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Performance Test on Solar Panel Using Phase Change Materials

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***Abstract*—** This project investigates the use of phase-change materials (PCM) to maintain the temperature of the panels close to the ambient. High operating temperatures induce a loss of efficiency in solar photovoltaic and thermal panels. The use of phase - change materials (PCM) to maintain the temperature of the panels close to the ambient. Hydrated salts have larger energy storage density and higher thermal conductivity but experience super cooling and phase segregation and The main advantages of PCM encapsulation are providing large heat transfer area, reduction of the PCMs reactivity towards the outside environment and controlling the changes in volume of the storage materials as phase change occurs. PCMs have been widely used in latent heat thermal-storage systems for heat pumps, solar engineering, and spacecraft thermal control applications. The uses of PCMs for heating and cooling applications for buildings have been investigated within the past decade. There are large numbers of PCMs that melt and solidify at a wide range of temperatures, making them attractive in a number of applications. Phase change materials are shown to be effective means of limiting temperature rise in photovoltaic devices. PCMs used in this test exhibits stable characteristics through repeated phase change cycles and no deterioration of PCMs was observed.

***Keywords*—** PCM, Solar, Photovoltaic cell, Conductivity. *(Key words)*

I. Introduction

1.1solar Energy

Solar energy is the most readily available source of energy. It does not belong to anybody and is, therefore, free. It is also the most important of the non-conventional sources of energy because it is non-polluting and, therefore, helps in lessening the greenhouse effect.

1.2 Available Solar Resource

The technical feasibility and economical viability of using solar energy depends on the amount of available sunlight (solar radiation) in the area where you intend to place solar heaters or solar panels. This is sometimes referred to as the available solar resource. Every part of Earth is provided with sunlight during at least one part of the year. "part of the year" refers to the fact that the north and south polar caps are each in total darkness for a few months of the year. The amount of sunlight available is one factor to take into account when considering using solar energy. There are a few other factors, however, which need to be looked at when determining the viability of solar energy in any given location. These are as follows:

- Geographic location
- Time of day
- Season
- Local landscape
- Local weather

Day and night is due to the Earth's rotation generated, but the season is due to the Earth's rotation axis and the Earth's orbit around the sun's axis was 23 °27'angle 11

And generated. The Earth rotates around the "axis" which through its own north and south poles a circuit from west to east every day. Per revolution of the earth cause day and night, so the Earth's rotation per hour is 15 °.In addition, the Earth goes through a small eccentricity elliptical orbit around the sun per circuit per year. The Earth's axis of rotation and revolution has always been 23.5° with the earth orbit. The Earth's revolution remains unchanged when the direction of spin axis always points to the Earth's North Pole. Therefore, the Earth's orbit at a different location when the sunlight is projected onto the direction of the earth is different, so it cause the formation of the Earth's seasons changes. Noon of each day, the sun's height is always the highest. In the tropical low-latitude regions (in the equatorial north and south latitude 23 ° 27 'between the regions), sunlight of each year, there are two vertical incidences at higher latitudes, the sun is always close to the equator direction. In the Arctic and Antarctic regions (in the northern and southern hemispheres are greater than (90 ° ~ 23 ° 27 '), in winter the sun below the horizon for a long time.

1.3 Solar Energy Measurements

Radiation data (the amount of solar energy available at a given location) for solar electric (photovoltaic) systems is often represented as kilowatt-hours per square meter (kWh/m2). Direct estimates of solar energy may be expressed as "watts per square meter" (W/m2). Radiation data for solar water heating and space heating systems is usually represented in British thermal units per square foot (Btu/ft2).

1.4 How Does Solar Energy Works?

Solar or photovoltaic (PV) cells are made up of materials that turn sunlight into electricity. Photovoltaic (PV) technologies including solar thermal hot water are renewable energy technologies and are clean energy alternatives compared to non renewable energy technologies that burn fossil fuels. PV cells are composed of layers of semiconductors such as silicon. Energy is created when

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photons of light from the sun strike a solar cell and are absorbed within the semiconductor material. 12

This excites the semiconductor's electrons, causing the electrons to flow, and creating a usable electric current. The current flows in one direction and thus the electricity generated is termed direct current (DC). One PV cell produces only one or two watts which isn't much power for most uses. In order to increase power, photovoltaic or solar cells are bundled together into what is termed a module and packaged into a frame which is more commonly known as a solar panel. Solar panels can then be grouped into larger solar arrays.

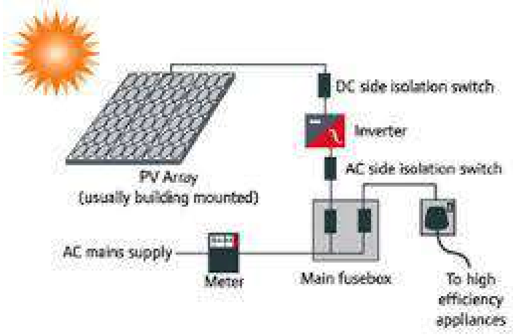

Fig.no.1 solar cell works

1.5 Structure Of A Solar Cell

A typical solar cell is a multi-layered unit consisting of a: *Cover* - a clear glass or plastic layer that provides outer protection from the elements. Transparent Adhesive - holds the glass to the rest of the solar cell.

Anti-reflective Coating - this substance is designed to prevent the light that strikes the cell from bouncing off so that the maximum energy is absorbed into the cell. **Front Contact** - transmits the electric current. 13

N-Type Semiconductor Layer - This is a thin layer of silicon which has been mixed (process if called doping) with phosphorous to make it a better conductor.

P-Type Semiconductor Layer - This is a thin layer of silicon which has been mixed or doped with boron to make it a better conductor.

Back Contact - transmits the electric current. **N-Layer**- is often formed from silicon and a small amount of Phosphorus. Phosphorus gives the layer an excess of electrons and therefore has a negative character. The n-layer is not a charged layer- it has an equal number of protons and electrons-but some of the electrons are not held tightly to the atoms and are free to move.

P-Layer- is formed from silicon and Boron and gives the layer a positive character because it has a tendency to attract electrons. The p-layer is not a charged layer and it has an equal number of protons and electrons.

P-N Junction - when the two layers are placed together, the free electrons from the n-layer are attracted to the p-layer. At the moment of contact between the two wafers, free electrons from the n-layer flow into the p-layer for a split second, then form a barrier to prevent more electrons from moving from one layer to the other. This contact point and barrier is called the p-n junction.

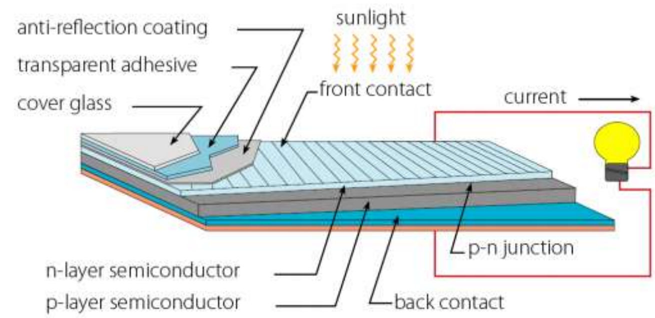

Fig.no.2 layer of solar panel 14

1.6 Thermal Energy Storage

Sensible Heat Storage

The use of sensible heat energy storage materials is the easiest method of storage. In practice, water, sand, gravel, soil, etc. can be considered as materials for energy storage, in which the largest heat capacity of water, so water is used more often. In the 70's and 80's, the use of water and soil for cross-seasonal storage of solar energy was reported. But the material's sensible heat is low, and it limits energy storage.

Latent Heat-Storage

Latent heat-storage units are storing thermal energy in latent (= hidden, dormant) mode by changing the state of aggregation of the storage medium. Applicable storage media are called "phase change materials" (PCM).. Commonly salts crystal is used in low-temperature storage, such as sodium sulfate de anhydrite / calcium chloride, sodium hydrogen phosphate 12-water. However, we must solve the cooling and layering issues in order to ensure the operating temperature and service life. Medium solar storage temperature is generally higher than 100 ℃ but under 500 ℃, usually it is around 300 ℃. Suitable for medium temperature storage of materials are: high-pressure hot water, organic fluids. Solar heat storage temperature is generally above 500 ℃, the materials currently being tested are: metal sodium and molten salt. Extremely high temperature above 1000 ℃ storage, fire-resistant ball alumina and germanium oxide can be used.

1.7 Chemical, Thermal Energy Storage

Thermal energy storage is making the use of chemical reaction to store heat. It has the advantage of large amount in heat, small in volume, light in weight. The 15

Product of chemical reaction can be stored separately for a long time. It occurs exothermic reaction when it is needed. It has to meet the needs of below conditions to use chemical reaction in heat reserve: good in reaction reversibility, no secondary reaction, rapid reaction, easy to separate the resultant and reserve it stably.. Now some of the chemical endothermic reaction could meet the needs of above conditions. Like pyrolysis reaction of Ca (OH)

1.8 Components Used To Provide Solar Power:

The four primary components for producing electricity using solar power, which provides common 110-120 volt AC power for daily use, are: Solar panels, charge controller, battery and inverter. Solar panels charge the battery, and the charge regulator insures proper charging of the battery. The battery provides DC voltage to the inverter, and the inverter converts the DC voltage to normal AC voltage. If 220-240 volts AC is needed, then either a transformer is added or two identical inverters are series-stacked to produce the 240 volts.

Fig.no.3 COMPONENTS USED TO PROVIDE SOLAR POWER

II. Phase Change Material

A phase-change material (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage (LHS) units.

2.1 Physical, Technical, And Economic Requirements

A suitable phase change temperature and a large melting enthalpy are two obvious requirements on a phase change material. They have to be fulfilled in order to store and release heat at all. However, there are more requirements for most, but not all applications. These requirements can be grouped into physical, technical, and economic requirements.

• Physical requirements, regarding the storage and release of heat:

– Suitable phase change temperature Tpc ⇒ to assure storage and release of heat in an application with given temperatures for heat source and heat sink.

– Large phase change enthalpy Δpch ⇒ to achieve high storage density compared to sensible heat storage.

– Reproducible phase change, also called *cycling stability* ⇒ to use the storage material as many times for storage and release of heat as required by an application.

The number of cycles varies from only one, when the PCM is used for heat protection in the case of a fire, to several thousand cycles when used for heating or cooling of buildings. One of the main problems of cycling stability is phase separation. When a PCM consists of several components, phases with different compositions can form upon cycling. *Phase separation* is the effect that phases with different composition are separated from each other macroscopically. The phases with a composition different from the correct initial composition optimized for heat storage then show a significantly lower capacity to store heat.

– Little sub cooling ⇒ to assure that melting and solidification can proceed in a narrow temperature range.

Sub cooling (also called *super cooling*) is the effect that a temperature significantly below the melting temperature has to be reached, until a material begins to solidify and release heat. If that temperature is not reached, the PCM will not solidify at all and thus only store sensible heat.

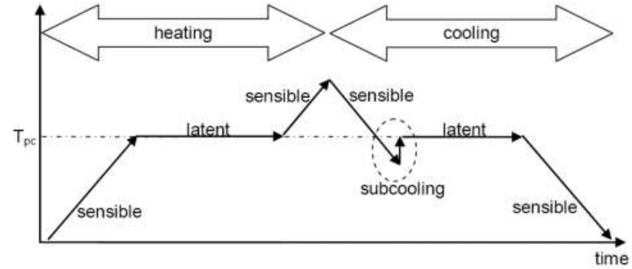

Fig.4 Schematic temperature change during heating (melting) and cooling (solidification) of a PCM with sub cooling.

– Good thermal conductivity ⇒ to be able to store or release the latent heat in a given volume of the storage material in a short time, that is with sufficient heating or cooling power. If a good thermal conductivity is necessary strongly depends on the application and the design of the storage.

• Technical requirements, regarding the construction of storage: 30

– Low vapour pressure ⇒ to reduce requirements of mechanical stability and tightness on a vessel containing the PCM

– Small volume change ⇒ to reduce requirements of mechanical stability on a vessel containing the PCM

– Chemical stability of the PCM ⇒ to assure long lifetime of the PCM if it is exposed to higher temperatures, radiation, gases,

– Compatibility of the PCM with other materials ⇒ to assure long lifetime of the vessel that contains the PCM, and of the surrounding materials in the case of leakage of the PCM

This includes destructive effects as for example the corrosivity of the PCM with respect to other materials, but also other effects that significantly reduce or stop important functions of another material.

– Safety constraints ⇒ the construction of a storage can be restricted by laws that require the use of non-toxic, non-flammable materials. Other environmental and safety consideration can apply additionally.

III. Material Selection

3.1SUITABLE MATERIAL - Mgcl2 - 6H2O

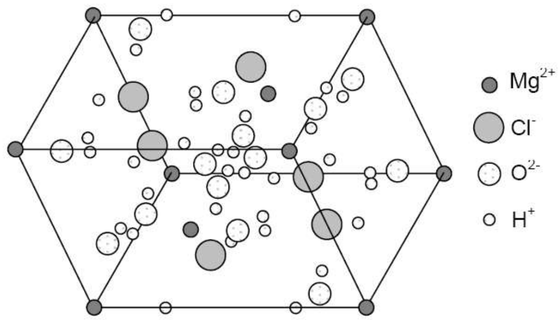

Fig.no.5 SUITABLE MATERIAL - $MgCl_2 - 6H_2O$

Molecular structure of the salt hydrate $MgCl_2 - 6H_2O$

The lattice consists of two parts: Cl^- ions, and 6 water molecules oriented octahedral around a magnesium ion Mg^{2+} and bound by ion-dipole bonds. Because of the stable crystal structure of salt hydrates, the melting temperature is higher than for water.

Anhydrous $MgCl_2$ is a Lewis acid. In the Dow process, magnesium chloride is regenerated from magnesium hydroxide using hydrochloric acid

$Mg(OH)_2(s) + 2\,HCl \rightarrow MgCl_2(aq) + 2\,H_2O(l)$

It can also be prepared from magnesium carbonate by a similar reaction.

Magnesium chloride is most commonly used for dust control and road stabilization. Its second-most common use is ice control. In addition to the production of magnesium metal, magnesium chloride also is used for a variety of other applications: fertilizer, mineral supplement for animals, wastewater treatment, wallboard, artificial seawater, feed supplement, textiles, paper, fireproofing agents, cements and refrigeration brine. Mixed with hydrated magnesium oxide, magnesium chloride forms a hard material called Sorel cement.

IV. RESULTS AND CONCLUTION

5.1 Solar Panel Without Phase Change Material

TIME	VOLT	AMPS	WATTS	ATM
9.30	18.3	.31	5.67	29
10	18.5	.35	6.47	30
10.30	18.6	.32	5.95	30
11	18.4	.34	6.25	31
11.30	18.5	.34	6.29	31
12	18.8	.35	6.58	32
12.30	18.9	.37	7.37	34
1	18.4	.36	7.36	35
1.30	18.5	.37	7.4	36
2	18.6	.34	6.32	35
2.30	18.6	.32	5.95	33
3	18.5	.31	5.73	32
3.30	18.8	.26	4.88	31
4	17.6	.22	3.87	33

Government Policies To Promote Renewable Energy Resources In India:

India is determined to becoming one of the world's leading clean energy producers. The Government of India has already made several provisions, and established many agencies that will help it achieve its goal. Renewable Energy, excluding large hydro projects already account for 9% of the total installed energy capacity, equivalent to 12,610 MW of energy. In combination with large hydro, the capacity is more than 34%, i.e. 48,643MW, in a total installed capacity of 144980 MW.

V. CONCLUSION

From these experiments, we can prove that by using phase change material the temperature rise of photovoltaic panel can be reduced. Various phase change materials are available for limiting temperature rise depending on their melting point and also to maintain the efficiency of solar panel. This phase change material has the capacity to increase the life time of solar panel. Phase change material are shown to be effective means of limiting temperature rise in photovoltaic devices PCMs used in this performance test exhibit stable characteristics through repeated phase change cycles. In this work, there were many repeated phase change cycles and no deterioration of PCMs was observed. The melting temperature and aspect ratio significantly increase the thermal performance and electrical performance of pv module

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