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Simulation and Analysis of Hybrid PV Panel

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Abstract: *This article is about the simulation and design of a hybrid photovoltaic-thermal (PV/T) solar system. It is a combination of photovoltaic panels with electrical components connected to the base and water running in copper pipes. The advantage of this process is that the photovoltaic equipment operates at a lower temperature and is therefore more efficient and produces hot water simultaneously with electricity. A system that can provide electricity and heat would be a very interesting application. The main idea of our project is to reuse the energy from the solar panels and make it usable. We created our design in Catia V5 and finished with some tools like full of holes and glass. Once it's done in Catia V5 we keep it and we like Abaqus software for analysis. We export our models from Catia to Abaqus in IGES format. We then use various tools in Abaqus to complete the analysis .Energy savings and efficiency are important today. As the cost per watt-hour falls each year, renewable energy is becoming more attractive. This happened because of extensive research over the past few years. Solar energy is an energy promise that will never go away. A combination of these systems that is Hybrid systems are gaining importance due to better use of solar energy. Use the efficient material concept, where the product is made of materials whose strength gradually changes, such as thermal conductivity, where solar energy can be used more efficiently. With this idea, it is possible to create a functional stepped replacement for photovoltaic panels and bulk water pipes.*

Keywords: Hybrid PV Panel, Solar Energy, Design, ThermalAnalysis, Optimizing.

I. INTRODUCTION

1.1 HYBRID SOLAR PANELS

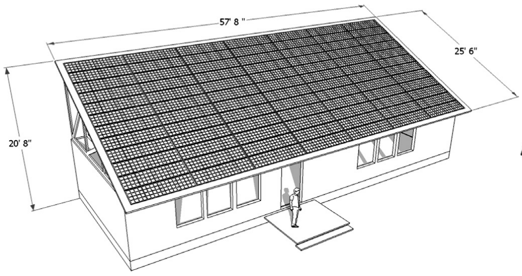
Hybrid solar panels can be combined with photovoltaic (PV), with water pipes thrown in from waterworks such as hot tubs and solar panels. Therefore, photovoltaic cells can operate at low temperatures while minimizing the amount of heat going to the substrate. Solar panel prototypes have been created and tested in different water and solar applications. The temperature of the solar panel can be measured and even simulated to measure the efficiency of the solar panel. Understanding energy conversion in hybrid solar panel prototypes will provide a basis for future solar panel design and optimization.

It is also possible to create custom designs that can be adhered to different materials and other sizes.

1.2 OVERVIEW

Solar panels have become a very effective and popular way of harvesting solar energy. Solar panel products on the market today often use photovoltaic (PV) cells to generate electricity.

Photovoltaic technology has made great progress since its invention in 1839, but there is still significant research to improve efficiency and reduce lifetime costs. The conversion efficiency for single crystal single junction silicon technology is still below 30%.



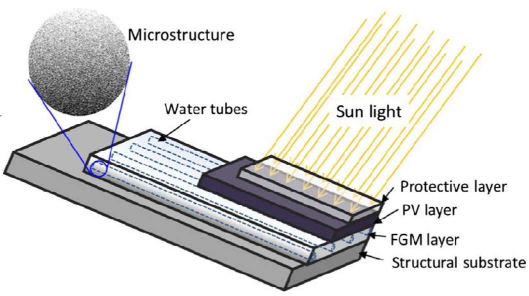


FIGURE 1. Plan of BIPVT roof **FIGURE 2.** Schematic illustration of the hybrid solar roofing panel.

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Therefore, a large part of solar energy is wasted by heat dissipation. Although some technologies such as cross-linking, multi-connection, optical frequency, multi-exciton generation cell, line electric heat and photovoltaic concentrator systems can improve energy efficiency. it may be less common in the future.

By using it in hybrid systems integrating photovoltaics with solar components, such as hot water (HW) systems, the EPBT of photovoltaic systems can be reduced. The combination of the two methods above is not a simple superposition of data and costs, but it provides a solution that can increase overall strength while reducing a lack of path. Photovoltaic devices can increase the efficiency of the photovoltaic system by controlling the temperature of the photovoltaic modules while improving the heating. Currently, many groups are investigating the performance of photovoltaic-thermal hybrid systems, which poses a major challenge for the solar-hybrid approach. By providing multiple functions for all devices and equipment, thewill meet new business and safety goals and change existing designs and structures to be more powerful and quality products.

The inside of the pipes is aluminium (Al) and insulation is epoxy. The composite structure below is made of fire resistant plywood that will be sourced from certified sustainable wood. The system has many different operating modes that are important for achieving system level efficiency and overcoming water cooling issues. When the sun is shining, the system will take the heat energy of the panel from the cold water. If the building needs to be heated by that time, the heat removed will be used directly to heat the floor.

If the building does not need to be heated at a certain time, the extracted energy is stored for future use or release. Thermal storage will be used in seasons when the ambient temperature is hot during the day and cold at night, and at night to heat the air. At night, if the temperature is still undesirable, the stored heat can be released into the cold air at night with water flowing through the panels, followed by the large plate of the plate heat exchanger. Phase change material (PCM) thermal storage unit will be used as this technology is proven and very promising as it provides reliable capacity without taking up too much space. The efficiency of the system is precisely controlled by the water flow.

By using temperature and water flow control systems, we can improve the energy efficiency of the roof for all environmental conditions that occur daily and seasonally.

The operation of the system is controlled by the flow. By using temperature and water flow control systems, we can improve the energy efficiency of the roof for all environmental conditions that occur daily and seasonally.

II. LITERATURE REVIEW

Thermal energy efficiency of buildings

The integrated multi-roof building is designed to harvest solar energy from photovoltaic (PV) and thermal energy, minimizing photovoltaic efficiency loss and eliminating equipment and energy costs. Silicon photovoltaic modules are embedded in a transparent protective layer and a hybrid photovoltaic panel layer made of a mixture of thermally conductive aluminium and insulating high-density polyethylene, and a water pipe cast in FGM. Solar energy is collected by photovoltaic modules in the form of photovoltaic electricity and heat. Due to the high thermal conductivity of the top of the FGM, the heat in the photovoltaic module is sent to the hybrid photovoltaic panel and stored by the water flowing through the pipes, so the temperature of the module can be controlled. Photovoltaic efficiency will be optimized.The stored hot water can be used for underfloor heating, or the heat can be pumped into the phase change material (PCM) chamber for nighttime heating or cooling, leaving more heat for cold nights. Thanks to the insulated FGM floor and the warm air collected by the water flow, excellent thermal comfort is provided and the cooling of the building is reduced. A heat-resistant structural substrate is embedded in the composite to provide support to the FGM and PV elements. This holistic design will full fill the basic functions of the building envelope: waterproofing, insulation, power generation and durability, while generating electricity and reducing energy consumption to a high level of energy efficiency and safety. A case study illustrates this idea.

Review on PV integration

The solar thermal and photovoltaic power industry is growing rapidly. New ideas for hybrid solar technology have been developed in many applications such as buildings, process plants and agriculture. Limit the building area to accommodate the solar energy required for active and/or passive solar generation using hybrid solar technologies, especially in the construction industry. The importance of low-carbon/zero-energy buildings is increasing with the

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world trend. In the last few years, hybrid photovoltaic/thermal (PVT) collector systems have been extensively studied theoretically, mathematically and experimentally.Along with other methods, new products and systems are planned. The ultimate success of technology depends on the long-term integration of product design/development and reliable operation/maintenance. This article provides a comprehensive review of scientific publications focusing on research and development activities over the past decade

Simulation and experimental validation on hybrid PV panel

Build a solar panel integrating photovoltaic (PV) with functional material (FGM) into the substrate, the water pipe is expelled by the water to the substrate as a heat and sunlight receiver. Therefore, the photovoltaic cell can operate at a low temperature while reducing the amount of heat going to the substrate. Solar panel prototypes have been created and tested in different water and solar applications. The measures and simulates the temperature inside the solar panel to measure the efficiency of the solar panel. The results of the final simulation are in good agreement with the experimental data.Understanding energy conversion in hybrid solar panel prototypes will provide a basis for future solar panel design and optimization. The finite element model is general and can be extended to different materials and other dimensions

Mathematical modelling and simulation of flat plate collector

The effect of boiling on the heat transfer coefficient of the liquid was also evaluated. Simulations were made at three different airflows (0.001, 0.005 and 0.01 kg/s) and at three different operating pressures (4, 6 and 8 bar) to understand the effect of burner size and pressure, heat loss coefficient and heater.

Heat transfer coefficient between the collector and the liquid. The simulation results show that the heat transfer coefficient of the liquid in the multiphase flow area has increased from 153.54 W/m2K to 610.27 W/m2K.

In the liquid single-phase region, the efficiency of the collector increases by 60%.8% to 68.2%, as the flow rate increases, the temperature change of the fluid increases from 39.24 W/m2K to 392.31 W/m2K and the operating power rises from 4 bar to 8 bar and the power increases.Equipment ratio increased from 72.5% to 62.3%.

To validate the simulation model, a test bench was set up and experiments were performed using HFE 7000 as the working fluid. A new simulation model was created using the HFE 7000 and the temperature of the liquid was compared with the temperature. Both the measured and simulated results show good agreement.

Performance of PV integrated system

Currently, commercial photovoltaic solar cells (PV) are relatively ineffective at converting solar energy to electricity, less than 20%. More than 80% of the absorbed sunlight after photovoltaic conversion is wasted in the environment. Hybrid PV/T systems include PV modules and energy extraction equipment. PV/T collectors generate electricity and heat. For efficient operation, it is necessary to keep the temperature of the photovoltaic modules at a low level.If the T system is operating near normal temperature, an overall efficiency of 60-80% can be achieved for the entire PV/T system. The cost of low temperature thermal energy is generally less than the cost of photovoltaic power generation. PV/T systems may be available in many models, but the most common models use water or air as the working fluid. Efficiency is the most important factor in financial analysis. Air conditioning is essential for high rated power installations such as building integrated photovoltaic systems.

Solar energy conersions

Photovoltaic panels absorb about 80% of solar radiation, while single-crystal and single-electrode silicon cells can achieve a maximum conversion of no more than 30% [910]. The main loss is heat dissipation; this temperature can increase the temperature of the photovoltaic cell, resulting in lower output power and thus efficiency. Works best for photovoltaic cells; cell temperature should be around 25°C.

III. DESIGN IN CATIA

1. Draw a square with requirements and gave padding with mirror extent.
2. Now select the left or right-side phase and then draw the required shape using the spline option.

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3. Select the top phase and draw three circles with certain diameter and then coincide with spline starting point for hollow pipe inside the block.
4. Now exit app and then select slot option and select the circle, spline for reference. Then half of the hole was obtained.
5. Take a plane with 0 distance and select the mirror with plane as reference.
6. Now mirror the remaining part with mirror option, then hole along with pipe was obtained.
7. Save the 3D model in STEP format and name it as CATIA.
8. Need to export the 3D model to the Abaqus software for Analysis part.

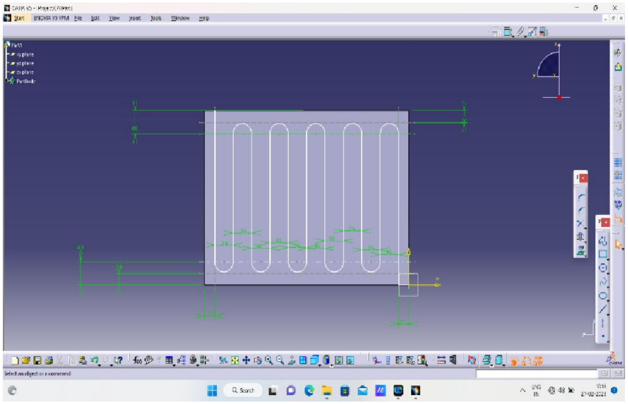

FIGURE 3. The constraint values of the block

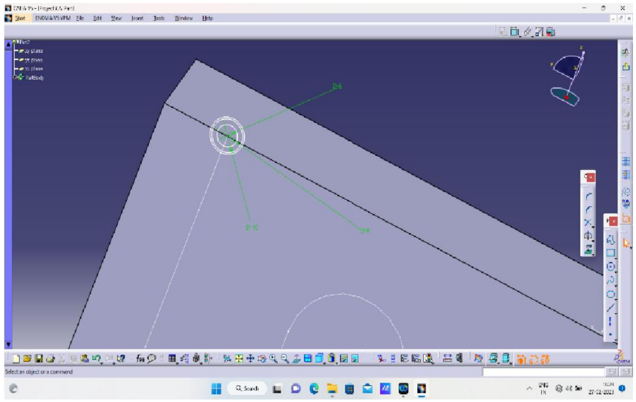

FIGURE 4. Circles with spline for hollow pipe

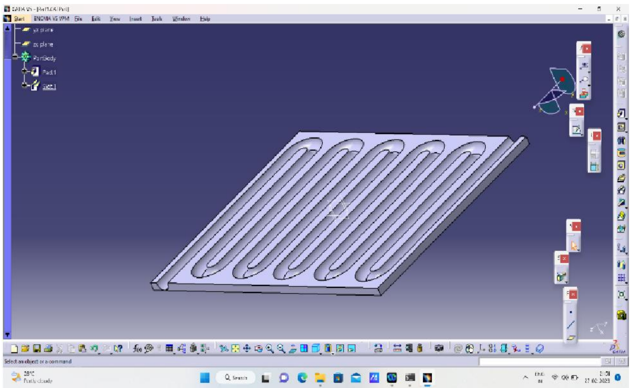

FIGURE 5. Block with slot option

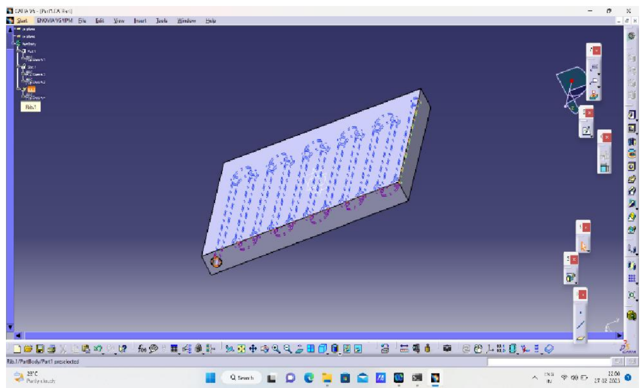

FIGURE 6. Block with inserted hollow pipe

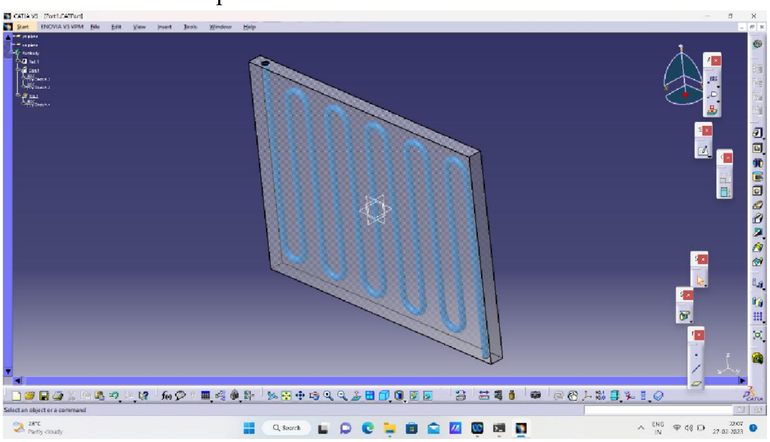

FIGURE 7. Complete CATIA Design of FGM Block

Then open the Abaqus software application, and import the saved file in the saved format (STEP). Then the 3D model is obtained in the Abaqus for the further analysis.

IV. ANALYSIS IN ABAQUS

1. Import the 3D model to Abaqus software for Analysis.
2. After importing part body from CATIA, now select material and name it as copper for the pipe inside the body and aluminium for outside body.
3. Give the element properties like mass density, Young's modulus, Poisson ratio and thermal conductivity as given values.
4. Create two sections for copper and aluminium separately and do the assign section for both materials separately.
5. Now select assembly and create part instance and select the option part by on the top.
6. Select the step option and create the step after the name as apply heat and select the option steady state.
7. Now select the option meshing, and select part option on the top. On the top select the meshing and select by element type then after that select the option heat transfer and click ok.
8. On the top itself select edges option and select the whole part and give by number and give that number as 4.
9. Create boundary condition and select the temperature give select the one side and give the value as 40 degrees and repeat the same process for remaining 3 sides.
10. Now select the load option and then select the heat flux, select the top side and give 800 w/meter square repeat the same process for bottom side with value of _300 for that side.
11. Now select the history output request and select the option thermal and click okay.
12. At last create a job with specified name and submit the body and after completion then select that job and left click it select the results and verify the results.

MATERIAL SELECTION

To define a new object in Abaqus, follow these steps:

1. Double-click the object in the tree structure.
2. Right-click on the material library and select "Create Material" from the menu.
3. Enter a name and description for the new product.
4. Click the Mechanical tab and select Flexibility from the menu.
5. Select Elastic from the list of available models.
6. Enter the appropriate values for the material's Young's modulus, Poisson's ratio, and thermal conductivity.
7. Click OK to save the new item.

MATERIALS	MASS DENSITY	YOUNGS MODULUS	POISSON RATIO	THERMAL CONDUCTIVITY
Aluminium	2.7 g/cm^3	7.0x10^10 Nm^2	0.31	247 W/m.K
Copper	8.96 g/cm^3	1.1x10^11 Nm^-2	0.32	385 W/m.K

TABLE 1. Material Properties

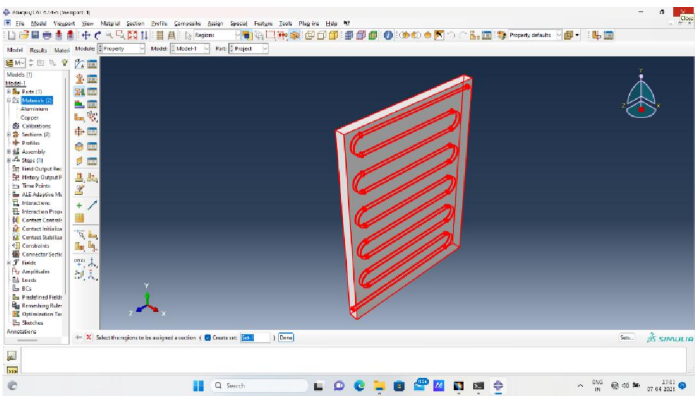

FIGURE 8. Assigining Materials

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MODEL MESHING

Double-click the Mesh node under Part in the model tree to begin meshing. Then click the Assign Element Type icon in the toolbar and select Standard for the element type. Select 3D Stress for Element and Linear for Element Shape to define four-node elements. Click OK to confirm. In the Toolbox area, click the Seed Edges: By Number icon (hold down to see more options) and select the entire geometry. Click done in the Instant field and define the number of dots on the edge as 1. Press Enter in the Instant field, then click. Done to answer the next question. In the toolbox area, click the Mesh Fragment icon, then click Yes in the prompt area to mesh the sample.

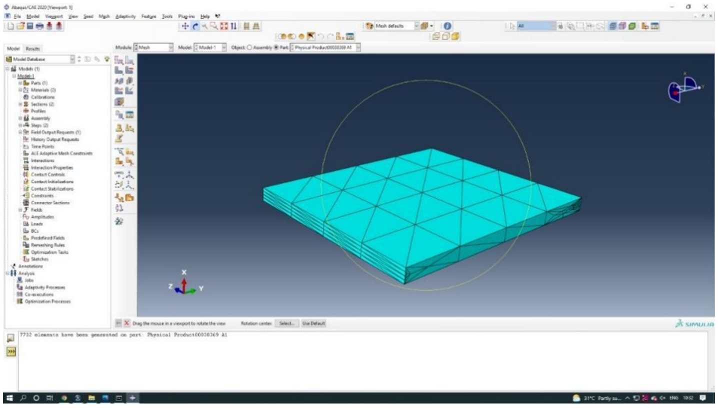

FIGURE 9. Meshing

BOUNDARY CONDITIONS

Double-click the BC node in the model tree to open the Create Boundary dialog box. Name the boundary condition and select Displacement/Rotation as the Type. Click Continue and select the nodes where the limit should be applied. Read the message that appears in the instant area and click Finish. In the form, select the degrees of freedom to constrain and set their values to zero.

Click the OK button to apply the boundary condition.

LOADS

Double-click the Loads node in the tree structure, give the load a name and select the appropriate load type (eg: pressure, force, moment). Click Continue and select the appropriate geometry to apply the load, then immediately click on the location. In the next form, specify the size and direction of the load, then click OK to apply.

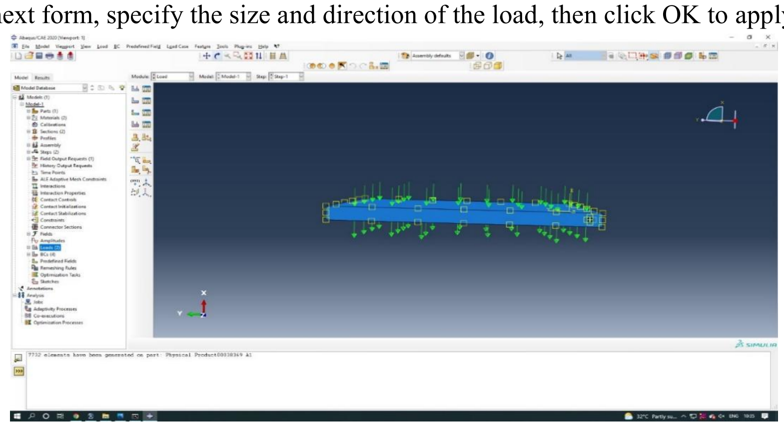

FIGURE 10. Applying Load and Boundary conditions

FINAL OUTPUT ANALYSIS

To start the analysis in Abaqus, double-click the Job node in the tree structure, give the job a name, click Continue, then click OK. Then click Task Manager in the toolbar and click Submit to start the analysis. During the analysis, you can

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monitor the progress by right-clicking the submitted job and selecting Track. After the analysis is complete, you can view the results by clicking the Menu button to open the visualization module of Abaqus.

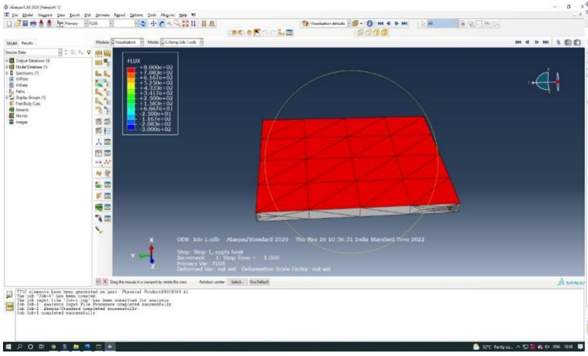

FIGURE 11. Output Flux

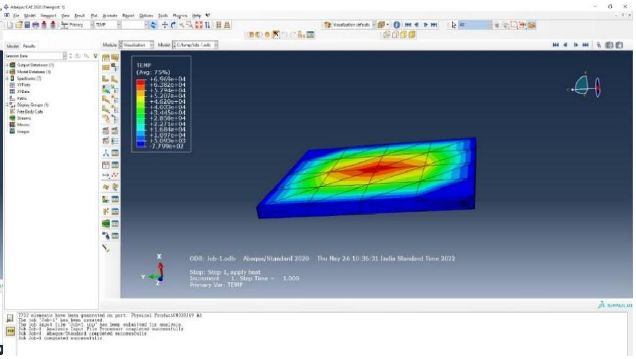

FIGURE 12. Output Temperature

VIII. PROCEDURE TO DEVELOP THE PROTOTYPE OF HYBRID PVPANEL

FABRICATION OF PROTOTYPE

Hybrid solar panel components

The following major components are included in the design:

1. Transparent protective layer: It functions as a water-proof membrane. A protective glass superstrate was used in the current performance analysis. Our future exploration of the superstrate design will include the adoption of existing standard test procedures to promote acceptance of polymer superstrates, which are attractive due to their lightweight.
2. PV (photovoltaic) polycrystalline layer: provides the direct current production; monocrystalline and a-Si, CIGs, and CdTe thin film are other alternative choices. All PV series array circuiting will be according to standards.

MATERIAL SELECTION

The PV layers used in the panels for this study were commercial poly crystalline Si solar cells of Trontek Make. The length, width and thickness of the solar cell were 45 cm, 35 cm and 2.5cm thick respectively. Pure Al flutter and Epoxy were used to fabricate layer. However, polyvinylchloride (PVC) can also be used to replace Epoxy in the future production. The volume fraction of Al powder gradually decreases from 50% at the top to zero at the bottom over a thickness of 12 mm. The thermal conductivity of Al and Epoxy are 238 W/m K and 0.26 W/m K, respectively. Although water tubes will eventually be formed with extrusion methods for mass production, in the prototype the water tubes were copper tubes with a diameter of 6.00 mm cast into the panel using a vacuum oven and mould.

PROCESSING TECHNIQUES

Though sophisticated techniques exist for development of Epoxy materials, since this is t first prototype developed, simple methodology has been followed as shown:

1. Measuring the volumes using a volumetric flask, mixing the volumes of Epoxy and Aluminium flutter in the flask itself and laying up has been epoxy and hardener in the ratio of 10:3 has been followed.
2. Preparing the copper tubing system to lay up at defined depth.
3. Fabricating a tray for filling Epoxy with Aluminium Chips.
4. Allowing it in open air for setting about 4 hours for initial setting and 72 hours for complete setting.
5. Laying up the Epoxy mixtures layer by layer and allowing to cure
6. Copper tubing is held in place and the next layer above it is laid up.
7. Each time levelling is checked for any adjustment that is necessary for small variations that has occurred.
8. Note that the comprised of 50% Aluminium and 50% Epoxy while the last (bottom most) layer is 100% Epoxy.

V. CONCLUSION

- The use of hybrid technology has proven to be an effective way to harness solar energy.Previous attempts to cool photovoltaic systems with photovoltaics encountered the problem of water return after thermal energy was obtained from photovoltaics.
- Significant improvement in solar panel performance was observed by providing the backup rating function.
- According to the design concept, a new building type can be created combined with three similar features.First, the efficient conversion of solar energy reduces or eliminates the need for combined electrical grids and the need for heating in the winter. Second, the overall design of the building envelope and the removal of heat from the roof will reduce the need for cooling in summer, thus reducing energy consumption. Finally, due to the elimination of regular work, all materials and other energy resources required to create a composite roof are reduced. This reduces the system's carbon footprint and other environmental impacts associated with building materials.

VI. SCOPE FOR THE FUTURE WORK

- A more vigorous testing is needed on the prototype for further development in design.
- Preparing Epoxy backup with other material combinations may be performed. Further the material property laws may be applied.
- The micro structure study may be under taken for better understanding.
- Means of compaction and laying up the layers more accurately can be performed.
- The testing may be performed for longer periods so that the life of Hybrid PV panel shall be appreciated.
- Simulation more such as CFD Analysis can be carried out with which have a better analysis on heat transfer and suggesting important design changes.

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