International Journal of Electrical Engineering.
ISSN 0974-2158 Volume 6, Number 1 (2013), pp. 11-18

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A Novel Design Technology of Photovoltaic Panel for Combined PV/T System

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Abstract

Researches on the area of combined PV/T system have been done since 1970s. They are mainly focussed on the collection of solar heat energy and electrical energy in the same area simultaneously. They use Glass to Tedlar type PV panel for collection of thermal energy below the panel with the help of $PV/T_{(air)}$ or $PV/T_{(water)}$ system. This paper explains the new technology of Glass to Glass type PV panel for observing more thermal energy below the panel so as to improve the efficiency of PV cell by reducing the temperature of cell by combined $T_{(air)}$ or $T_{(water)}$ system. In this paper, new design methods and fabrication process of PV panel was explained step by step with the character of all the layers used for designing the PV panel.

Keywords — PV Panel, Glass to Tedlar, Glass to Glass, Layer design, PV/T Application.

INTRODUCTION

A Photovoltaic / Thermal hybrid solar system is a combination of photovoltaic and solar thermal system which produces both electricity and heat from one integrated system. Based on the heat transmitting medium used in thermal system they are majorly classified in to two categories, namely Air and Water based thermal system. The Air and Water are used to observe the heat produced below the PV panel. The efficiency of the PV cell will improve when it maintains at 25˚C (STC) as a constant temperature. The thermal system operates based on the temperature below the PV panel. The PV panel consist of five layers namely Glass, EVA, PV cell, EVA, Tedlar (back sheet) in the order of top to bottom of the panel as shown in Figure.1.The character of tedlar will not allow the light below the panel because it is not transparent. So the temperature below the cell was lesser then the top of the panel. For avoiding this problem, the new design method of glass to glass model was designed as shown in Figure.3. By this method, the temperature passes to the bottom of the panel, and it increases the thermal efficiency of the system. It also reduces the cell temperature, so the efficiency of the PV cell also increased. The effect of temperature on the PV panel causes reduction in efficiency as shown in the Figure 2.

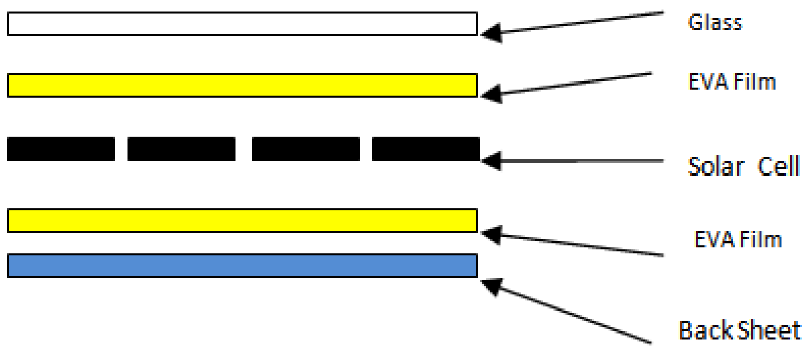

Figure 1. The Layers in Glass to Tedlar Type PV Cell

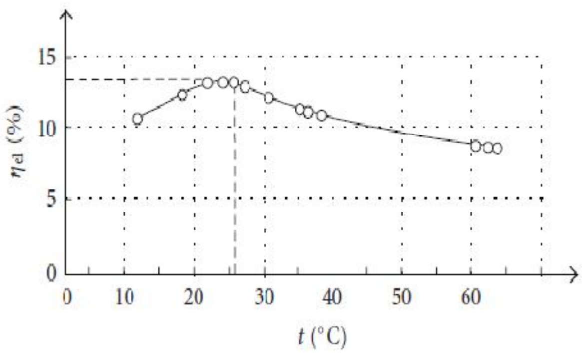

Figure 2. The Photovoltaic (PV) Cell Efficiency Vs Temperature

PANEL DESIGN

Normally, the PV panels are designed in the rating of 18W, 36W, 50W, 74W, 125W, 150W etc. by the manufacture in the company. Here, the 74W panel design was considered for testing. The size of the panel is 775*650mm with the glass to glass type. It consists of 36 numbers of cut cells in the size of 78*156mm, by the laser cutting the full cells in the size of 156*156 are cut into two pieces in the size of 78*156 for 74W panel. All the 36 cells are integrated as shown in the Figure 4.

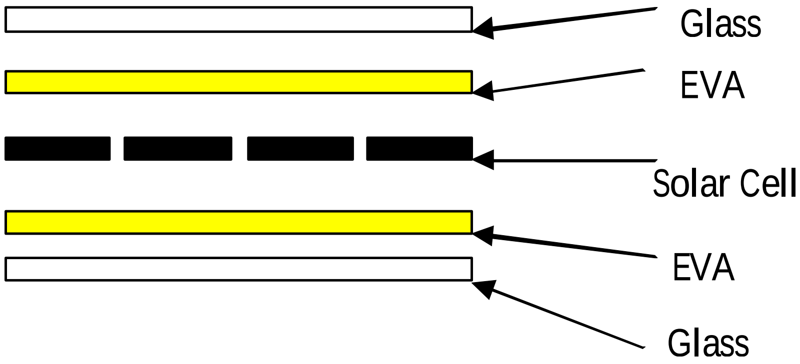

Figure 3.The Layers in Glass to Glass Type PV Cell

Glass Details

Normal transparent glass was used in the size of 775*650mm, 3.2mm thickness, the characteristics and test results of the glass are given in the Table. I. Two similar character glasses are used on top and bottom of the panel.

EVA Details

EVA film for encapsulating solar modules (EV1050G1) which is mainly used for PV module encapsulation are based on Ethylene Vinyl Acetate (EVA) copolymer and supplemented by special chemical accessories. It could effectively protect to the PV cell, and has excellent performance of transmittance and ageing resistance. It provides structural support, electrical isolation, physical isolation/protection, and thermal conduction for solar circuits, as well as to maximize the service life of solar module. All the specifications of EVA are given in Table. II

Characteristic:

- High volume resistivity and lasting adhesion strength holding capacity, and insure PV modules have long service life.
- Low yellowness index change and low light transmittance attenuation insure the high service efficiency of PV modules.
- Excellent compatibility with flux, welding ribbon, location tape, back sheet and silica gel.
- The product quality stability ensured by the complete and scientific quality management system.

All grades of EVA film for encapsulating solar modules are based on “ultra fast-cure” series EV1050G1. With EV1050G1, new technology is available as below:

- High Transmittance (HT) Technology: A lower UV-cutoff allows more high energy photons to strike the PV modules. HT technology could lower the UV-cutoff of EVA film to make it similar with that of solar glass and improve the anti-reflection of solar glass. It effectively improves photoelectric conversion efficiency of PV module.

- “Reinforced Friendly” (RF) technology: RF technology is typically used between solar cell and back sheet for PV module encapsulation. RF technology could eradicate stresses in the EVA film to get non-shrink property. With RF technology, EVA film will reduce lamination process time and have the characteristics of non-shrink of film, non-shift of cells, reducing the probability of the bubble and hungry joint during the period of processing and lasting bonding capability. Consequently, it improves the producing efficiency and finished products rate, and extends the service life of the PV module.

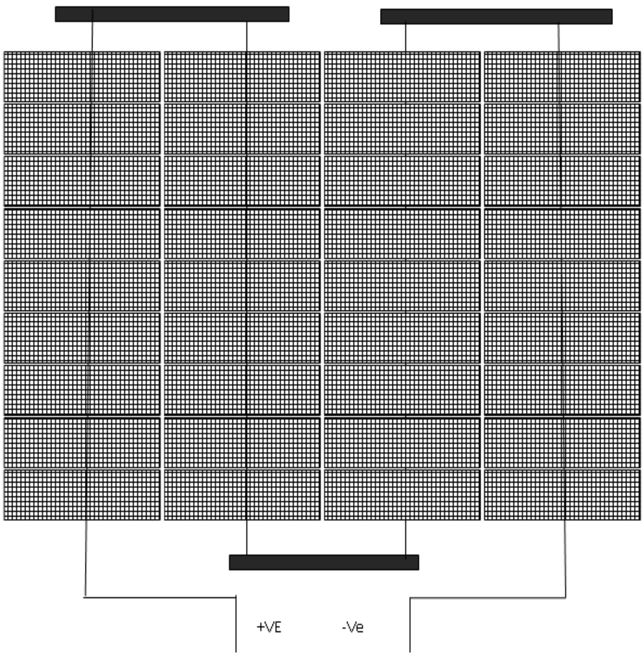

Figure 4.Diagram of Cell Configuration

PV cell

Totally 36- numbers of polycrystalline Silicon PV cut cells in the area size of 78*156mm and 180-350 micrometer thickness are arranged as per the Fig.4 then they are integrated with help of aluminum coated copper leads by soldering rod. Voc=21.99v, Isc=4.96A Pmax=78.03W, Vmax=18.11v,Imax=4.309A are the test results of 74W PV panel at irradiance of 1000W/m^2 and temp at 26˚C.

Tedlar

Tedlar is also called as back film; it is manufactured to give a variety of design from thermoplastic and fluoropolymer as a backing sheet for photovoltaic solar module, due to its excellent strength, weather resistance, UV resistance and moisture barrier properties. It is a new multi-layer back film based on one layer of high durability special low oligomer polyester film, one layer of high voltage insulation polyester film and one layer of high durability fluoro polyethylene resin. The cell side treated with a special polyethylene layer which provides good adhesion to EVA. The structure of SPE-35 has been designed to provide the best performance of properties in terms of moisture barrier, electrical insulation and weather ability.

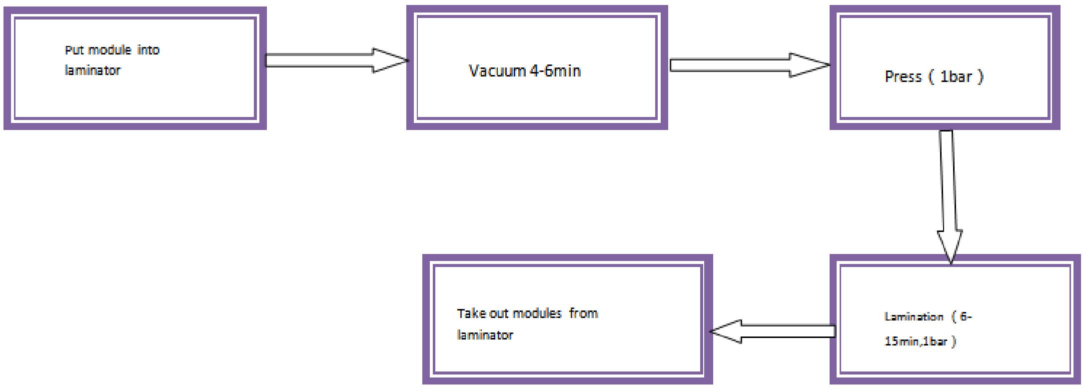

Figure 5. Steps in PV Panel Lamination

LAMINATION PROCESS

The steps in the lamination process shown in Figure 5, the above said layers are kept one over other as per the Figure 3 and placed inside the lamination machine as shown in Figure 6. The air inside the panel and inside the machine are taken out and made as a vacuum within 4-6 minutes then applied pressure of 1bar then kept the panel at a temperature of 132˚C for 13 minutes. Due to the temperature, the EVA layers get melted and fixed with all other layers. After the process the laminated panel was taken out to make it cool for some time. Then the edging process is finished and the frame around the glass is fixed. It is very transparent for light and heat from top to bottom.

Figure.6 Lamination Machine for PV Cell

CONCLUSION

The experimental validation for the new designed Glass to Glass PV/T solar collector was tested, and it was found that there was a good result about the overall efficiency. In Glass to Glass PV panel were found to be the electrical and thermal efficiency of 15.5% and 52.2% respectively. Outlet temperature, back surface temperatures were decreased and electrical efficiency was increased when the water mass flow rate increased. Glass to Glass PV/T solar collector experienced higher outlet temperature so the thermal efficiency of glass to glass was more than glass to tedlar PV/T solar collector.

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Annexure I

TABLE I: CHARACTERISTICS OF GLASS

Parameters	*Permissible limits*	*Observations on testing*
Dimension	Length (mm) 1480 ±1.0mm Width (mm) 650 ±1.0mm (For 125W Panel)	Within limit
Thickness	3.2±0.2mm	3.11-3.18 mm
Transmissivity	≥91%	≥91%
Impact resistance	Wt. of Drop Ball- 227±2gms Ht. of Drop ≤ 3.5mm	No specimens fractured
Edge processing	Seamed / Polished for glasses above 350 x 350 mm	Polished
Fragmentation	40 in 50 mm x 50 mm	54
Scratch	Length >5mm Scratch width < 1mm 4 Scratch width > 1mm 0	Within limit
Spherical bubbles	>1mm Unlimited 1-2mm 3	Within limit
Longitudinal bubbles	Length(mm) 4-10 10-25 Width < 1mm 8 2	Within limit

TABLE II: EVA CHARACTERISTICS

Property	Units	EV1050G1 (Ultra Fast Cure)	EV1050G2 (High Transmittance)	EV1050G1/RF (Reinforced Friendly)
Surface Uncured)	-	One Side Embossed	One Side Embossed	One Side Embossed
Gel Content	%	>80	>80	>80
Adhesion	N/cm	>100 (To glass) >80 (To back sheet)	>100 (To glass) >80 (To back sheet)	>100 (To glass) >80 (To back sheet)
Density	g/cm3	0.95	0.95	0.96
Thickness	mm	0.5	0.5	0.5
Melt Flow Rate	g/10min	22±5	22±5	22±5
Transmittance	%	>91	>91	>91
Tensile Strength	MPa	15	15	25

Elongation at Break	%	>500	>500	>500
Young's Modulus	Mpa	5	5	8
Water Absorption	%	<0.1	<0.1	<0.1
Melt Point	˚C	70±5	70±5	70±5
Volume Resistivity	Ω▪cm	>1×1014	>1×1014	>1×1014
UV Cutoff Wavelength	nm	360	300	360
Refractive Index		1.49	1.49	1.49

K.Jaiganesh received B.E. degree in Electrical and Electronics Engineering from Periyar University, Salem in 2002.The M.E. degree in Power Electronics and Drives from Anna University, Chennai in 2006.He is currently pursuing his doctoral degree in Anna University, Coimbatore. He is currently working as an Assistant Professor in the Department of Electrical and Electronics Engineering at K.S.Rangasamy College of Technology (Autonomous Institution). He is a Life member of ISTE, ISEEE. His research interests are renewable energy sources, inverters, converters, Solid State DC& AC Drives and special machines.

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