COMPLEXITIES OF CONCENTRATED PHOTOVOLTAICS

MUKUL KISHORE

Deptt. of Physics, Hindu College,Moradabad-244001 (U.P.)

Abstract:- Solar thermal utilization can be categorized into low- temperature solar thermal systems, which may not involve sunlight concentration, and high-temperature solar-thermal systems, which require sunlight concentration. Concentrated Photovoltaics (although not a solar-thermal process) crosscuts with solar thermal utilization through the use of concentrators. A brief summary of ongoing research in silicon and III-V- based concentrator cells is also provided here. There is also ongoing research to improve the long term reliability of concentrator systems and to develop standard tests for concentrator cells and systems.

Introduction:- Concentrating photovoltaic (CPV) system uses a large area of lenses or mirrors to focus sunlight on a small area of photovoltaic cell. The primary attraction of CPV systems is their reduced usage of semiconducting material which is expensive and in short of supply. Additionally, increasing the concentration ratio improves the performance of general photovoltataic materials and also allows for the use of high performance materials such as gallium arsenide. Despite the advantages of CPV technologies their application has been limited by the cost of focusing, tracking and cooling equipment.

At 14 suns, the open circuit voltage for the concentrator CIGS solar cell was reported 736 mV with fill factor and efficiency 80.5% and 21.5% respectively [1] way back in 2002. Later, 41.1% conversion efficiency of solar cell was reported underconcentrated sunlight.[2]

High temperature solar systems use various mirror configurations to concentrate the light and then convert the sun’s energy into high-temperature heat. The heat can be converted into electricity through a generator, or it can be used to drive chemical reactions. A plant consists of three parts: an optical system that collects and concentrates the light, a receiver or reactor that converts the light to heat, and an “engine” that convert heat to electricity or “reactor” that converts heat to chemical potential.[3]

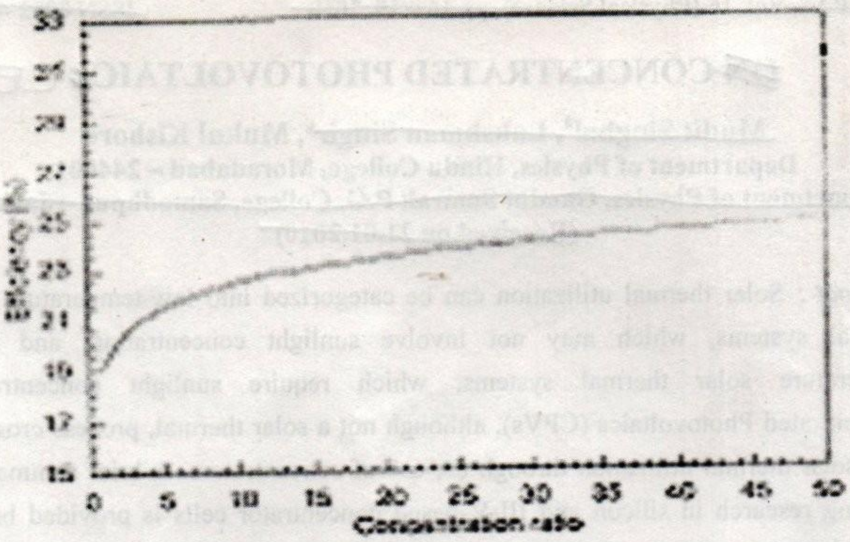
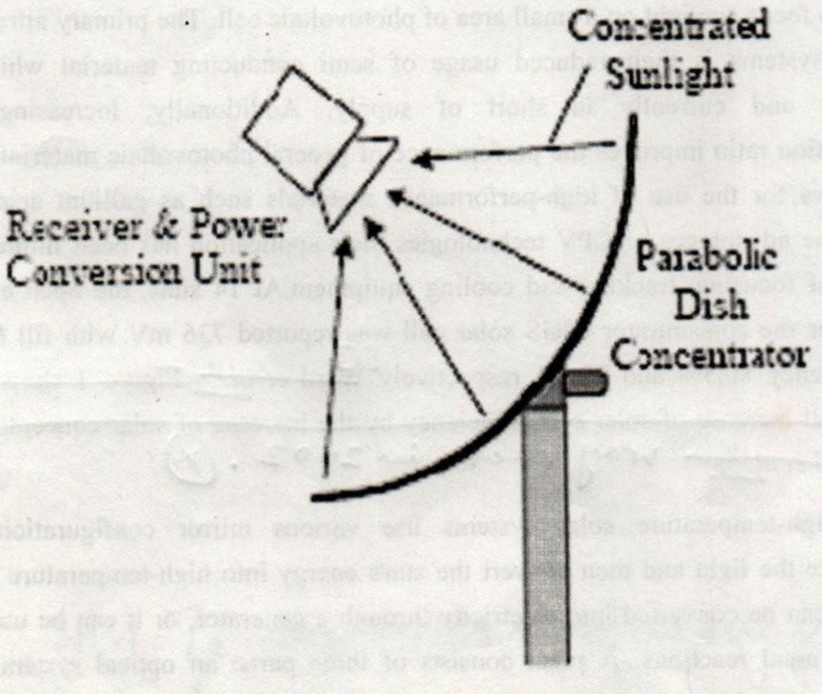


Figure – 1 : **Exponential Increase in Efficiency of Solar Cell as a Function of Concentration Ratio.**



Solar Thermoelectric Power Generator: Direct thermal-to- electric energy conversion engines based on thermoelectric devices and thermo-photovoltaic (TPV) energy converters provide new opportunities for medium power ranges that may reveal direct photovoltaic (PV) power conversion and involve no moving parts.

Thermoelectric energy conversion technology, based on the Peltier effect and the Seebeck effect, exploits the thermal energy of electrons (and holes) for the energy conversion between heat and electricity, including power generation, refrigeration, and heat poumping.[4].

A thermoelectric power generator has a maximum efficiency given by

$$\eta = \frac{T_h - T_c}{T_h} \frac{\sqrt{1+ZT_m} - 1}{\sqrt{1+ZT_m} + T_c / T_h}$$

where, T_h,T_c= temperatures at the hot and cold sides, T_m=mean temperature, Z= measure of the electronic power produced by the thermal gradient, divided by the thermal conductivity.

The product of Z and the working temperature T forms a non dimensional figure of merit ZT. With a value of ZT between 3 and 4, thermoelectric devices would have an efficiency approaching that of an ideal heat engine. Thus, the key for the thermoelectric technology is to find materials with ZT>3. Materials with reasonable ZT are often heavily doped semiconductors and some semimetals. The ZT value of a given material is temperature dependent; it usually peaks at certain temperature and drops off at higher temperatures. Illustration of a solar-thermoelectric power generation is shown in Figure-2.

The efficiency of a TPV power generator system can be roughly split into several factors:

$$\eta = \eta_{source} . \eta_{spectral} . \eta_{diode} . \eta_{mech}$$

where, η_{source} = efficiency of the conversion of the energysource (fossil, solar, nuclear) into thermal radiation from the

emitter, $\eta_{spectral}$= combined efficiency of the emitter and filter thatrepresents the fraction of photon energy above the band gapo

reaching the PV cell among all photon energy emitted, η_{diode} =efficiency of the PV cell converting the photon energy above the

band gap into electricity, η_{mech} = efficiency of converting PV cell electrical power output to the system power output that includes the energy lost in the pumping systems for fuel injection and thermal management.[5]

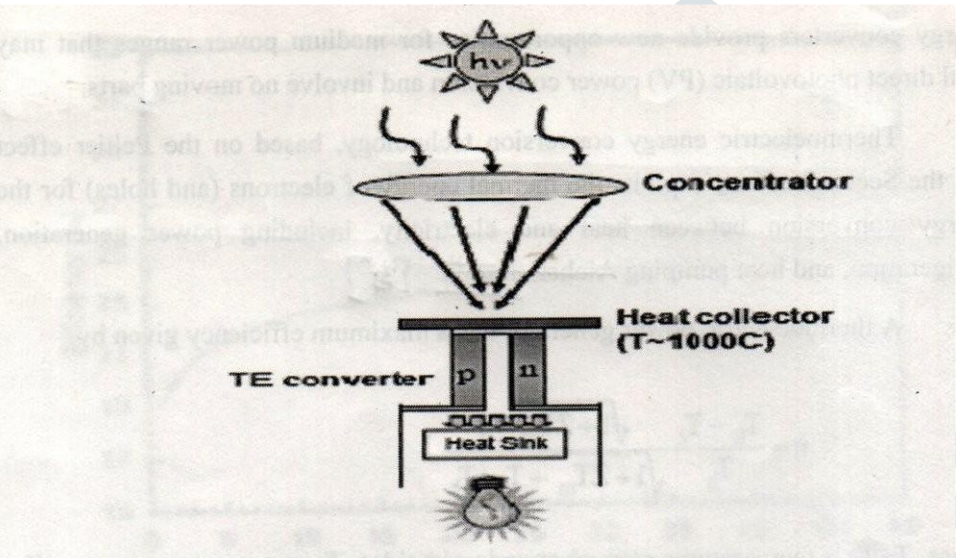


Figure – 2

Conclusion: Materials for construction of solar thermal reactors require chemical and thermal stability at temperatures >1,500°C and solar radiative fluxes >5,000 suns. Advanced ceramic materials and coatings are needed for operating in high- temperature oxidizing atmospheres and for withstanding severe thermal shocks occurring in directly irradiated solar reactors. The development of high-temperature materials for solar reactors has moved ahead from early stages. Progress in the above field is crucial in assessing the technological viability of such processes prior to the estimation of their economical feasibility.

References:-

1. Ward J.S.; Ramanathan K.; Hasoon F.S.; Coutts T.J.; Keane J.; Contreras M.A.; Moriarty T. and Noufi R. (2002): Prog. Photovolt. Res.

Appl. Vol. 10, pp 41-46.

2. Guter W., Siefer G. et.al.

   Applied Physics Letters 94(22), 223504-1-6 (2009).

3. Luque A.

   Journal of Applied Physics 110(3) 031301-1-19 (2011)

4. Aicher T.; Kastner P.; Gopinath A.; Gombert A.; Bett A.W.; Sehlegl T.; Hebling C. and Luther J.

   (2004): Proceedings of 6th Conf. on Thermophotovoltaic Generation of Electricity, Freiburg, Germany, 738, pp. 77- 78.

5. Omar Z. Sharaf and Mehmet F. Orhan

   Renewable and sustainable energy reviews, vol. 50, Page 1500-1565, Oct. 2015.