



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 11, November 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Experimental Investigation of Thermal Performance of Light Weight Solar Concentrator

Jaydeep M Khade¹, Vijay J Dhembare², Sanket V Bhosale³

Department of Production Engineering, D Y Patil College of Engineering, Akurdi Pune, India

ABSTRACT: This is the time when India has to think about capacity enhancement of energy security. This can be achieved with encouragement to use of non conventional energy sources like solar energy. Intense study and research in the field of solar energy have resulted into use of solar energy for domestic purpose. The commercial use of solar energy is not so popular due to its low efficiency and more ROI. The researchers showed that efficiency can be enhanced with hybrid PV+T technology which increases gain of solar energy per unit carpet area. In this research work line focusing concentrator for PV+T solar system is designed and analyzed for its performance. The attempts are made to make concentrator of light weight by replacing existing traditional base materials like steel, aluminum by Fiber reinforced plastics. The materials are tested for its strength and computer simulations were helped to decide thickness of concentrator. The state of art has been achieved by replacing reflecting mirrors by light weight polymer reflecting sheets. The concentrator tested for its optical efficiency and energy gain. The result shows that the system gain increased by four times as compared to normal PV system and two times when compared with normal solar thermal system. In addition to this weight of the concentrator is reduced by 50% which can reduce parasitic load on solar system.

KEYWORDS: Solar energy, concentrators ,FRP, plane focus, polymer reflectors.

1. INTRODUCTION AND LITERATURE REVIEW

Solar energy is most popular source from other non conventional energy resources as they are convenient to decentralize, install and maintain. The research in solar energy is going on from the invention of solar photovoltaic effect which is discovered by Alexander Edmond Becquerel in 1839 to till date and will go on, to serve technology with more efficiency. Solar Photovoltaic and solar thermal are two conventional tracks of solar energy utilization while, solar PV+T is emerging technology. As concentration on PV cell increases its operating temperature increases (Mark A Schuetz , 2012, Yun da, Yimin Xuan ,2012). Temperature can be maintained with air or water based PV +T system (Hegazy, 2000 and Devtore,2013). The heart of PV+T system is it's concentrator , high concentration (models with 57,47,37 sun) requires high performance heat removal system and are difficult to maintain as compared to medium concentration systems (Han et al.2010). Performance of concentrator model composed with Fresnel lens and mirrors is evaluated for it's thermal as well as electricity gain (Kong & ZilinXu et.al, 2013) . Different materials are tested for its optical properties (Philipp Good,2016). Further research on PVT receiver have been carried out with linear concentrator with efficient reflective material (Stanley, 2000). The comparison of line focusing concentrators with point focusing concentrators have been carried out for it's overall gain and optical efficiency (Vashi Sharma,2015). The literature for making PV+T system more efficient and user friendly is investigated (More et.al,2015). The literature study shows that ample amount of work has been done on PV+T concentrator design but no attempt had been made to make concentrator with different material other than conventional materials like C.I , aluminum which reduces additional load on generated power. In present research work non-conventional material is used with integrated characteristics. The views of manufacturability and maintenance also have to be taken into account while designing concentrator for application based PV+T systems.

II. PV+ T SYSTEM

The present commercial solar energy utilization systems are either photovoltaic or Thermal systems. The trend of combining these two system facilitates more gain from the same area. However these types of system are difficult to construct and the research to increase their performance is the challenge for the researchers in this area. The system should be designed to increase electric gain with concentration but as concentration increases efficiency of solar cell

decreases due to rise in temperature. This may often lead to drastic reduction in life of solar cells. Therefore removal of this heat becomes essential as concentration level goes on increasing. On the other hand the receiver should collect the thermal energy reflected by the concentrators. This can be possible only with specially designed concentrators.

2.1 Concentrators

The main objective of concentrator is to direct incident solar energy on receiver of the solar system.

Though there are many types of concentrator viz. flat plate, parabolic dish type, hyperbolic, Fresnel lense, its selection is based on the design demand of solar system. Following are the requirements of good concentrator

1. It should withstand wind load.
2. It should have smooth surface finish.
3. It must be rigid as well as light in weight.
4. It should be easy to manufacture and maintain.

PV+T system developed is equipped with special purpose concentrator which is line focusing parabolic concentrators whose ray diagram is shown in fig. below.

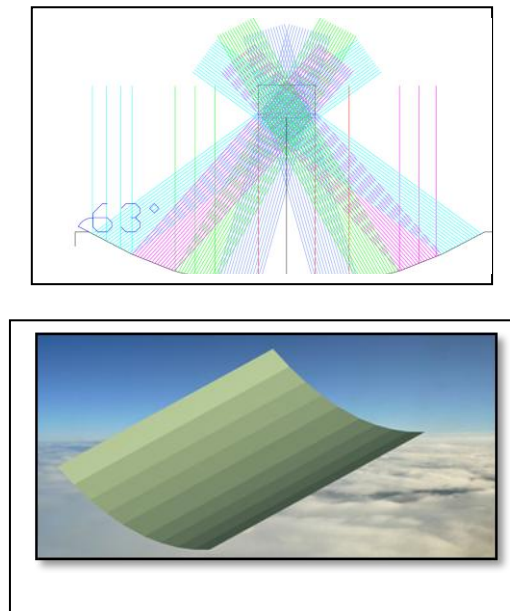


Fig. 1

Ray Tracing diagram and isometric view of Line focusing parabolic through concentrator.

Base material of solar concentrator is Galvanized Iron sheet, Aluminum etc. The base materials need to be changed to make system light weight without compromising in the quality of surface finish and strength of material. Reduction in material weight ultimately reduces the load on generated power consumption for track and trace system.

2.1.1 Material Selection:-

The solar concentrator material should require good surface finish, corrosion resistance, high impact strength, Light weight, dimensional stability, high dielectric strength and low moisture absorption tendency etc. In addition to these properties in order to percolate the solar system in society the material should be easily available, low cost and should have local manufacturability.

Fiber reinforced plastic is the material which could satisfy all above requirements hence the FRP material is tested for its impact strength and the result of the same are shown in table below.



Table 1 Result of Impact Test

Sr.no.	Material of Specimen	Impact Strength by Izod test (Kgm)	Impact Strength by Charpy test (Kgm)
1	FRP(green)	2.6	1
2	FRP(blue)	2.2	1.2

Table .2 Comparison of FRP and Aluminum Properties

Parameter	Fibre glass (FRP)	Aluminium
Tensile strength	11.3 kg/mm	10.4 kg/mm
Maintenance	Free from corrosion so average maintenance	It corrodes so requires frequent maintenance
Temperature effect	Temperature effect is nil	Shape deforms due to linear expansion/contraction of al.
Electricity conduction	Highly bad conductor of electricity	Highly good conductor of electricity
Cost	slightly High- for instant, but for Long-term it is Cheaper	Cheaper- for instant, but for Long-Term it is Higher
Reliability	overall –reliability is high	overall–reliability is low

Thus the qualitative analysis of the table shows that, fiber reinforced plastic can be chosen as a base material.

2.1.2 Reflector Material:

Reflector material guides the solar incident radiation for collection at the receiver end. Reflector material also captures the diffused radiation. The reflective material of the concentrator should have more reflectivity (more than 0.9), light in weight, more thermal stability, high resistance to oxidation, easy to handle, easy to maintain. The materials now in used are

1. Glass mirror
2. Aluminum coated polymer
3. Silvered – polymer reflector materials
4. Silvered Teflon reflector material
5. Polymer multilayer reflector material

The aluminum coated polymer sheet of 3M is used here which is having high reflectivity 0.94-0.96. This material is comparatively low cost than silver coated sheets, easy to handle and self cleaning ability.

III. DESIGN OF CONCENTRATOR

Simple parabolic concentrator has been designed with focal length 1100mm and with 7X concentration. The Thickness of the Fiber Reinforced concentrator is decided by considering drag force and lift force derived from wind tunnel testing of the concentrator module. For the rays incident on the reflector plane, Incident ray, reflected ray and the normal at the point of incidence all lie in the same plane.

Angle i = angle r.....(I)

Length of plane= length of focal plane/3

For parabola,

$y = 4X^2$

Where, y –vertical dimension

X horizontal dimension of parabola

As tracker is introduced to continuously position the plane so that the incident rays will always perpendicular to the plane of reflector. As in equation I, the angle of inclination of the plane from the horizontal Θ is given by plotting ray diagram as shown in fig below. The size of concentrator is calculated to generate 1KW power (PV+T)

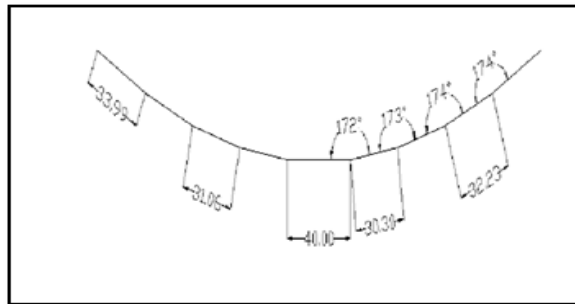


Fig. 2 specially designed line concentrator

IV. DEVELOPMENT OF CONCENTRATOR

Concentrator is fabricated by hand layup method. According to area and thickness of concentrator resin and hardeners are chosen from manufacture’s chart. Following Steps had been followed for development of FRP concentrator.

1. Aligning for Size

- First align properly 1mx1m laminated paper on table.

2. Preparation of Binder and Matrix

- Take mixture of polyester resin, cobalt Napthelet, M.E.K.P(1.2kg,15ml,15ml)
- Curing period depends on concentration of hardener.
- Apply above mixture on laminated paper.

3. Hand Layup.

- Add 680gm CSM (chopped silicon matrix) on above layer.
- Again apply resin on glass wool & apply mixture up to required thickness.

4. Curing

- Place laminated paper on above layer.
- Remove air bubbles by pressing roller on paper.
- Place this sheet in mould

5. Finishing

- Remove Sheet after four hours from mould.
- Remove Extra fibers from edges.

After mounting FRP model on supporting structure reflector sheet gets pasted uniformly conforming there is no air trap between the two surfaces.

V. TESTING OF CONCENTRATOR

Impact test for material testing had been already carried out. Surface finish test will ensure optical efficiency of concentrator. The actual implementation will check actual gain.



Table 3 solar gain

Time In Minute	PV without concentration	PV with Concentrator	Thermal with concentration	PV+T with concentration
0	0	3.12	304.584	304.584
5	3	6	297.4152	297.4152
10	6.4666	8.94	320.4528	320.4528
15	9.62	11.84	263.06	263.06
20	12.546	14.76	316.224	316.224
25	15.477	17.688	319.152	319.152
30	19.11	20.58	271.8	271.8
35	21.75	23.2	274.42	274.42
40	24.14	25.56	251.658	251.658
45	23.14	26	201.854	201.854

5.1 Surface finishes Testing:

Rough surface will deflect incident radiation in different direction instead of reflecting on receiver surface. This makes important to make smooth surface of FRP concentrator. The most care was taken while fabricating concentrator base of FRP by hand lay-up method. The roughness of the fabricated surface is measured by using surface roughness tester. In surface roughness the tester shows Ra = 0.253 micron.

5.2 Testing for Solar Gain

Photovoltaic gain, Thermal gain and PV+T gain calculated by taking separate observations by keeping same input to the system. The performance of the system was checked with concentration and without concentration for PV, Thermal as well as PV+T system with the specially designed concentrator. The observations are taken at latitude 17° and longitude 74.26°. The observations were recorded in March from 7 am to 5 pm. The wind speed measured by anemometer was 8.25 m/s and at an angle of 250.52°.

Photovoltaic gain

$$Q = V * I$$

Thermal gain

$$Q = m * Cp * \Delta T$$

$$Q_{total} = Q_{photovoltaic} + Q_{thermal}$$

$$Efficiency = \frac{Total\ Gain\ of\ Energy}{Area\ of\ concentrator}$$

VI. RESULT AND DISCUSSION

The Analysis of solar energy gain calculation shows that solar gain increases with increase in concentration ratio. Thermal system has higher gain as that of electrical systems. Thermal gain can be again increased with concentration. Photovoltaic+ Thermal gain with specially designed concentrator increases solar energy conversion 20%. The average gain by PV+ T system with specially designed PV+T concentrator is 600watt which can fulfill much of the demands of

commercial and industrial users also. Thermal gain of about 300 watt can be used to process industries or for refrigeration .More the concentration more will be gain but even distribution of intensity on PV cell is challenging task and the care should be taken in while designing concentrator. The graph of analysis of the system for different output is shown in figure below.

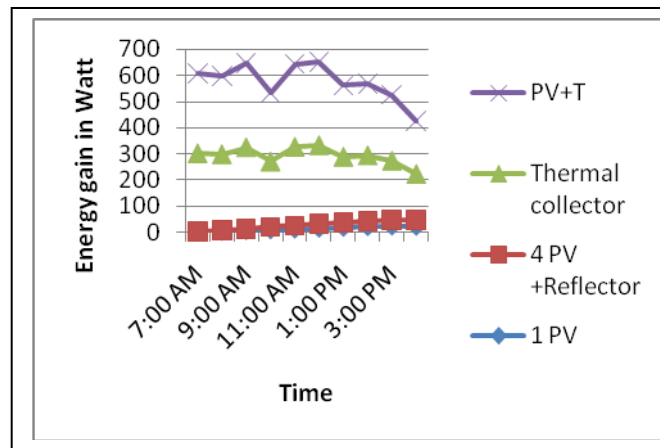


Fig.3 Analysis of systems with specially designed concentrator for PV+T system

VII. CONCLUSION

There is less foot print area utilization for photovoltaic + thermal unit which increases overall gain of solar energy. Upper and lower arrangement for mounting makes use of almost all incident radiation falling on the same area. This technologically improved combi system can be used for different applications like electrification + water heating, water cooling + water heating + electrification, refrigeration + water heating +electrification etc.

REFERENCES

1. Mark A Schuetz (2012), A. Shell, Scott A. Brown, Gregory S. Reinbolt ,“ Design and construction of a 7 X Low concentration photovoltaic’s system based on parabolic Concentrators”, Journal of Photovoltaics , IEE vol 2.issue 3382-387.
2. Yun da,Yimin Xuan (2012), “Effect of temperature on performance of nanostructured silicon thin film solar cells”, Solar Energy 115109-119
3. Hegazy, A.A. (2000). Comparative study of the performances of four photovoltaic/thermal solar air collectors. Energy Conversion and Management, vol. 41, p. 861-881, DOI:10.1016/S0196-8904(99)00136.
4. V.V. Deotare, D.V.Padole , S.K. Sawant, (2013) “High efficiency auto tracking solar combined heat and power generation system”, Indian journal of applied Research vol.3 issue 7 , 221.
5. Xinyuen Han, Vernie Everett, Yiping Wang, Li Zhu(2010), “Numerical Analysis of direct liquid immersed solar cell cooling of a linear concentrating”, Photovoltaic Specialists Conference (PVSC), 35th IEEE.
6. Chengdong Kong , Zilin Xu,(2013), "Outdoor performance of low concentrated photovoltaic thermal hybrid system with crystalline silicon solar cells", Journal of Applied Energy , 618-625.
7. Philipp Good, Thomas Cooper, Marco Querci, Nicolay Wiik, Gianluca Ambrosetti, Aldo Steinfeld(2016), “Spectral reflectance, transmittance, and angular scattering of materials for solar concentrators”, Solar Energy Materials and Solar Cells ,Volume 144, 509–522.
8. SatyenK.DeB (2000),“Recent Developments in High Efficiency PV Cells ”, the World Renewable Energy Congress VI Brighton, U.K. July 1-7, 2000.
9. Vashi Sharma,Jayanta K. Nayak , Shireesh B. Kedare(2015), “Comparison of line focusing solar concentrator fields considering shading and blocking”, Solar Energy Volume 122, 924–939
10. CameronStanley,Ahmad Mojiri, MirzaRahat, Andrew Blakers, Gary Rosengarten (2016), “Performance testing of a spectral beam splitting hybrid PVT solar receiver for linear concentrators”, Applied Energy Volume 168, Pages 303–313.
11. Supriya Sagar More , G.Ravindranath , Sagar Eknath More (2015), “RECENT TECHNOLOGICAL DEVELOPMENTS IN PV+THERMAL TECHNOLOGY: A REVIEW”, International Journal of Research in Engineering and Technology, volume 4,issue 4,387-391.



INNO SPACE
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details