Photovoltaic Cell With Concentrating Collector- A Review

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ABSTRACT

Various aspects of photovoltaic cell with concentrating collector have been discussed in this paper. To full fill today's energy demand and alternative to conventional fuel,photovoltaic cell is good alternative, but main problem is higher cost, larger size of panel required and lowerconversion efficiency. A simple wayof reducing cost ofphotovoltaic cell is to replace some of the photovoltaic area with less expensive optics such as lenses or mirror. The optical devices concentrate sunlight on a small area of cells and increased power output. Under high concentration of solar radiation, photons with wavelength above threshold areconverted into heat and remaining energy in to electricity. Waste heat must be dissipated efficiently in order to maintain normal working temperature; high photovoltaic cell temperaturehas adverse effect on electrical performance of the cells and life. Cooling arrangement is provided to reduce temperature, increased power output and efficiency.

Keywords: cooling system, Concentrating collector, Photovoltaiccell.

Introduction

Continuouslyincreasing world energy demand, threat of global warming and limited sources of conventional energy like coal, oil, natural gases, there is a needto develop reliable, cost-effective renewable sources of energy. To meet today'senergydemand; solar energy is promising source of energyin future [17]. Solar energy can be categories in two ways, one is thermal application that converts solar energy into thermal energy, andother is photovoltaic system whichconverts solar energy directly into electricity. But main disadvantage with solar energy is low thermal and electrical energy conversion efficiency.

Photovoltaic (PV) cells are semiconductor devices which convert sunlight into electricity. Photons below a threshold wavelength have enough energy to break an electron-hole bond insemiconductor crystal, which in turn can drive a current in a circuit. But theproblems with simple photovoltaic cell are lower electrical conversion efficiency up to 6% to 15% only and high initial cost. In order to solve this problem,concentrating photovoltaic (CPV) systems utilize low cost optical elements like Fresnel lens or mini-reflecting mirrors.

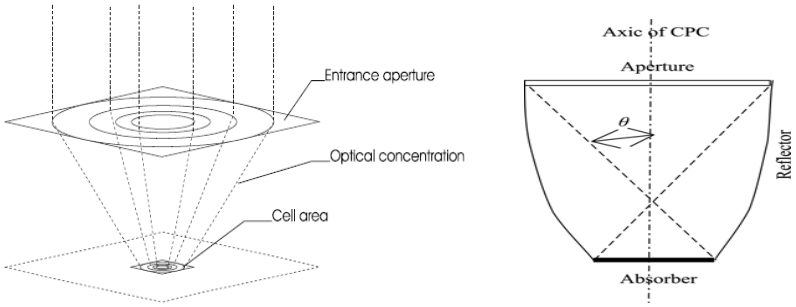

Fig.1 Arrangement of concentrating PV cell with Fresnel, compoundcollectorarrangement

In concentratingphotovoltaic system portion of energy converted to electricity and remaining as wasteheat.[14] Proposedaluminum and copper heat pipe cooling arrangement.[21].In concentrating photovoltaiccell, area of the cell is reduces by concentrating solar energy on to the smaller area by different concentrating lenses and mirror with different concentration ratio and geometries. It increasedconversion efficiency of a cell up to 25% to 40% andcost of solar cell is reduces because of fewer cell are needed for the same output (1]proposed silicon on glass Fresnel lens panel and multifunction cell. Maria et al.[2].Suggest method for characterization of incident angle dependence of the optical efficiency of asymmetric reflecting collector. From past of a research it focus various method used for concentration and there limitation in below table.

Table1:- Method of concentrations

	Low concentration	**Medium concentration**	**High concentration**
Degreeof concentration	2-10	10-100	More than 100
Tracking?	No tracking necessary	1-axis tracking sufficient	Dual axis tracking required
Cooling	No cooling required	Passive cooling sufficient	Active cooling required in most instances.
Photovoltaic material	High quality silicon		Multi-junction cells

Highconcentration of solar radiationhaving a high flux density. From some of energy is converted to electricity remainingenergy is absorbed by solar cell and converted into heat.Which increases the temperature of solar cell?It has also been observed increasing the operating temperature of crystalline silicon solar cell reduces the efficiency by 0.4e0.5% by 1k. [3].
.[4].During operation of CPV increasedsolar cell temperatures which deteriorate the entire performance of components (solar cell, lens). To achieve better performance, solar cell temperature has to be maintained near to operating conditions, estimation and maintaining the

solar cell temperature near to the operating conditions are one of most important tasks in PV concentrating system. For it he proposed air cooling with back plate and aluminum fins.
Bladimir et al.[5]Proposed CFD analysis with liquid cooled heat sink with micro channel flow field configuration for concentrated solar cell after CFD analysis he concluded that liquid usually have higher heat capacity & thermal conductivity than air therefore it reduce pumping power consumption, a heat sink which hasa low maximum temperature difference per unit of heat flux, a low thermal resistance, and a good heating surface temperature distribution. SUN [6]proposed compound parabolic concentrating collector with air cooling system he concluded that with increasing mass flow rate of air increases electrical and thermal efficiency. as shown in fig. 2

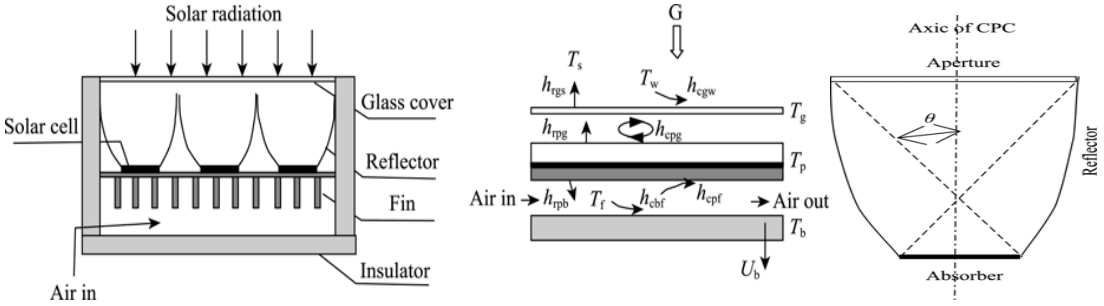

Fig.2 Parabolic concentrating PV collector with air cooling arrangement.

For the maximum power output purpose it is essentially that solar radiation should be always perpendicular to photovoltaic cell. But the position of the sun changes from time to time and day to day. Due to the change in the orientation of the sun solar flux density going to change and solar cell output get affected by it. [19] study effect of solar tracking system on electrical output.
The angle of the sunlight to the normal is the angle of incidence (θ). Assuming the sunlight is staying at a constant intensity (λ) the available sunlight to the solar cell for power generation (W) can be calculated as: $W = A \lambda \cos(\theta)$ as shown in fig.3

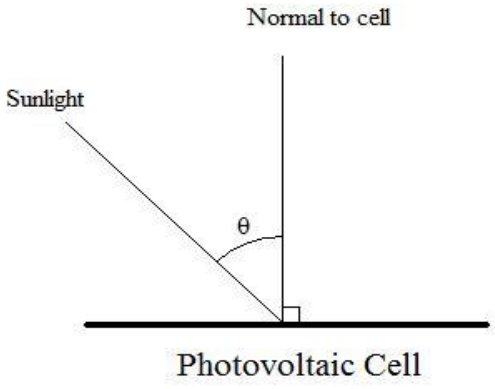

Fig. 3

To maintain the solar radiation perpendicular to photovoltaic cells the tracking system in best alternative. Tracking system is categories in following way:-

- Single axis tracking which follow the sun from east to west through daily path.
- Two axis tracking which follow the sun from east to west through daily path, and change tilt angle of the module according to the seasons.[7].Focus on two axis tracking system [8] Show effect of single tracking system on performance of PV panel. By using the solar tracking system the power output increased double than power required to drive motor for tracking system. The solar tracking system increased initial cost by 20% but the investment of tracking system can be refund in two years because of more power output.[20] presented by using tracking system efficiencyincreased 13.9%.

Table 2:- shows comparison between various tracking system

	Flat plate horizontal surface	**Fixed mounting, optimum angle**	**1-axis tracking**	**1-axis with seasonal adjustment**	**2-axis tracking**
	-15%	0%	20%	26%	32%
	0%	5%	10%		20%

REVIEW OF WORK CARRIED OUT BY DIFFERENT AUTHOR ON CONCENTRATING PHOTOVOLTAIC CELL.

Li Guiqiangab, Pei Gang et al.[9]had proposed that series of PV and thermal outputs and efficiencies are simulated and calculated between different concentration ratios (1.5, 2, 2.5,and 3) of CPCs and common flat PV/T systems at different sunlight conditions and influence of different concentration ratios and different absorber temperatures for the overall PV/Tefficiencies of CPC-PV/T systems. At the same time, at concentration ratio=3 Tw=30^0c thermal efficiency =0.676 & electrical efficiency =0.126 results show that the CPC-PV/T system with a U type pipe reduce solar area 66.7%. Also available heat for space heating. Graph show the relationship betweenthermal, electricalefficiency and cooling water temperature.

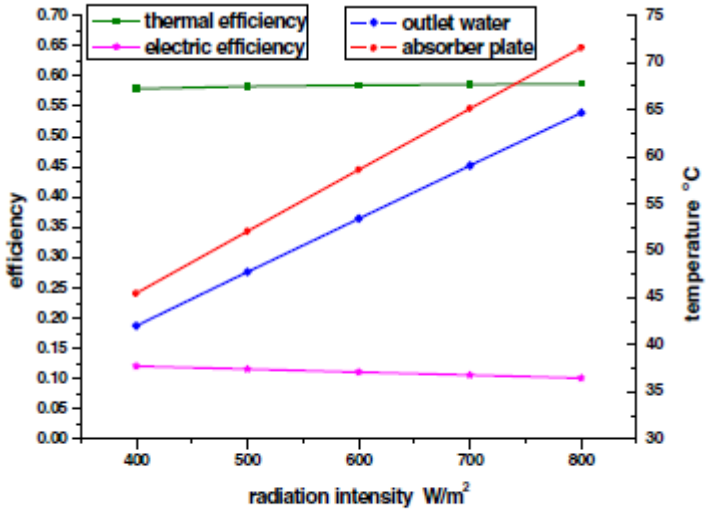

Figure 4. Efficiency and outlet water temperature at different radiation intensities

Xinyue Han, Yiping Wang et al.[10] suggested that mono crystalline silicon concentrator solar cell of 0.5ohms 300m thick and 40*50mm in size concentrated by 100*100mm Fresnel lens with 20suns, 20suns, 30suns and cooling medium used as de-ionized (DI) water, ISO propyl alcohol, ethyl acetate,dimethyl silicon and air. After experimentation he had been found that CPV with liquid cooling current density (Isc) and open circuit voltage increases than CPV with air cooling. It concluded that maintaining lower CPV cell temperature, leading to increase the power output of CPV-T system.

Yuehong Su et al. [11].suggested that the lens wall concentrating parabolic collector having the more power output than simple photovoltaic mirror concentrating parabolic collector cell. The optical efficiency is also more.

Sendhil Kumar Natarajan, Tapas Kumar Mallick et al.[12]had proposed thenumerical study of solar cell temperature for concentrating PV system with concentration ratio of 10x. He developed and compares two dimensional thermal modelsto predict the temperature for PV concentrator system (solar cell and lens) with and without passive cooling arrangements; also effect of wind velocity on the cell temperature correlation can be present. Apart from that integrated optical, thermal and electrical simulation will also be carried out to predict the overall performance of the present configuration of solar concentrating PV.

Anjaroyane et al. [13]concluded that the cells are the most expensive part of a photovoltaic system. A simple way of reducing system costs is therefore to replace some of the photovoltaic area with less expensive optics such as mirrors or lenses, one can afford to use higher efficiency cells. Under high concentration there is also a considerably higher heat load that needs to be

dissipated. For that purpose water cooling arrangement is provided. It reduce cost, size, and increased the efficiency.

KhaledToufe et al.[15].suggested that the combination of a thermal collector and a photovoltaic module in a single system allows for increased efficiency of the total conversion of solar energy. Two configurations of hybrid solar collectors are studied in this paper, classified according to their absorber design: the first was an absorber made of galvanized steel tub and the second, a copper sheet and tube. The thermal and electrical performances of the firstconfigurations are the best. One can say that the first configuration of hybrid PVT collector is with it slow cost and simple design a good alternative for the liquid hybrid photovoltaic thermal collectors.

Mohamed Dakkaket al. [16]suggested that thepractical performance study ofone axis mechanical tracking system. The solar tracker follows the sun based on a program, which describes the suns movement. With this method, the tracker follows the sun even when clouds are covering the sky, making it ready to produce as soon as the sun shines through the clouds and always optimizing the angle for optimal production. The PV cell are characterized by high reliability, long life, low operating cost and low maintenance cost but the biggest disadvantage is very low thermal efficiency so to increase the efficiency by using tracking system was concluded after the performance 1) 15% increase the efficiency. 2) An increase of 20% of capital cost in tracking system may be less in higher powers, for exampleit may be used the same motor to track double power.

CONCLUSIONS

The forgone discussion on the use of concentrating photovoltaic cell suggests that that there is a need for developing a reliable and cost effective photovoltaic cell with theconcentrating lenses which focused the solar radiation on to the smaller area. The intensity of solar radiation increased, which increased the output of solar cell and reduce size and cost for same power output. Higher solarconcentration increasedthe heat load on a solar cell, some energy is converted into the electricity and remaining heat isdissipated to maintain lower temperature of the cell. If the temperature of cell increases, itdeteriorates solar cell and reduce life and conversion efficiency. Cooling arrangementis required. To maintain solar radiation perpendicular to photovoltaic cell, two axis solar tracking system is used which increased power output. In this way by using the proposed way the efficiency of solar increased from 6% to 30%.

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