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Research Article

A critical technological literature review of - Photovoltaic / Thermal Solar Collectors System

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Abstract

This paper gives a critical technological review on various types of solar thermal system, photovoltaic thermal system and applications of solar thermal collectors is presented. The benefit offered by, solar energy on conventional sources of energy is presented. A historical introduction of solar energy is followed by a thermal analysis of various collectors including Parabolic Trough, Parabolic Dish, Fresnel lens, solar chimney, compound parabolic and flat-plate collectors and their performance. Application of various types of solar thermal collectors system like water heating, space heating and cooling, refrigeration, industrial process heat, thermal power systems applications. As we aware about solar energy systems can be used for a wide range of applications and provide significant benefits, therefore, they should be used whenever possible.

Keywords: *Solar energy, Solar thermal collectors, Parabolic Collector, Photovoltaic thermal collectors.*

1. Introduction

The planet is progressively marching towards a serious electric energy crisis, due to an increasing need of electric energy becoming greater than its supply. We have always accepted that the energy we make use of each day is not unlimited, still we take it for granted. Coal, petroleum, electrical power, even water has inadequate availability. But, we have not taken sufficient precautions to handle a possible energy crisis. Oil and gas have already become too pricey, and with each passing day, they are becoming being extinct. Prices have been rapidly increasing for the past five years, due to the rising desire and the escalating shortage of energy resources. The solar energy considered as the one source of renewable energy, alternatives to the energy sources (Aurora, Domkundwar, 2007).

Solar energy is utilized in various ways, such as industrial & domestic water heating, drying of products, space heating, cooling & refrigeration, power production etc. These are all solar thermal application. Solar energy can be directly converted to electrical energy by using photovoltaic energy, but with a price tag. Using thermal part of radiation is comparatively cheap and provides good source for low grade thermal energy usage (NSPI, 1998).

Solar energy can be classified into two systems; thermal energy system which converts solar energy into thermal energy and photovoltaic energy system which converts solar energy into electrical energy. The vital component in solar energy system is the solar collector. In the thermal system, the collector is heated by the sun and the heat is then transferred to a working fluid (NSPI, 1998). In the photovoltaic system, the collector is comprised of photovoltaic cells which convert the solar radiation into electrical energy. When solar radiation incident on Photovoltaic (PV) cell can generates electricity. The term Photo means light and Voltaic means electricity. A photovoltaic (PV) cell, is known as Solar Cell, which is made up of a semiconductor device that generates electricity when light falls on it. When sunlight strikes a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons then move through the cell, creating and filling the holes in the cell. It is this movement of electrons and holes that generates electric current. The Physical process in which a PV cell or Solar cell converts sunlight into electricity is known as the Photovoltaic Effect (James & James, 2010).

Therefore, increase in operating temperature will decrease in efficiency of PV cell. To improve the electrical efficiency of PV cell proper cooling is necessary. For heat extraction from PV cell by using water circulation was attached to the back of the absorber. Normally, these two collection systems are used separately. It has been shown that these systems can be combined to form photovoltaic thermal (PVT) system. The term PVT use to solar thermal collectors that uses PV cells as an integral part of the absorber plate. The system generates both thermal and

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electrical energy simultaneously (Adnan Ibrahim *et al*., 2011)

1.1 Advantages and Disadvantages of Solar Technology

The solar energy technology is having certain advantages and disadvantages comparing to other energy sources. Following are the some advantages such as: It does not produce any hazardous/ radioactive waste material, Clean and noiseless environment technology, Low maintenance cost, Good performance and reliable system (James & James, 2010).

There are some disadvantages also in this system such as: Longer payback period, High production and installation cost, Required more space for hot water and electricity generation (Adnan Ibrahim et al., 2011).

2. Various types of Solar Thermal Collectors System and Applications

Solar thermal power currently leads the way as the most cost-effective solar technology on a large scale. It currently beats other PV systems, and it also can beat the cost of electricity from fossil fuels such as natural gas. Some of the solar thermal technologies are discussed.

2.1. Flat Plate Collector System

Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark-coloured absorber plate. These collectors heat liquid or air at temperatures less than 80°C. Flat-plate collectors are used for residential water heating and space-heating installations (S P Sukhame *et al*,)

2.2. Solar Drying Technology

Food drying is a very simple, ancient skill. It is one of the most accessible and hence the most widespread processing technology. Sun drying of fruits and vegetables is still practised largely unchanged from ancient times. Traditional sun drying takes place by storing the product under direct sunlight. Solar dryers have some advantages over sun drying when correctly designed. They give faster drying rates by heating the air to 10-30˚C above ambient, which causes the air to move faster through the dryer, reduces its humidity and deters insects (S P Sukhame *et al*,). The faster drying reduces the risk of spoilage, improves quality of the product and gives a higher throughput, so reducing the drying area that is needed.

2.3. Solar Space Heating Technology

Solar space heating is used in countries of cold region. Solar space heating systems can be either active or passive. Passive systems use building components such as floors, walls, and sun spaces to collect and store heat (S P Sukhame *et al*,). It may use air or liquid as a working fluid. Trombe wall is an example of passive space heating.

2.4. Solar Thermal Power Technology

It is essential therefore to list the various factors that contribute to plant output variation. The performance of the power plant however depends on several parameters including the site location, solar insolation levels; climatic conditions specially temperature, technical losses in cabling, module mismatch, soiling losses, transformer losses and the inverter losses. Concentrated solar power (CSP) generation utilizes various means to convert solar radiation to heat which can generate electricity either immediately or following storage. CSP generation therefore offers a means to potentially supply solar electricity in line with demand. The various types of CSP generation are described below (B.H Khan).

2.4.1. Parabolic Trough Collector System

Parabolic troughs consist of long parallel rows of identical concentrator modules typically glass mirrors - that are curved in only one dimension, forming troughs. Tracking the sun from east to west while rotating on a north-south axis, the trough focuses the sun’s energy on a pipe located along its focal line. A heat transfer fluid, typically oil at temperatures up to 400°C, is circulated through the pipes and then pumped to a central power block area, where it passes through a heat exchanger (B.H Khan). The oil’s heat is then passed to a working fluid, such as water or steam, which is used in turn to drive a conventional turbine generator.

2.4.2. Parabolic Dish Collector System

Parabolic dish systems consist of a parabolic-shaped point focus concentrator in the form of a dish that reflects solar radiation onto a receiver mounted at the focal point. These concentrators are mounted on a structure with a two-axis tracking system to follow the sun. The collected heat is typically utilized directly by a heat engine mounted on the receiver moving with the dish structure. Stirling and Brayton cycle engines are currently flavored for power conversion. The concentrated beam radiation is absorbed into a receiver to heat a fluid or gas to approximately 750°C. This fluid or gas is then used to generate electricity. Dish technology produces relatively small amount of electricity compared to other CSP technologies – typically in the range of 10 to 25 kW which results in high capital costs (B.H Khan). Stirling dish technologies are capable of achieving the highest efficiency of all types of CSP systems. Stirling dishes, given their small foot print and the fact they are self-contained, can be placed on slopes or uneven terrain, unlike PTC, LFC and solar towers.

2.4.3. Linear Fresnel Reflector Technology

Use reflectors made of several slices of mirrors with small curvature approximating a parabola. Mirrors are mounted on trackers and configured to reflect sunlight onto elevated linear reflectors. Water flows through the receivers and is converted into steam and the intermediate heat transfer fluid is not required. These systems have lower investment costs and also lower optical performance as compared to parabolic trough collectors (S P Sukhame *et al,*). This technology is still in the developmental stage. It needs less land for deployment, as mirrors are flat and can be spaced closely (B.H Khan). The weight is also less. The height above ground is also less, so an added advantage is less air resistance. It can generate steam of temperature 270˚C. This technology is very cost effective.

2.4.4. Solar chimney

The solar chimney consists of a large area of above-ground translucent panes, a vertical pipe, the chimney, and a wind turbine. Air is heated by solar radiation under a low circular glass roof open at the periphery; this and the natural ground below it form a hot air collector. Continuous 24 hours-operations is guaranteed by placing tight water-filled tubes under the roof. The water heats up during the daytime and emits its heat at night. These tubes are filled only once, no further water is needed. In the middle of the roof is a vertical chimney with large air inlets at its base. The joint between the roof and the chimney base is airtight. As hot air is lighter then cold air it rises up the chimney. Suction from the chimney then draws in more hot air from the collector, and cold air comes in from the outer perimeter. Thus solar radiation causes a constant up draught in the chimney. The energy this contains is converted into mechanical energy by pressure-staged wind turbines at the base of the chimney, and into electrical energy by conventional generators. The solar chimney which is a prototype built at manzanares, Spain (S P Sukhame *et al,*).

2.4.5. Compound Parabolic Concentrator

The Compound Parabolic Concentrator (CPC) is a special type of solar collector fabricated in the shape of two meeting parabolas. It belongs to the non-imaging family, but is considered among the collector having the highest possible concentrating ratio. Also because of its large aperture area, only intermittent tracking is required (S P Sukhame *et al,*). It is obtained by joining the focus to the opposite aperture edge. The concentration ratio is given by w/b. The height and aperture area for a CPC are calculated as per the desired operating temperature. To reduce the cost the height is generally truncated to half as it doesn't much affect the concentration ratio. The acceptance angle is also generally kept large so that tracking may be required intermittent only. For a concentrating collector the amount of diffused radiation that can be collected is given by 1/CR. The general Concentration Ratio for a CPC is around 3–10, while that for PTC and Parabolic Dish Collector is more than 1000 (S P Sukhame *et al,*).Thus the advantage of a CPC is that it can collect diffuse radiation too. Thus its performance is satisfactory in cloudy atmosphere (B.H Khan).

2.5. Flat Plate PVT Collector Systems

The PVT collectors can be broadly classified into flat plate collector, concentrating collector and solar water/air PVT type collectors. (Rakesh Kumar et al, 2011) flat plate PVT collector can be classified into water PVT collector, combination of water /air PVT collector and air PVT collector, depending on the type of working fluid used (Adnan Ibrahim et al., 2011).
Flat plate PVT collectors its look similar to the flat plate thermal collectors. The difference is that PV panel attached on the top of the absorber plate (B.H Khan).. The glass cover, PV module, absorber plate with tubes and insulation (Ebrahim M. Ali Alfegi *et al,* 2009)

2.6. Influence of the Temperature and Solar Radiation Variation on PV Output

The output relationship between current (I) and voltage (V) under prevailing conditions of sunlight and temperature. A PV cell converts only a small fraction (approximately less than 20 %) of the irradiance (S P Sukhame *et al,*). into electrical energy. The balance is converted into heating of the cell. As a result, cell can be expected to operate above ambient temperature (Kenneth S. Deffeyes *et al,*). If the temperature is increased, there is marked reduction in the voltage. As per Ohms law (and the equation Power = Voltage x Current), the result of reduced voltage is reduced power output. The PV generator power increases as the solar radiation increases (Bello Y Idi *et al,* 2011).

3. Developments in CPC and Flat-Plate PVT Collector Systems Reported in the Last Decade

The energy consumption in the world, particularly in the industrialized countries, has been growing at an alarming rate. Moreover, the pollution hazard arising out of fossil fuel burning has become quite significant in recent years. About 86% of the world's energy supply comes from the fossil fuels (Aurora, Domkundwar, 2007).. According to (Deffeyes *et al*) oil has already started to peak. (Sadorsky, *et al.*)mentioned that oil prices are often indicative of inflationary pressure in the economy which in turn could indicate the future of interest rates and investments, gas and coal reserves, in the other hand are larger than oil, it will latter tend to be progressively replaced by the former, which should attenuate a price explosion. Pareto mentioned that this process will push energy prices higher, until sustainable sources replace dependency on fossil fuels as major source of energy. (Constatntinos and Bouroussis,2004) mentioned that the sustainable energy such as solar prices higher, until sustainable sources replace dependency on fossil fuels as major source of energy. He mentioned that the sustainable energy such as solar energy in a form of solar radiation has been identified as one of the promising source of energy to replace the dependency on other energy resources. The global need for energy savings requires the usage of renewable sources in many applications. One of the renewable sources of energy is the photovoltaic solar energy (PV). As revealed by (Hoffmann, 2006), the photovoltaic (PV) solar market has shown an impressive 33% growth per year since 1997 until today. Hybrid photovoltaic/thermal system in the other hand is the continuity of the photovoltaic solar energy system; it combined both systems into one system known as Hybrid photovoltaic/thermal (PV/T or PVT) solar system. As reported by (Zondag *et al*, 2002), the system can be segregated into two parts; the photovoltaic technology which derived from solar cell technology and convert into electricity, and thermal solar technology which derived from the thermal collector and convert the solar energy into heat (Adnan Ibrahim et al., 2011).

3.1 Advances in PVT systems used in CPC

(Oommen *et al.*, 2002)has designed and developed compound parabolic concentrators to collect solar energy and to generate steam through experimentation. A CPC reflector profile with a V groove at the bottom of the reflector to reduce the gap losses was designed with a half acceptance angle of 23.5° for a tubular absorber of OD 30 mm. Five troughs fabricated with fiberglass substrate pasted over with UV stabilized self-adhesive aluminized polyester foil having high specular reflectivity 85% joined together side by side comprise the CPC module with an aperture area of 2.04 m2. Copper tubes coated with NALSUN selective coatings and enclosed by borosilicate glass envelope act as absorbers. The reflector absorber assembly housed in a single glass wool insulated wooden box forms the CPC collector. Using water as the heat transfer fluid efficiency tests were carried out with different inlet temperatures (40–70 °C). A theoretical model was developed by setting up different heat balance equations and a reasonable agreement between theoretical computed values and the experimental values was observed. He found out that the instantaneous efficiency (59%) of the CPC module was high even at higher operating temperatures, when compared to flat plate collectors.

(Kalogirou, 2004), carried out a survey of the various types of solar thermal collectors including flat-plate, compound parabolic, evacuated tube, parabolic trough, Fresnel lens, parabolic dish and heliostat field collectors and applications including solar water heating, which comprise thermosyphon, integrated collector storage, direct and indirect systems and air systems, space heating and cooling, which comprise, space heating and service hot water, air and water systems and heat pumps, refrigeration, industrial process heat, which comprise air and water systems and steam generation systems, desalination, thermal power systems, which comprise the parabolic trough, power tower and dish systems, solar furnaces, and chemistry applications. The application areas described that solar energy collectors can be used in a wide variety of systems, could provide significant environmental and financial benefits, and should be used whenever possible. (Bogren, 2004), performed experiments on low concentration photovoltaic and photovoltaic thermal system with two dimensional reflectors were studied and optimised the design. A new biaxial model for incidence angle dependence of optical efficiency was developed. Concentration of light results in high cell temperatures, and uneven irradiance distribution on cells with parabolic reflectors leads to high local current and temperature, which reduce fill-factor and voltage. Cooling the cells using water increases the voltage and makes it possible to utilize the thermal energy. The performance of a 4X concentrating PVT was evaluated with water inlet temperature at 30 °C. If it was operated at 50 °C, this system produce 250 kWhelectrical and 800 kWhthermal per m2 cell area and year. Optical performance increased by 20% by using better reflectors and anti- reflectance glazing. Low concentration photovoltaic system for façade integration were studied and optimised for electricity production. Optimisation was carried out on the basis of measured short circuit current versus solar altitude. He was found that the use of 3X parabolic reflector increase the annual electricity production by more than 40%.

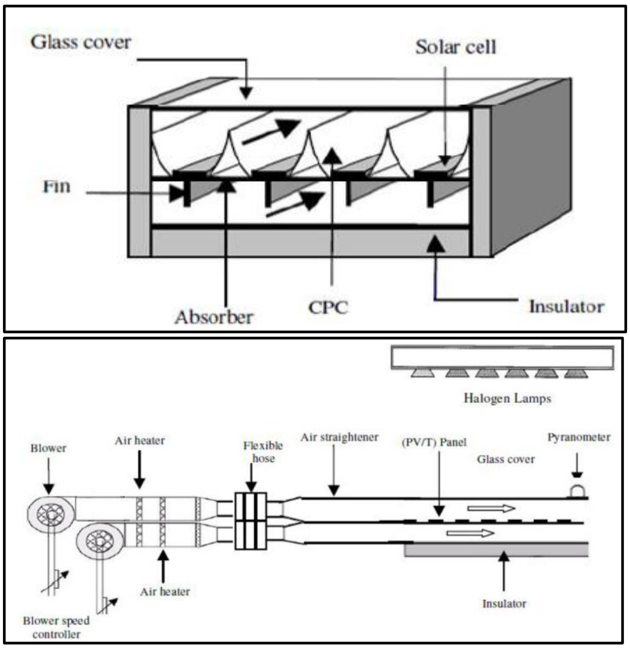

Fig. 2.1 Schematic model and experimental setup of a double-pass photovoltaic thermal solar collector with CPC and fins

High solar reflectance is crucial to system performance but by using a low- angle scattering reflector, the fill factor and power are increased due to more even irradiance on the modules. (Othman et al., 2005) has proposed design and fabricated double-pass photovoltaic thermal solar air collector with CPC and fins shown in fig. 2.1 schematic model and experimental setup. Compound parabolic concentrator (CPC) used to increase the radiation intensity falling on the solar cells and fins attached to the back side of the absorber plate to improve heat transfer to the flowing air. Energy balance equations have been developed for the various nodes of the system. They observed that combined efficiency varies from 39 to 70% at mass flow rate of 0.015–0.16 kg/s and radiation intensity of 500 W/m2 at inlet air temperature 32 °C. Effect of Solar IR give an impact to the electrical performance of the CPC and reduced to 50% of the actual electrical energy produced mean while the thermal performance increased by 10% of the predicted value.

(Tchinda *et al.*, 2006) has developed set of mathematical equations to study thermal processes in a CPC collector with a flat one-sided absorber with a flat one-sided absorber. The effects of various parameters like length (L) of the tube (1m and 1.5m), mass flow rate (m) (0.0004, 0.0008 and 0.0012 kg/s); on the thermal performance of such a CPC was studied. They obtained that, for a given L, the efficiency increases as m increases, and outlet temperature of the heat transfer fluid decreases with an increase of m. The shorter length is more efficient than long CPC (Muhammad-Sukki *et al.*, 2010), carried out a survey review on solar concentrators and their benefits to make solar technology affordable. This study evaluated some of the established designs of solar concentrators like Parabolic Concentrator, Hyperboloid Concentrator, Fresnel Lens Concentrator, Compound Parabolic Concentrator, Dielectric Totally Internally Reflecting Concentrator, Flat High Concentration Devices, and Quantum Dot Concentrator etc. which have shown significant contribution to the solar technology. In spite of the advance designs achieved so far, there are still a lot of improvements that can be done especially on the concentrator designs. (Chu *et al*, 2011) carried out a review and comparison of different solar energy technologies. They concluded that in order to choose the right solar system for a specific geographic location, it is necessary to understand and compare the basic mechanisms and general operation functions of several solar technologies that are widely studied. They evaluated that concentrated photovoltaic systems, dye sensitized solar cells and solar thermoelectricity systems are emerging technologies under intensive study. They have also studied that photovoltaic solar panels (PV) and concentrated solar power (CSP), since they are the two most commonly deployed technologies and are expected to have rapid growth in both the short- and long-terms. (Su *et al.*, 2012) has proposed a novel design and simulated novel lens-walled CPC using for fast and accurate PHOTOPIA optical analysis tool. Simulation has been focused on the comparison of the trough lens-walled CPC with other common trough CPCs in terms of actual acceptance angle, optical efficiency and optical concentration ratio. They found that at an incidence angle of 25 deg which is larger than the half acceptance angle θmax= 14.5 deg of the mirror CPC-4 and θmax= 23:5 deg for the mirror CPC-2.5, the lens-walled CPC-4 can still have an optical efficiency of more than 0.4 and an optical concentration ratio of about 1.7. This clearly indicates the advantage of the presented lens-walled CPC-4 having a larger actual acceptance angle. As, larger actual acceptance of the lens walled CPC-4 can allow collection of more solar radiation in summer and winter.

3.2 Advances in PVT Systems used in Flat Plate

(H.A. Zondag *et al*, 2003), experimental results compared with simulated results for one cover sheet and tube PVT collector system. The electrical and thermal efficiency of PVT collector was (8.9% & 58%) with ambient temperature (20°C) and solar radiation (800W/m2). Out of nine combinations the channel below transparent PV design gives the best electrical and thermal efficiency (9% & 63%) but, one cover sheet and tube design is alternative to the channel below transparent PV because its efficiency is only 2% less. But, for low temperature application the uncovered PVT collector will give better results because average water outflow temperature (28°C). (Ali Al-Mohamad, 2004), Sun tracking design to follow solar radiation using a programmable logic controller (PLC) unit was used for the movement of a PV module. In case of tracking mode, for the period 6:00 to 10:00 am and 15:00 to 17:00 pm overall output power gain exceeds 40%. However, the improvement was about 2-4% during mid-day. The overall daily output power gain was increased by more than 20% compared to fixed mounted system (Wei He *et al.*, 2006), performed experimentation on Hybrid PVT Collector using water as a coolant for improving the energy performance. In this case, about 4.6% of incident solar radiation had been converted into electrical energy. The maximum final water temperature was 61.7 °C at 31.8 °C initial water temperature in storage tank. The experimental result shows that thermal efficiency 40% which is about 80% of conventional solar thermosyphon collector system. A. (Hunter Fanney *et al*, 2006), carried out computer simulation on three different modules to measure electrical performance. They compare the measured power output of the three different modules at standard rating conditions including the response of each module to changes in cell temperature (0 °C and 75 °C), angle of incidence (0 to 80 deg.), and air mass under outdoor conditions.

(Jie Ji *et al*, 2007) model and simulated hybrid PVT collector system designed was able to generate electricity and water heating (with natural circulationThe hot water load per unit heat collecting area exceeded 80 kg/m2, the electrical efficiency was 10.15%, thermal efficiency 45%, total efficiency was 52% and primary energy saving up to 65%, with PV covering factor of 0.63 and front glazing transmissivity of 0.83. Results show that higher the PV cell covering factor (0.7, 0.8, and 0.9) and glazing transmissivity (0.7, 0.8, and 0.9) better the overall efficiency (50.012, 52.669 and 55.301).

(Sangani & solanki, 2007) designed and fabricated V-trough photovoltaic (PV) concentrator system with conventional PV modules. Performance of PV modules is evaluated for aluminium and mirror reflectors with reflectivity 85% and 79%. The output power is increased to 157 W/m2 with the use of V-trough concentrator system as compared to 105 W/m2 from flat PV system. The higher power output can be consider by the wider trough angle in case of model-B and model-C (37.85° and 30°) as compared to model-A (15°). The wider trough angle results in reduced flux density reaching to the cell surface due to higher reflection from modules glass cover. Lower PV module temperature measured for both model-B and model-C (60-65°C) as compared to the model-A (80-85°C). This implies that trough angle should be below 30°. (J K Tonui *et al*, 2007), fins attached the back side of the wall for heat transfer augmentation in an air cooled PVT solar collector to improve its (Electrical & Thermal) overall performance. Steady state thermal efficiencies of the modified systems are compared with those of typical PVT air system which are shown in fig.2.2. Module temperature was measured (55-75°C) with no air circulation at ambient temperature (30°C) and with air circulation, PV module temperature was (45- 65°C). For the forced convection with flow rate (60m3/h) and 15 cm channel depth, the thermal efficiency using fins 30%, Thin Metallic Sheet 28%. Daily temperature profile of the outlet air, the PV rear surface and channel back wall are presented confirming increasing PVT system electrical and thermal outputs. (Ebrahim Ali alfegi *et al,* 2008) presents an experimental study on influence of mass flow rate (0.0316 to 0.09 kg/s) on PVT system performance. Where PV cell pasted directly on the absorber with fins attached at the back of the absorber. The effect of mass flow rates on the efficiencies (electrical, thermal, and overall) at solar radiation 400 W/m2 and inlet temperature of air 30°C. The electrical efficiency varies from 10.50 to 12.09%, thermal efficiency varies from 17 to 26.433% and overall efficiency varies from 27.50 to 40.044%. He observed that higher mass flow rates will increase the PVT system efficiencies. It is important to use fins as integral part of the absorber surface in order to achieve meaningful efficiencies for thermal and electrical output of the PVT.

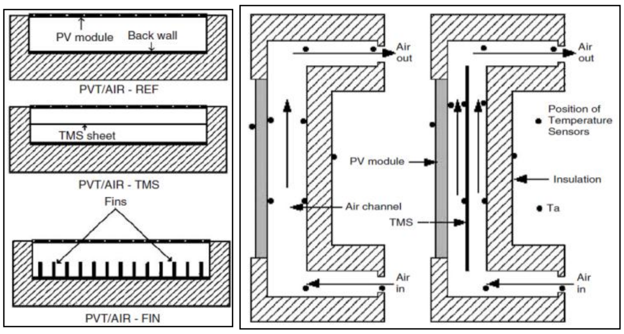

Fig. 2.2 Cross-sectional view of PVT/AIR collector models and schematic diagrams of temperature sensors for REF & TMS systems

(Goh Li Jin *et al*, 2010), present an experimental study on single pass PVT with rectangular tunnel absorber system air as a cooling medium. PVT collector was tested with and without rectangular tunnel the single pass solar PVT air collector system. Solar radiation set to (385.2 and 817.4 W/m2) and mass flow rate of air set to (0.0110, 0.0287, 0.0409, 0.0552 and 0.0754 kg/sec) at ambient temperature of 25°C. The electrical, thermal, and overall efficiency of PVT system was 10.02%, 54.70% and 64.72% at solar radiation of 817.4 W/m2, mass flow rate 0.0287 kg/sec has been obtained.

(Adnan Ibrahim *et al*, 2011) flat plate PV/T collector classification, design and performance evaluation of water, air and combination of water and air based. The tube and sheet design is the simplest and easiest to be manufactured, even though, the efficiency is 2% lower compared to other types of collectors such as, channel, free flow and two-absorber. (H. Tabaei *et al*, 2012), the output power from photovoltaic cells with booster reflector made of Al foil is higher than concentrator made of stainless steel 304. The study indicates that maximum temperature for PV array without reflector(WR) (65°C), with stainless steel 304 reflector (WSSR) (83°C) and aluminium foil reflector (WAFR)(84°C) with booster reflector is always below the maximum working temperature (90°C) defined by the module manufacturers; so this temperature rise is supposed to be not harmful to generation characteristics. The concentrating solar radiation on the PV cells increases the mean PV cells mean output power WR (51.6W), WSSR (55.9W), WAFR (58.8W)and consequently increases water pump mean flow rate WR (88L/h), WSSR(95L/h), WAFR(103L/h). (Ionut-Razvan Caluianu *et al,* 2012), using thermal model the PV module has been developed and validated by performing experimentation. The temperature and velocity profile of air at the exit section has been studied. Simulation is carried out by applying Galerkin Finite Element method to the flow and energy equations. As the channel width increases (10, 20, 30 mm) the mean air temperature at the exit section varies approx. 50°C to 30°C and mean air velocity varies from 0.21m/s to 0.29m/s. Convective and irradiative phenomena occur in the channel this develops two boundary layers stand out, one at the PV module and one at the roof wall. (Xinqiang Xu *et al.*, 2013) computer simulation were developed for performance and reliability of a hybrid concentrating photovoltaic thermal (CPVT) water collector. The collector consists of a solar concentrator, 18 single junction germanium cells connected in series, and a water channel cooling system with heat-recovery capability. Two cooling conditions at different water flow rates (0.01 & 0.03 m/s) with fixed inlet water temperature (25°C). The thermal efficiencies (72.2 to 72.7%) and electrical efficiencies (15.6 to 15.9 %) of the collector are improved less than 1%, while the maximum cell temperature (72.4 to 51.4°C) and outlet water temperature (56.2 to 35.5°C). The cell fatigue life for the operating conditions at 0.03 m/s flow rate is about 14 years longer than that for 0.01 m/s flow rate.

Conclusions

Change in global climate and increasing prices of conventional fuel supply have lead to development in solar energy technology, which are non-conventional energy technology (Bhaskar B. Gardas *et al*, 2012). The installation of solar thermal equipment and PV systems are growing rapidly due to increasing demand of electrical and thermal energy. In the past decade, performance of the PVT system had been studied theoretically, numerically, experimentally and software simulation. Focus has been shifting towards development of multi-functional product, with reduced life cycle cost, and system optimization. (Adnan Ibrahim *et al,* 2011) Concentration ratio of CPC was better than flat plate reflector for solar incident radiation. In this view, the use of CPC to concentrate solar incident radiation on Photovoltaic thermal (PVT) systems is introduced which is capable to produced electrical and thermal energy. Application of PVT system depends on the climate condition and geographical location. Also, Depending on the solar radiation and ambient temperature level high or low, PVT/w and PVT/a system can be useful (Rakesh Kumar *et al*, 2011). Air type PVT system has low thermal conductivity, hence poor heat transfer between the absorber plate and the flowing air. Hence, the air heater efficiency is low (H.Tabaei *et al*, 2012). Water type PVT system has better heat transfer media than air. But, Problem of using water as a heat transfer medium are like Weight, Cost, leakage, corrosion and Maintenance cost increase if we compare with air type PVT system. After understanding these points one can say that, (Rakesh Kumar *et al*, 2011). Air Cooled PV/T system is more advantageous over water cooled system, if low temperature water heating is not the purpose of the PV/T system. The double pass PV/T solar air collector with fins and compound parabolic concentrator (CPC) gives very good electrical and thermal energy output (M.Y.Othman *et al*, 2006), So, that comparative study carryout to improve thermal efficiency of the PV/T system is done by passing different gases, over a finned, single and double duct & single pass solar collector.

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