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DESIGN AND THERMAL ANALYSIS OF SOLOR PANEL BY FEA

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ABSTRACT:

Solar PV modules collect the sun's energy and convert it into direct current (DC) electricity. The amount of electricity produced is proportional to the amount and intensity of sunlight. The response of the photovoltaic (PV) solar panel temperature is dynamic with respect to the changes in the incoming solar radiation. During periods of rapidly changing conditions, a steady state model of the operating temperature cannot be justified because the response time of the PV solar panel temperature becomes significant due to its large thermal mass,And this paper is represented wind forces and external atmospheric force acted on solar panel system varying with structural analysis. In real operating conditions, the effective PV panel temperature is subjected to randomly varying ambient temperature and fluctuating wind speeds and directions; parameters that are not replicated in controlled, indoor experiments. A new thermal model is proposed that incorporates atmospheric conditions; effects of PV solar panel material composition and mounting structure. Experimental results are presented which verify the thermal behaviour of a photovoltaic solar panel for low to strong winds and external forces.
Key words: catia software, solar system panel, thermal analysis, structural analysis.

1. INTRODUCTION

1.1 Solar Energy System

Solar energy is the light and radiant heat from the Sun that control Earth's climate and weather and protract life. It is a renewable source of energy and originates with the thermonuclear process that transfers about 650,000,000 tons of hydrogen to helium per second. This action produces lots of heat and electromagnetic radiation. The produced heat remains in the sun and is helpful in upholding the thermonuclear reaction and electromagnetic radiation together with visible, infrared and ultra-violet radiation flow out into space in all directions. Solar energy is in reality nuclear energy. Similar to all stars, the sun is a large gas sphere made up mostly of hydrogen and helium gas. In the internal surface of sun 25% of hydrogen is fusing into helium at a rate of about 7 × 1011 kg of hydrogen per second. Heat from the center is first and foremost spread out, and then sends down, to the Sun surface, where it keeps up at a temperature of 5800 K. According to Stefan-Boltzmann's Law, the total energy that is released by the Sun, and therefore, the quantity of solar energy that we get here on Earth, is significantly reliant upon this surface temperature. Now a day's solar energy system play an important role in the field of producing electricity or other domestic uses like water heating, cooking etc. As we know that major part of generated electricity or electricity depends upon coal which is used in

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thermal power plant (in In India 65% of total power is generated by the thermal power plant). But the main problem is here that the fuel used in thermal power plant is coal which is in limited amount and may be not available in future to produce or generate electricity.Solar energy system is the pollution free source of energy and always available because, sun is the single source of solar energy (also known as renewable energy or non conventional energy) which sits at the central point of solar system and radiate energy at an tremendously huge and fairly constant rate, per day per year as the form of electromagnetic radiation. Sun contained huge amount of energy but the whole energy not utilized at earth due to some reason like

•Earth is revolve at about its polar axis.

•Atmospheric reason of earth.

•Earth is relocating from the sun.

1.2 Solar Electricity

When sunlight strikes on photovoltaic solar panels solar electricity is produced. That is why this is also referred to as photovoltaic solar, or PV solar.

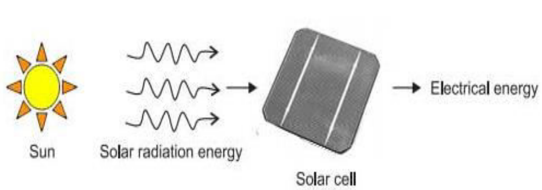

Fig.1.solar electricity

1.3 Solar Panels

The main part of a solar electric system is the **solar panel**. There are various types of **solar panel** available in the market. **Solar panels** are also known as **photovoltaic solar panels**. Solar panel or solar module is basically an array of series and parallel connected **solar cells**. The potential difference developed across a **solar cell** is about 0.5 volt and hence desired number of such cells to be connected in series to achieve 14 to 18 volts to charge a standard battery of 12 volts. Solar panels are connected together to create a solar array. Multiple panels are connected together both in parallel and series to achieve higher current and higher voltage respectively.

There are mainly four **types of solar power panel**.

Stand Alone or Off Grid type Solar Power Panel

1. Grid Tie type Solar Power Panel
2. Grid Tie with Power Backup or Grid Interactive type Solar Power Panel
3. Grid Fallback type Solar Power Panel.

Construction of Solar Cell

The junction diode is made of SI OR Gas. A thin layer of p-type is grown on the n-type semiconductor. Top of the p-layer is provided with a few finer electrodes which leaves open space for the light to reach the thin p-layer and it under lays p-n junction. Bottom of the n-layer is provided with a current collecting electrode.

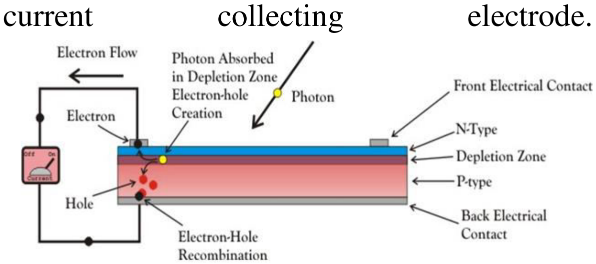

Fig.1.3construction .Solar cell

1.6.1 Working Principle of Solar Cell

When light reaches the p-n junction, electron is excited to the valance band under

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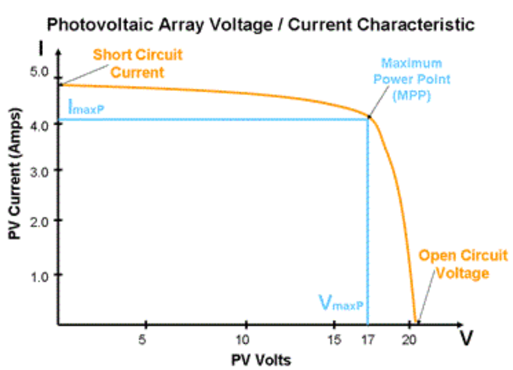
the condition that light energy is higher than the band gap energy, it generates the electron and holes which are equal in number in the valance and conduction band respectively. These electron hole pairs move in opposite directions to the barrier field. Electrons move towards the n-side and the hole is moved towards the p-side. So a voltage is set up which is known as photo voltage and when a load is connected, the current flows.

Graph 1

V-I Characteristics of a Photovoltaic Cell



Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes significant number of free electrons in the crystal. This is the basic reason of producing electricity due to photovoltaic effect. **Photovoltaic cell** is the basic unit of the system where photovoltaic effect is utilized to produce electricity from light energy. Silicon is the most widely used semiconductor material for constructing photovoltaic cell. The silicon atom has four valence electrons. In a solid crystal, each silicon atom shares each of its four valence electrons with another nearest silicon atom hence creating covalent bond between them. In this way silicon crystal gets a tetrahedral lattice structure. While light ray strikes on any materials some portion of light is reflected, some portion is transmitted through the materials and rest is absorbed by the materials. Same thing happens when light falls on silicon crystal. If the intensity of incident light is high enough, sufficient numbers of photons are absorbed by the crystal and these photons in turn excite some of the electrons of covalent bonds. These excited electrons then get sufficient energy to migrate from valence band to conduction band. As the energy level of these electrons is in conduction band they leave from the covalent bond leaving a hole in the bond behind each removed electron. These are called free electrons move randomly inside the crystal structure of the silicon. These free electrons and holes have vital role in creating electricity in **photovoltaic cell**. These electrons and holes are hence called **light-generated electrons and holes** respectively. These light generated electrons and holes cannot produce electricity in the silicon crystal alone. There should be some additional mechanism to do that. When a pentavalent impurity such as phosphorus is added to silicon the four valence electrons of each pentavalent phosphorous atom are shared through covalent bond with four neighbour silicon atoms and fifth valence electron does not get any chance to create covalent bond. This fifth electron then relatively loosely bounded with its parent atom. Even in room temperature the thermal energy available in the crystal is large enough to disassociate these relatively loose fifth electrons from their parent phosphorus atom. While this fifth relatively loose electron is disassociated from parent phosphorus atom, the phosphorous atom immobile positive

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ions. The said disassociated electron becomes free but does not have any incomplete covalent bond or hole in the crystal to be re-associated. These free electrons come from pentavalent impurity are always ready to conduct current in semiconductor. Although there are numbers of free electrons but still the substance is electrically neutral as the number of positive phosphorous ions locked inside the crystal structure is exactly equal to the number of the free electrons come out from them. The process of inserting impurities in the semiconductor is known as doping and the impurities are doped are known as dopants. The pentavalent dopants which donate their fifth free electron to the semiconductor crystal are known as donor. The semiconductors doped by donor impurities are known as n-type or negative type semiconductor as there is plenty of free electrons which are negatively charged by nature.

CHAPTER – 2

LITERATURE REVIEW:

K.H. Hussein(1943-) et al have developed a new Maximum Power Tracking (MPT) algorithm to track Maximum Power Operating Point (MPOP) by comparing the incremental and instantaneous conductance of the PV array. The drawbacks of Perturb and Observe method were analyzed and it showed that the Incremental Conductance algorithm has successfully tracked the MPOP even when atmospheric conditions changes rapidly. The work was carried out by both simulation and graphs. A new method for MPPT named CVT (Constant Voltage Tracking) is proposed by Zheng Shicheng et al with the analysis of characteristic curve and operation theory of PV array. A lower power photovoltaic (PV) system with simple structure has been designed. This method has been verified by PV charging system and it showed that MPP of PV array can be tracked well by applying the charger controller.

An adjustable Self-Organizing Fuzzy Logic Controller (SOFLC) for a Solar powered Traffic Light Equipment (SPTLE) with an integrated MPPT system on a low-cost microcontroller has been presented by Noppadol Khaehintung et al. It comprises of boost converter for high performance SPTLE. Variation of duty ratio for DC-DC boost converter is implemented on PIC16F876A RISC-microcontroller.

A fuzzy based perturb and observe (P&O) MPPT in solar panel was presented by C. S. Chin et al. The solar system is modeled and analyzed in MATLAB/SIMULINK. Simulation results showed that fuzzy based (P&O) MPPT has better performance and more power is produced from solar panel.

Panom Petchjatuporn et al introduced a maximum power point tracking algorithm using an artificial neural network for a solar power system. By applying a three layers neural network and some simple activation functions, the maximum power point of a solar array can be efficiently tracked. The tracking algorithm integrated with a solar powered battery charging system has been successfully implemented on a lowcost PIC16F876 RISC-microcontroller without external sensor unit requirement. The experimental results with a commercial solar array showed that the proposed algorithm outperforms the conventional controller in terms of tracking speed and mitigation of fluctuation output power in steady state operation. The overall system efficiency was well above 90%.

Chapter-3

3.1 DESIGN:

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate

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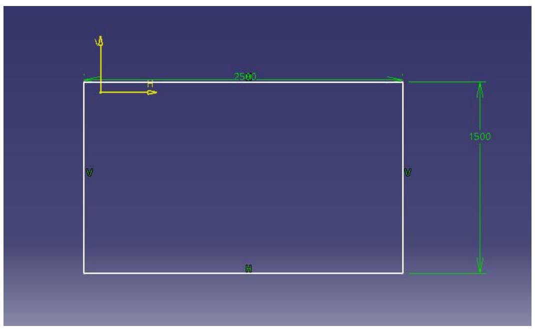
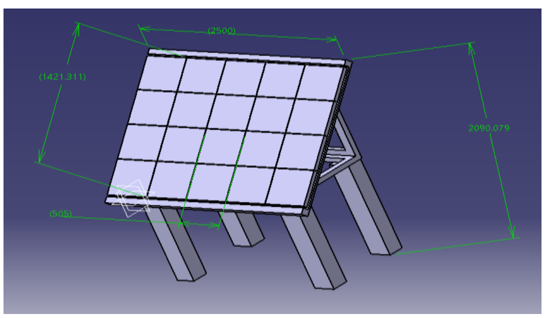
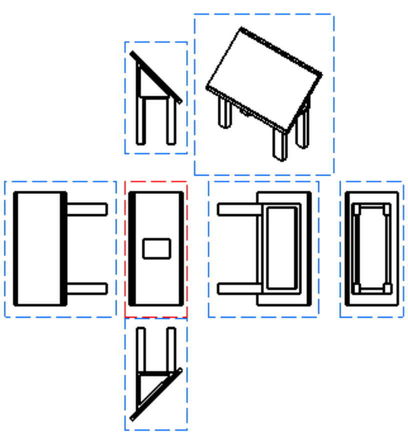
complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse





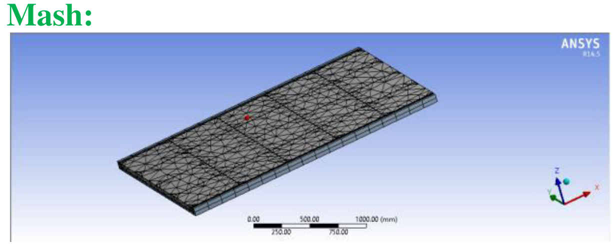


4 Ansys:

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.
5. A typical ANSYS analysis has three distinct steps.
6. Pre Processor (Build the Model).

Mash:



Thermal Analysis:

ANSYS is capable of both steady state and transient analysis of any solid with thermal boundary conditions.

Steady-state thermal analyses calculate the effects of steady thermal loads on a system or component. Users often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished. ANSYS can be used to determine temperatures, thermal gradients, heat flow

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rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following

Type	Temperature	Convection	Radiation	Heat Flux
Magnitude	90. °C (ramped)			1100. W/mm² (ramped)
Film Coefficient		5. W/mm²·°C (ramped)		
Ambient Temperature		40. °C (ramped)		
Correlation			To Ambient	
Emissivity			1. (step applied)	

Loads:

Material data:

Glass

Thermal Conductivity	1.4e-003 W mm^-1 C^-1
Density	2.5e-006 kg mm^-3
Specific Heat	7.5e+005 mJ kg^-1 C^-1

.2Structural Steel

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

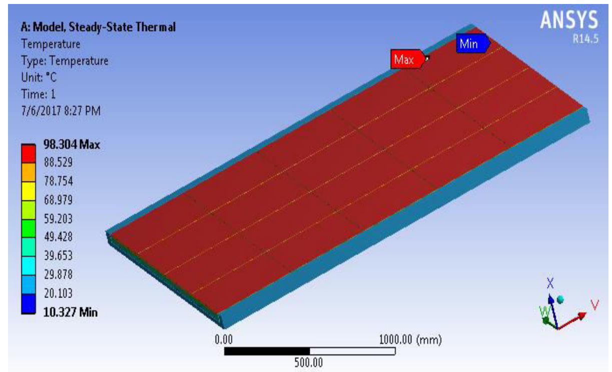

Fig.5.1.6.steady-state thermal Total Temperature of the panel;

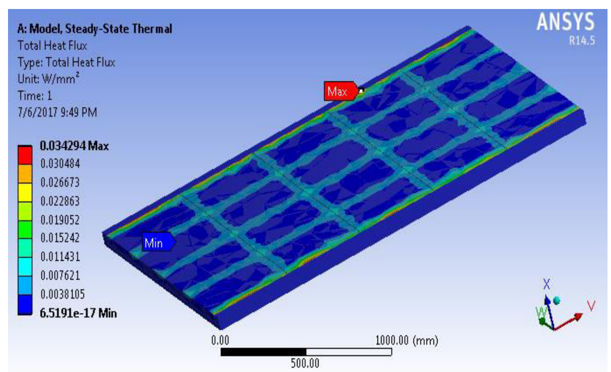

Fig.5.1.7.steady-state thermal Total Temperature of the panel;

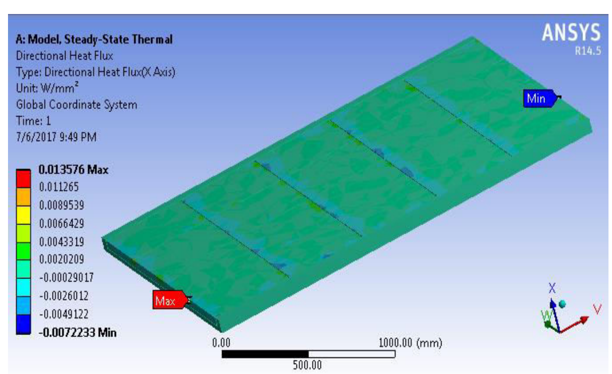

Fig.5.1.8.steady-state thermal Directional heat flux of panel

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Object Name	Temperature	Total Heat Flux	Directional Heat Flux
Minimum	10.327 °C	6.5191e-017 W/mm²	-7.2233e-003 W/mm²
Maximum	98.304 °C	3.4294e-002 W/mm²	1.3576e-002 W/mm²

Transient Structural analysis:

Material data:

Structural Steel :

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
22	2.e+005	0.3	1.6667e+005	76923

Glass:

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
20	70000	0.22	41667	28689

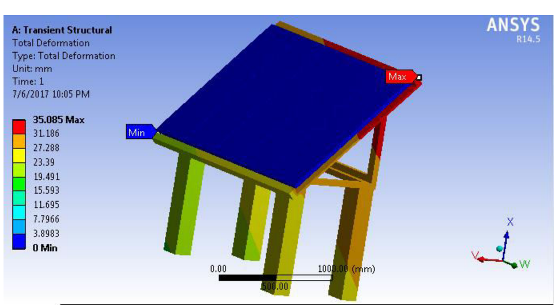

Fig.5.2.2.Transient structural total deformation 1

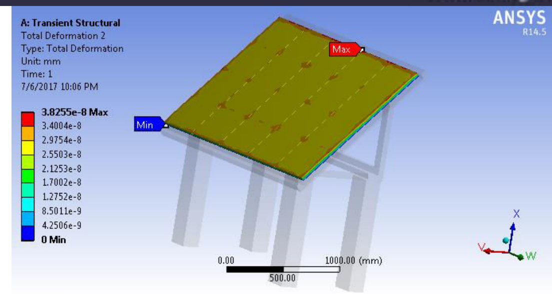

Fig.5.2.3 Transient Structural total deformation 2

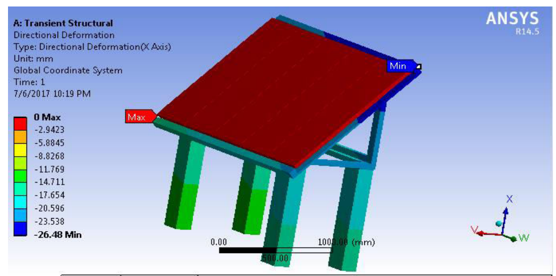

Fig.5.2.4 Transient Structural directional deformation

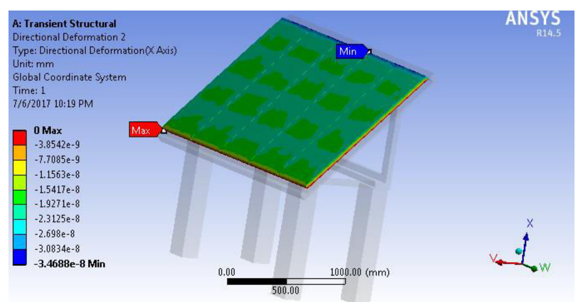

Fig.5.2.5Transient Structural directional deformation 2

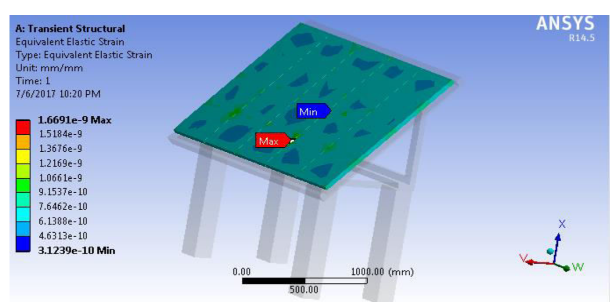

Fig: 5.2.6 Transient Structural Equivalent stress

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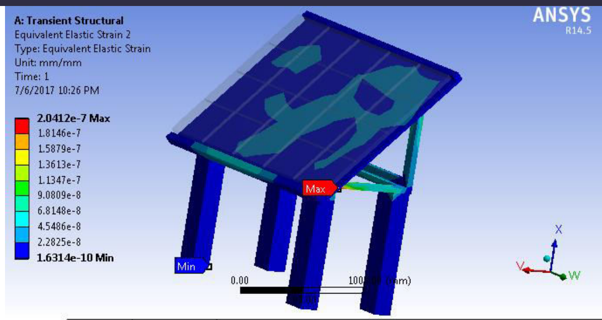

Fig: 5.2.7 Transient Structural Equivalent stress 2

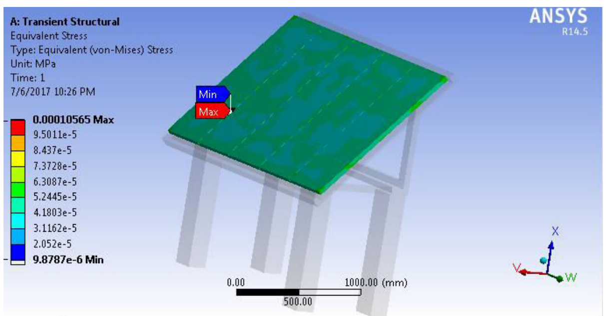

Fig: 5.2.8 Transient Structural Shear Elastic Strain

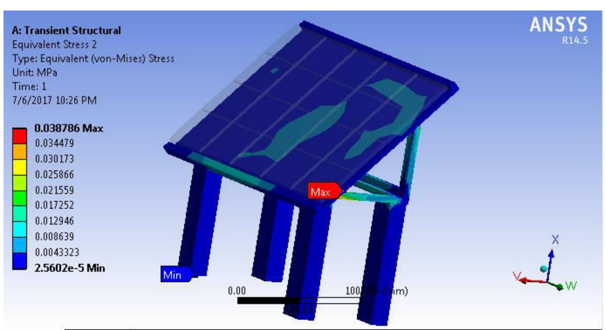

Fig: : 5.2.8 Transient Structural Shear Elastic Strain

Object Name	Equivalent Elastic Strain 2	Equivalent Stress	Equivalent Stress 2	Shear Elastic Strain	Maximum Shear Elastic Strain
Minimum	1.6314e-010 mm/mm	9.8787e-006 MPa	2.5602e-005 MPa	-1.062e-009 mm/mm	1.7087e-010 mm/mm
Maximum	2.0412e-007 mm/mm	1.0565e-004 MPa	3.8786e-002 MPa	1.3234e-009 mm/mm	2.555e-007 mm/mm

CONCLUSION:

From above results are obtaining from ansys software. Design is done with the help of catia v5 software, observing above results glass material is used for solar panel and structural steel is used for supported body

From thermal analysis of solar panel obtained Minimum 10.327 °C and Maximum98.304 °C temperature values, total het flux is Minimum 6.5191e-017 W/mm²and Maximum 3.4294e-002 W/mm² values.

From structural analysis obtained results total deformation of solar panel is Maximum35.085 mm, von misses stress are min 9.8787e-006 MPa and max1.0565e-004 MPa values, strain values of solar penal is Minimum 1.6314e-010 mm/mm nd Maximum 2.0412e-007 mm/mm

FUTURE GROWTH OF SOLAR IN INDIA:

The solar industry's structure will rapidly evolve as solar reaches grid parity with conventional power between 2016 and 2018. Solar will be seen more as a viable energy source, not just as an alternative to other renewable sources but also to a significant proportion of conventional grid power. The testing and refinement of off-grid and rooftop solar models in the seed phase will help lead to the explosive growth of this segment in the growth phase. Global prices for photovoltaic (PV) modules are dropping, reducing the overall cost of generating solar power. In India, this led to a steep decline in the winning bids for JNNSM projects. With average prices of 15 to 17 cents per kilowatt hour (kWh), solar costs in India are already among the world's lowest. Given overcapacity in the module industry, prices will likely continue falling over the next four years before leveling off.

REFERENCES:

[1]. Zondagetal (2003) developed steady state dynamic simulation models of a serpentine PV/T water collector and checked the accuracy with the experimental data.

[2]. Zarachenkoetal (2004) stressed the importance of good thermal contact between the solar cells and thermal absorber and introduced a new substrate material with a 2mm aluminium plate covered by an insulating film and pointed out that solar cells must be smaller than the size of the absorber.

[3]. Kalogeria and Tripanagnostopoulos (2006) examined the thermosyphon and forced circulation options in PV/T water based collectors based on Polycrystalline Silicon (pc-Si) and amorphous Silicon (a-Si) solar cells in three different cities (Nicosia, Athens and Madison)

[4]. Dubey and Tiwari (2008) examined the performance of a self sustained single glazed PV/T water collector with a partial coverage of PV module in New Delhi.

[5]. Erdil et al (2008) constructed and tested a hybrid PV/T system based on open loop domestic water pre heating system which produced thermal energy of 2.8 kWh/day and electrical output of 7 kWh/day. The payback time was estimated to be 1.7 years.