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Enhancement of Solar Panel Efficiency with the Adoption of Antireflective Coating Techniques

Rajvikram M[1]*, Leoponraj S[1] and Ramkumar S[1]
[1]Department of Electrical and Electronics Engineering, Sri Venkateswara College of Engineering, Chennai, Tamilnadu - 602117, India

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Solar, one of the major sources of renewable energy these days can also be used to generate electrical energy. Some losses occur on the surface of the solar panel and thereby reduces the efficiency and the lifetime of the solar panel. The main intention of this work is to reduce the reflective losses by coating antireflective materials and to reduce the thermal losses by selecting the necessary cooling technique from the several cooling techniques proposed. This reduction in losses consequently improves the lifetime and the efficiency of the solar panel. The antireflective chemical adopted in this method is Zinc sulfide and Silicon dioxide (ZnS-SiO_2-ZnS). The FLIR image is also included in this paper for clearly understanding the effect of antireflective materials on the solar panel. This method is the most economical and consists of several advantages compared to other methods. This work can further be improved by combining the proposed cooling techniques along with the antireflective materials.

Keywords: Thermal loss, Optical loss, Antireflective material, Cooling technique, Zinc sulphide, Silicon dioxide

Introduction

Energy in any form is indispensable in the world and of it, solar plays a major role as it is readily available in nature. The energy obtained from solar can be increased to higher values by consequently cooling the solar panel[1]. Krauter and Rajvikram M *et al* explained that various techniques have been proposed to reduce the temperature and reflective losses, a detailed analysis of those techniques is presented here[2,11]. Nicholas T *et al.* conducted an experiment by using Tealight candle as a PCM material and it was filled in the gap between aluminum tubes. With Tealight candle as the PCM material, there was only a slight increase in the efficiency[3,6]. Chao H *et al.* explains that other hybrid techniques were also constructed using Photovoltaic/Thermal, the efficiency value obtained were 35.33% and 12.77% as thermal and electrical output respectively[4,7]. Taiseer M *et al.* explains that another such advanced technology is the fins cooling, through which the efficiency value obtained is improved by 1.35%[5,8]. Rajvikram M *et al.* has also achieved the increase in efficiency of the PV by means of experimenting with heat dissipating materials such as aluminium and heatsink[9,10]. Even though these methods produce only a little increase in efficiency, the cost of manufacturing and maintenance is high.

*Author for Correspondence:
E-mail: rajvikram787@gmail.com

Inference

All the above-discussed methods in the introductory section, only reduces the temperature of the solar panel but the reflective losses were not considered which still reduces the lifetime and the overall efficiency of the solar panel. The main aim of our work is to reduce the reflective losses of the solar panel by using anti-reflective technique and increase the overall lifetime and efficiency of the solar panel. This can be considered as an economical technique as the cost of antireflective materials is less.

Selection of cooling technique using switch case programming

Algorithm

Step 1: Start.
Step 2: Declare a variable 'n' to store the efficiency value.
Step 3: Get the efficiency value and store it in the variable 'n'.
Step 4: Pass the efficiency value into the switch case
Step 5: In case 1, Display the techniques to obtain efficiency in the range of 10%-20%.
Step 6: In case 2, Display the techniques to obtain efficiency in the range of 21%-30%.
Step 7: In case 3, Display the techniques to obtain efficiency in the range of 31%-40%.
Step 8: In case 4, Display the techniques to obtain efficiency in the range of 41%-50%.

Step 9: In case 5, Display the techniques to obtain efficiency in the range of 51%-60%.

Step 10: In case 6, Display the techniques to obtain efficiency in the range of 61%-70%.

Step 11: In case 7, Display the techniques to obtain efficiency in the range of 71%-80%.

Step 12: Stop the program execution.

A flowchart extending the data given in algorithm is also included for better and easy understanding.

System description

In this work, an anti-reflective coating is used to reduce the reflective losses. A detailed report of the coating material, its properties, and choice of using this specific material are explained in the upcoming sections.

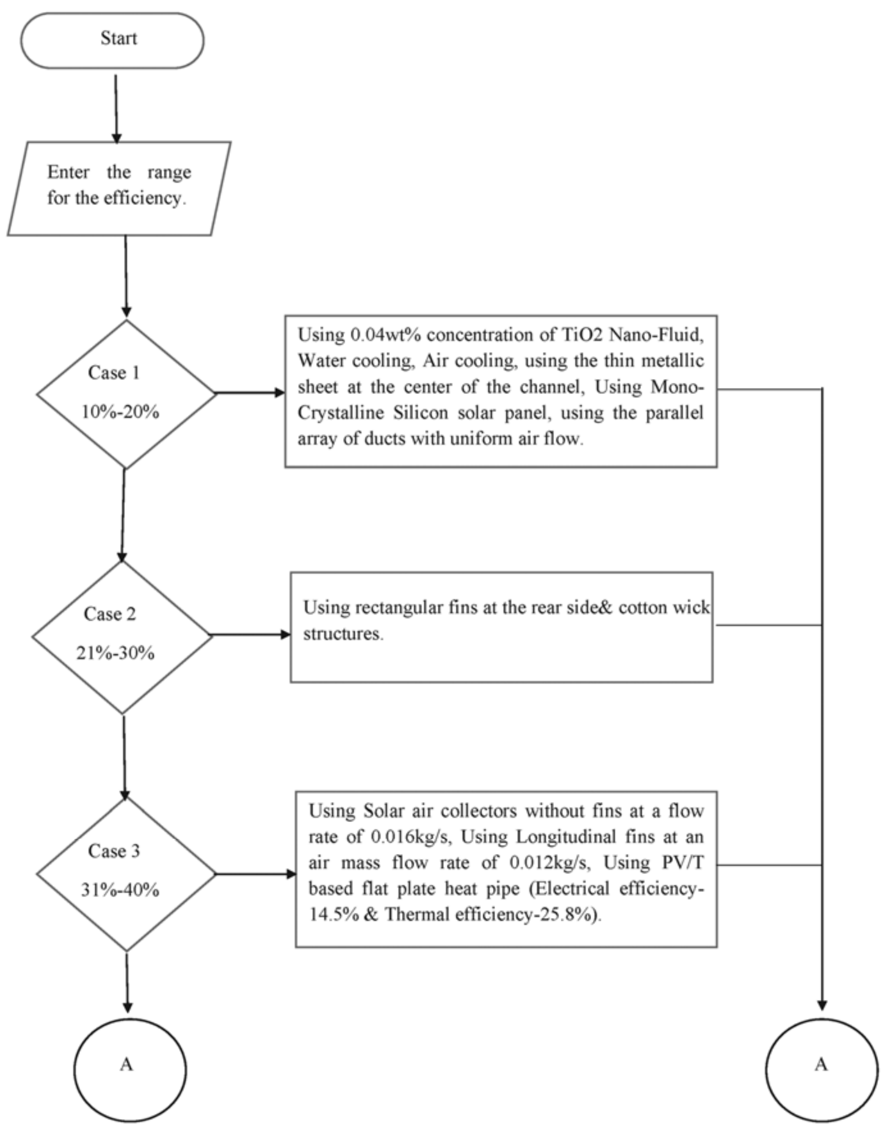
Coating material

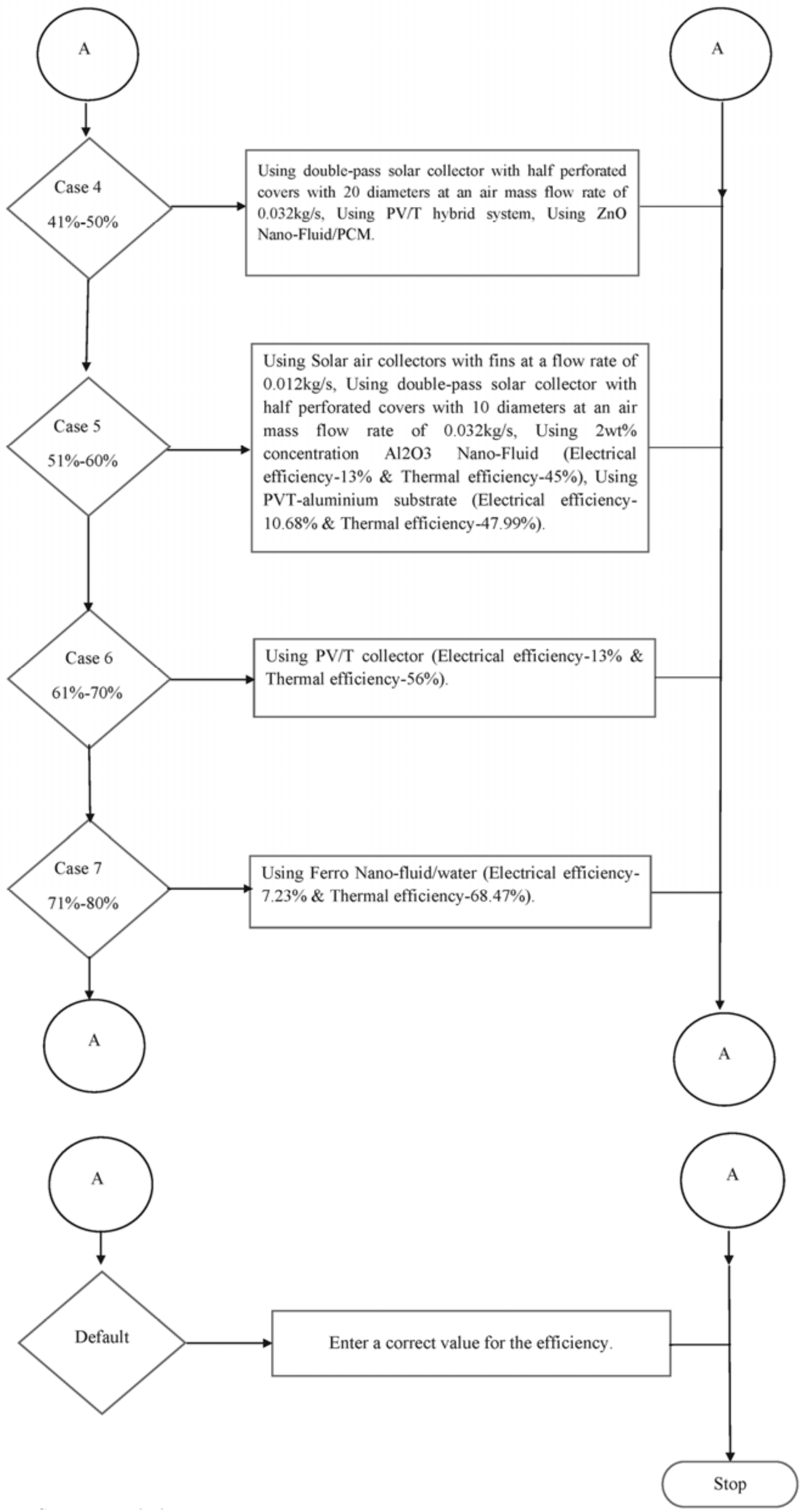
- HF (solution foretching) Coating (Each 2-layercoating)
- ZnS (toplayer)
- SiO_2(middlelayer)
- ZnS (toplayer)

Properties of the material opted

- Zinc sulphide is an efficient photocatalyst, it produces hydrogen gas from water. It has good optical properties.
- Silicon dioxide has high melting point of about 1,713°C. It passivates the surface and protects from contamination.

Flowchart





Choice of the material

They are highly non-toxic, colorless, odorless, high-temperature resistance and high anti-reflective property. These chemicals are economical and the lifetime is improved by using this chemical. Also, avoids contamination and protects the surface.

Table 1 — Overall comparison results of coated and the uncoated solar panel.

Resistance in (Ω)	40	60	80	100	200	500	1000
The uncoated solar panel under 60W lamp P (W)	5.2	3.4	2.577	2.19	0.978	0.357	0
Uncoated under solar irradianceP (W)	6.16 (11%)	4.03	3.11	2.555	1.216	0.448	0
Coated solar panel (ZnS-SiO_2-ZnS) under 60W lamp P (W)	5.9	4.41	3.18	2.26	1.156	0.369	0
Coated solar panel (ZnS-SiO_2-ZnS) under solar irradianceP (W)	6.49 (14.5%)	4.325	3.15	2.77	1.11	0.4391	0

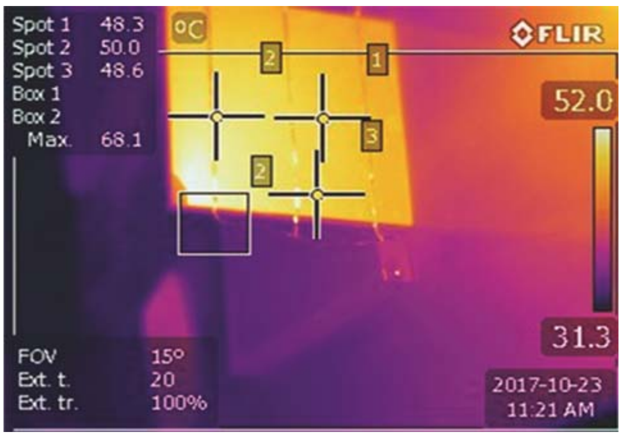


Fig. 1 — FLIR Image of the Coated Solar panel

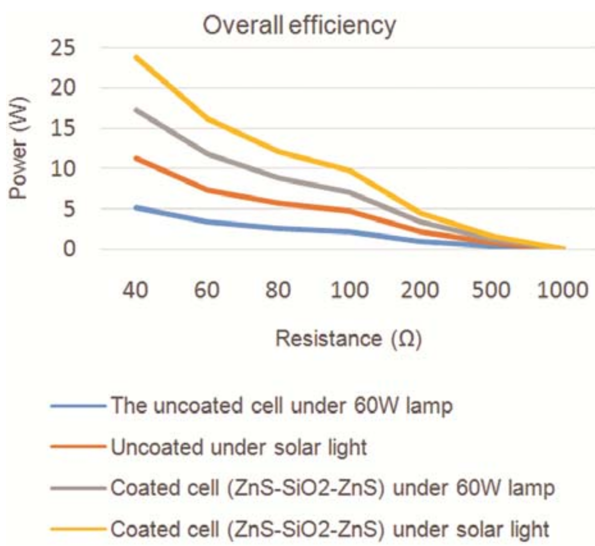


Fig. 2 — FLIR Comparison graph of coated and uncoated solar panel

Experimental procedure

The prepared coating solutions are coated on the surface of the solar panel. The solar panel is dried and then the connections are made. The V-I-P characteristics are noted down. The readings were taken for both the uncoated solar panel and the coated solar panel. The temperature difference between the coated and the uncoated solar panel were also noted down. The FLIR image (Figure 1) has been used to obtain the temperature difference between the uncoated and the coated solar panel. The experiment was performed under sunlight and also 60W light to know the effect of both the temperature and output power. It was seen that the temperature through coating reduced compared to the temperature of the uncoated solar panel.

Results and discussion

Table 1 gives the overall comparison results of the coated and uncoated solarpanel. It is seen that the efficiency value increases in case of the uncoated solar panel when compared to the coated solar panel. The uncoated solar panel under sunlight shows better effect than the solar panel under the 60W lamp. It is seen that the temperature drop for the coated solar panel is more compared to the uncoated solar panel. This drop in temperature consequently increases the power output of the solar panel which leads to increment in efficiency. The efficiency value increases by 3.5% for the coated solar panel when compared to the uncoated solar panel. Also, with increase in the resistance value, the output voltage of the solar panel increases. Also, this increase in resistance of the solar panel, decreases the output current of the solar panel. This increase in output voltage with a consequent reduction of output current in turn decreases the power output of the solar panel. With the inference from the data collected, a comparison graph for overall coated and uncoated solar panel is presented as a line chart (Figure 2).

Conclusion

There are many ongoing researches carried out for improving the efficiency of the solar panel like air cooling, water cooling, and PCM cooling. In this work, the chemical zinc sulphide and silicon dioxide are used as an antireflective agent for efficiency improvement and the results are shown in the form of graphs and table. The results show the improvement in the overall efficiency values of the solar panel. Also, the chemical elements opted are cost-effective and hence this method is economical. The FLIR imaging camera is used to capture the thermal images of the solar panel for better understanding. The anti-reflective technique reduces the reflective losses occurring in the solar panel and helps in overall efficiency improvement. Further, to reach higher efficiency values anti-reflective techniques can be combined along with the advanced cooling techniques to reduce the temperature loss and to improve the overall efficiency of the solar panel.

References

1 Lihua Ma & Zhiqiang Yin, Possible solar modulation of winter half-year temperature in the central region of eastern China during the past 2000 years, *IJMS*.**47.** (2018).

2 Krauter S, Increased Electrical Yield via Water Flow Over the Front of Photovoltaic Panels, *Sol. Energy Materials& Sol. Cells.* **5.** *(*2015).

3 Nicholas T, Wong J & Cheng, G, Experimental Study of the Efficiency of the Solar panel by Phase Change Material cooling, *Ind conference on Material Technology and Energy*. **7.** (2017).

4 Chao H & Kun Y, Experimental study of Photovoltaic/ Thermal (PVT) Hybrid Panel, *IJSGCE*.**11.** (2015).

5 Taiseer M, The Efficiency of Photovoltaic Modules Using Different Cooling Methods: A Comparative Study, *JPEE*.**5.** (2017).

6 Teo HG, Lee PS & Hawlader M, An Active cooling system for Photovoltaic Modules, *Applied Energy*.**7.** (2016).

7 Lipping T, Abhijit D & Gabriel F, Efficiency gains of the photovoltaic system using latent heat thermal energy storage, *1st Int Conference on Energy and Power*.**8.** (2016).

8 Xiao T, Zhenhua Q & Yaohua Z, Experimental Investigation of Solar Panel Cooling by a Novel Micro Heat Pipe Array, *IJEPE*.**3.**(2016).

9 Rajvikram M, Leoponraj, S, Ramkumar S, Akshaya H & Dheeraj A, Experimental investigation on the abasement of operating temperature in solar photovoltaic panel using PCM and aluminium, *Sol. Energy J.* (2019).

10 Rajvikram M & Sivasankar G,Experimental study conducted for the identification of best heat absorption and dissipation methodology in solar photovoltaic panel,*Sol.Energy J.* (2019).

11 Rajvikram M, Leoponraj S, A method to attain power optimality and efficiency in solar panel, *Beni Suef Univ. J. Basic Appl. Sci.* (2018).