated polyester differs from a saturated polyester such as Terylene™ which cannot be cured in this way. It is usual, however, to refer to unsaturated polyester resins as ‘polyester resins’, or simply as ‘polyesters’.

VINYLESTER RESINS

Vinylester resins are similar in their molecular structure to polyesters, but differ primarily in the location of their reactive sites, these being positioned only at the ends of the molecular chains. As the whole length of the molecular chain is available to absorb shock loadings this makes vinylester resins tougher and more resilient than polyesters.

The vinyl ester molecule also features fewer ester groups. These ester groups are susceptible to water degradation by hydrolysis which means that vinylesters exhibit better resistance to water and many other chemicals than their polyester counterparts, and are frequently found in applications such as pipelines and chemical storage tanks.

EPOXY RESINS

The large family of epoxy resins represent some of the highest performance resins of those available at this time. Epoxies generally out-perform most other resin types in terms of mechanical properties and resistance to environmental degradation, which leads to their almost exclusive use in aircraft components. As a laminating resin their increased adhesive properties and resistance to water degradation make these resins ideal for use in applications such as boat building. Here epoxies are widely used as a primary construction material for high-performance boats or as a secondary application to sheath a hull or replace water-degraded polyester resins and gel coats. The term ‘epoxy’ refers to a chemical group consisting of an oxygen atom bonded to two carbon atoms that are already bonded in some way. The simplest epoxy is a three-member ring structure known by the term ‘alpha-epoxy’ or ‘1,2-epoxy’. The idealized chemical structure is shown in the figure below and is the most easily identified characteristic of any more complex epoxy molecule.

COMPARISON OF RESIN PROPERTIES

The choice of a resin system for use in any component depends on a number of its characteristics, with the following probably being the most important for most composite structures:

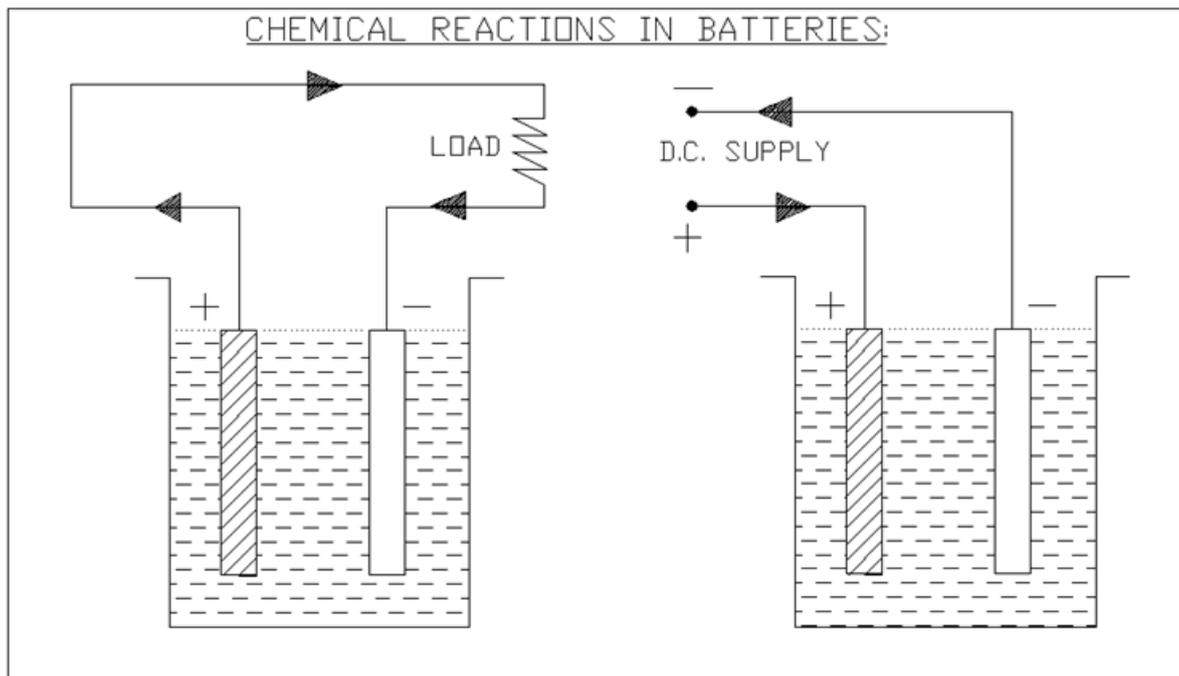
Adhesive Properties

Mechanical Properties

Degradation From Water Ingress.

In isolated systems away from the grid, batteries are used for storage of excess solar energy converted into electrical energy. The only exceptions are isolated sunshine loads such as irrigation pumps or drinking water supplies for storage. In fact for small units with output less than one kilowatt. Batteries seem to be the only technically and economically available storage means. Since both the photo-voltaic system and batteries are high in capital costs. It is necessary that the overall system be optimized with respect to available energy and local demand pattern. To be economically attractive the storage of solar electricity requires a battery with a particular combination of properties:

- (1) Low cost
- (2) Long life
- (3) High reliability
- (4) High overall efficiency
- (5) Low discharge
- (6) Minimum maintenance
- (A) Ampere hour efficiency
- (B) Watt hour efficiency



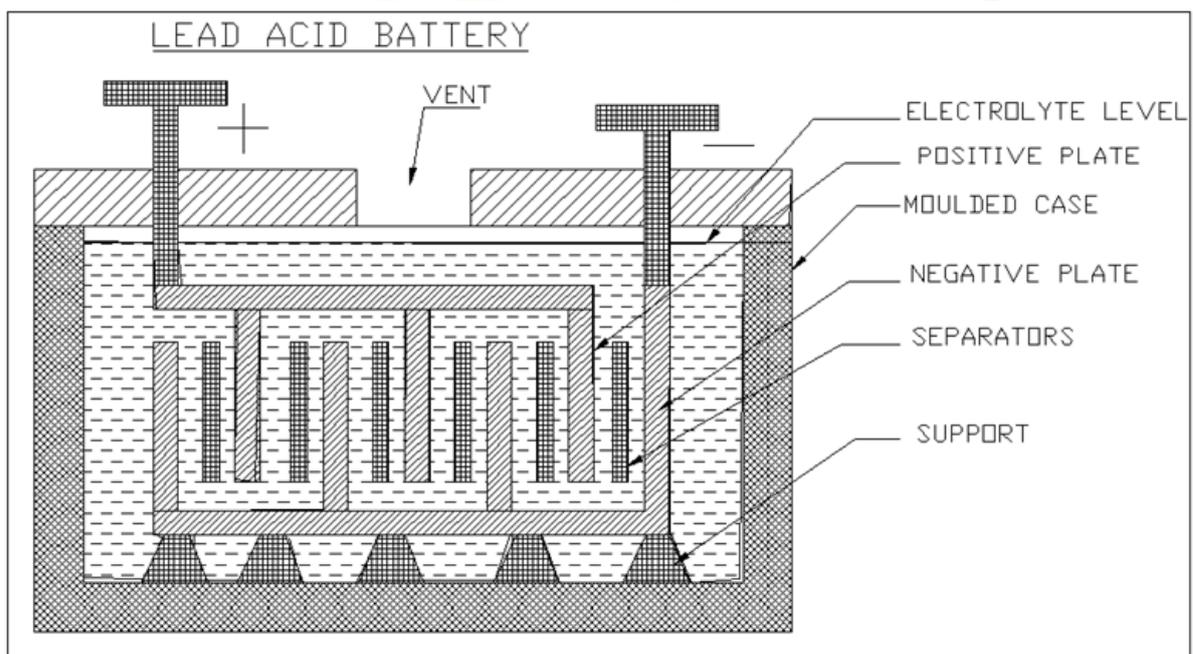
LEAD-ACID WET CELL:

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the engine in an automobile, for example, the load current to the starter motor is typically 200 to 400A. One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery. The lead acid cell type is a secondary cell or storage cell, which can be recharged. The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents

shortens the useful life to about 3 to 5 years for an automobile battery. Of the different types of secondary cells, the lead-acid type has the highest output voltage, which allows fewer cells for a specified battery voltage.

CONSTRUCTION:

Inside a lead-acid battery, the positive and negative electrodes consist of a group of plates welded to a connecting strap. The plates are immersed in the electrolyte, consisting of 8 parts of water to 3 parts of concentrated sulfuric acid. Each plate is a grid or framework, made of a lead-antimony alloy. This construction enables the active material, which is lead oxide, to be pasted into the grid. In manufacture of the cell, a forming charge produces the positive and negative electrodes. In the forming process, the active material in the positive plate is changed to lead peroxide (PbO_2). The negative electrode is spongy lead (Pb). Automobile batteries are usually shipped dry from the manufacturer. The electrolyte is put in at the time of installation, and then the battery is charged to from the plates. With maintenance-free batteries, little or no water needs to be added in normal service. Some types are sealed, except for a pressure vent, without provision for adding water. The construction parts of the battery are shown in figure.



CHEMICAL ACTION:

Sulfuric acid is a combination of hydrogen and sulfate ions. When the cell discharges, lead peroxide from the positive electrode combines with hydrogen ions to form water and with sulfate ions to form lead sulfate. Combining lead on the negative plate with sulfate ions also produces sulfate. Therefore, the net result of discharge is to produce more water, which dilutes the electrolyte, and to form lead sulfate on the plates. As the discharge continues, the sulfate fills the pores of the grids, retarding circulation of acid in the active material. Lead sulfate is the powder often seen on the outside terminals of old batteries. When the combination of weak electrolyte and sulfating on the plate lowers the output of the battery, charging is necessary. On charge, the external D.C. source reverses the current in the battery. The reversed direction of ions flows in the electrolyte results in a reversal of the chemical reactions. Now the lead sulfates on the positive plate reactive with the water and sulfate ions to produce lead peroxide and sulfuric acid. This action re-forms the positive plates and makes the electrolyte stronger by adding sulfuric acid.



3. Results and discussion

CARING FOR LEAD-ACID BATTERIES:

Always use extreme caution when handling batteries and electrolyte. Wear gloves, goggles and old clothes. “Battery acid” will burn skin and eyes and destroy cotton and wool clothing. The quickest way to ruin lead-acid batteries is to discharge them deeply and leave them standing “dead” for an extended period of time. When they discharge, there is a chemical change in the positive plates of the battery. They change from lead oxide when charge out lead sulfate when discharged. If they remain in the lead Sulfate State for a few days, some part of the plate does not return to lead oxide when the battery is recharged. If the battery remains discharged longer, a greater amount of the positive plate will remain lead sulfate. The parts of the plates that become “sulfate” no longer store energy. Batteries that are deeply discharged, and then charged partially on a regular basis can fail in less than one year. Check your batteries on a regular basis to be sure they are getting charged. Use a hydrometer to check the specific gravity of your lead acid batteries. If batteries are cycled very deeply and then recharged quickly, the specific gravity reading will be lower than it should because the electrolyte at the top of the battery may not have mixed with the “charged” electrolyte. Check the electrolyte level in the wet-cell batteries at least four times a year and top each cell off with distilled water. Do not add water to discharged batteries. Electrolyte is absorbed when batteries are very discharged. If you add water at this time, and then recharge the battery, electrolyte will overflow and make a mess.

Keep the top of your batteries clean and check that cables are tight. Do not tighten or remove cables while charging or discharging. Any spark around batteries can cause a hydrogen explosion inside, and ruin one of the cells, and you.

On charge, with reverse current through the electrolyte, the chemical action is reversed. Then the pb ions from the lead sulfate on the right side of the equation re-form the lead and lead peroxide electrodes. Also the SO_4 ions combine with H_2 ions from the water to produce more sulfuric acid at the left side of the equation.

CURRENT RATINGS:

Lead-acid batteries are generally rated in terms of how much discharge currents they can supply for a specified period of time; the output voltage must be maintained above a minimum level, which is 1.5 to 1.8V per cell. A common rating is ampere-hours (A.h.) based on a specific discharge time, which is often 8h. Typical values for automobile batteries are 100 to 300 A.h. As an example, a 200 A.h battery can supply a load current of 200/8 or 25A, used on 8h discharge. The battery can supply less current for a longer time or more current for a shorter time. Automobile batteries may be rated for “cold cranking power”, which is related to the job of starting the engine. A typical rating is 450A for 30s at a temperature of 0 degree F.

Note that the ampere-hour unit specifies coulombs of charge. For instance, 200 A.h. corresponds to $200\text{A} \times 3600\text{s}$ (1h=3600s). the equals 720,000 A.S, or coulombs. One ampere-second is equal to one coulomb. Then the charge equals 720,000 or $7.2 \times 10^5\text{C}$. To put this much charge back into the battery would require 20 hours with a charging current of 10A. The ratings for lead-acid batteries are given for a temperature range of 77 to 80°F. Higher temperature increases the chemical reaction, but operation above 110°F shortens the battery life. Low temperatures reduce the current capacity and voltage output. The ampere-hour capacity is reduced approximately 0.75% for each decrease of 1° F below normal temperature rating. At 0°F the available output is only 60 % of the ampere-hour battery rating. In cold weather, therefore, it is very important to have an automobile battery unto full charge. In addition, the electrolyte freezes more easily when diluted by water in the discharged condition.

SPECIFIC GRAVITY:

Measuring the specific gravity of the electrolyte generally checks the state of discharge for a lead-acid cell. Specific gravity is a ratio comparing the weight of a substance with the weight of a substance with the weight of water. For instance, concentrated sulfuric acid is 1.835 times as heavy as water for the same volume. Therefore, its specific gravity equals 1.835. The specific gravity of water is 1, since it is the reference.

In a fully charged automotive cell, a mixture of sulfuric acid and water results in a specific gravity of 1.280 at room temperatures of 70 to 80°F. as the cell discharges, more water is formed, lowering the specific gravity. When it is down to about 1.150, the cell is completely discharged. Specific-gravity readings are taken with a battery hydrometer, such as one in figure (7). Note that the calibrated float with the specific gravity marks will rest higher in an electrolyte of higher specific gravity. The decimal point is often omitted for convenience. For example, the value of 1.220 in figure (7) is simply read “twelve twenty”. A hydrometer reading of 1260 to 1280 indicates full charge, approximately 1250 are half charge, and 1150 to 1200 indicates complete discharge. The importance of the specific gravity can be seen from the fact that the open-circuit voltage of the lead-acid cell is approximately equal to

$$V = \text{Specific gravity} + 0.84$$

For the specific gravity of 1.280, the voltage is $1.280 + 0.84 = 2.12\text{V}$, as an example. These values are for a fully charged battery.

CHARGING THE LEAD-ACID BATTERY:

The requirements are illustrated in the figure. An external D.C. voltage source is necessary to produce current in one direction. Also, the charging voltage must be more than the battery e.m.f. Approximately 2.5 per cell is enough to cover the cell e.m.f. so that the charging voltage can produce current opposite to the direction of discharge current. Note that the reversal of current is obtained just by connecting the battery VB and charging

source VG with + to + and -to-, as shown in figure. The charging current is reversed because the battery effectively becomes a load resistance for VG when it is higher than VB. In this example, the net voltage available to produce charging currents is $15-12=3V$. A commercial charger for automobile batteries is essentially a D.C. power supply, rectifying input from the AC power line to provide D.C. output for charging batteries. Float charging refers to a method in which the charger and the battery are always connected to each other for supplying current to the load. In figure the charger provides current for the load and the current necessary to keep the battery fully charged. The battery here is an auxiliary source for D.C. power. It may be of interest to note that an automobile battery is in a floating-charge circuit. The battery charger is an AC generator or alternator with rectifier diodes, driven by a belt from the engine. When you start the car, the battery supplies the cranking power. Once the engine is running, the alternator charges the battery. It is not necessary for the car to be moving. A voltage regulator is used in this system to maintain the output at approximately 13 to 15 V. The constant voltage of 24V comes from the solar panel controlled by the charge controller so for storing this energy we need a 24V battery so two 12V batteries are connected in series. It is a good idea to do an equalizing charge when some cells show a variation of 0.05 specific gravity from each other. This is a long steady overcharge, bringing the battery to a gassing or bubbling state. Do not equalize sealed or gel type batteries. With proper care, lead-acid batteries will have a long service life and work very well in almost any power system. Unfortunately, with poor treatment lead-acid battery life will be very short.

4. Conclusion

By completing this project works, we have achieved a clear knowledge of Solar energy and its importance for the current scenario and also the effective implementation on residential apartments by using non-conventional energy with and without coated. This project would be fruitful in both domestic & industrial backgrounds. This project although fulfilling our requirement has further scope for improvements. Some of the improvements that could be made in this solar window unit are listed below.

- By adding solar panel auto tracking system
- By adding some components to make solar heater cum cooler and other applications.

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