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Research Paper

PERFORMANCE STUDY ON EFFECT OF NANO COATINGS ON LIQUID FLAT PLATE COLLECTOR: AN EXPERIMENTAL APPROACH

B Jaya Prakash[1]*, B Vishnuprasad[1] and V Venkata Ramana[1]

*Corresponding Author: B Jaya Prakash, ✉ jp_33@rediffmail.com

In the solar energy industry great emphasis has been placed on the development of better and efficient systems as these are utilized in the form of heat and electricity for both domestic and industry purpose. The system is integration of several sub systems namely coated solar collectors; absorbers; plates shape and size, type of coatings, and techniques of applying these coatings are major governing parameters to evaluate the performance. This paper is a proposal for a research study to analyze both theoretically and experimentally the performance of a liquid flat plate collector coated with selected Nano materials. The objectives, possible outcomes were presented along with the coating materials and their applying methods for high absorbtance and low emmitance.

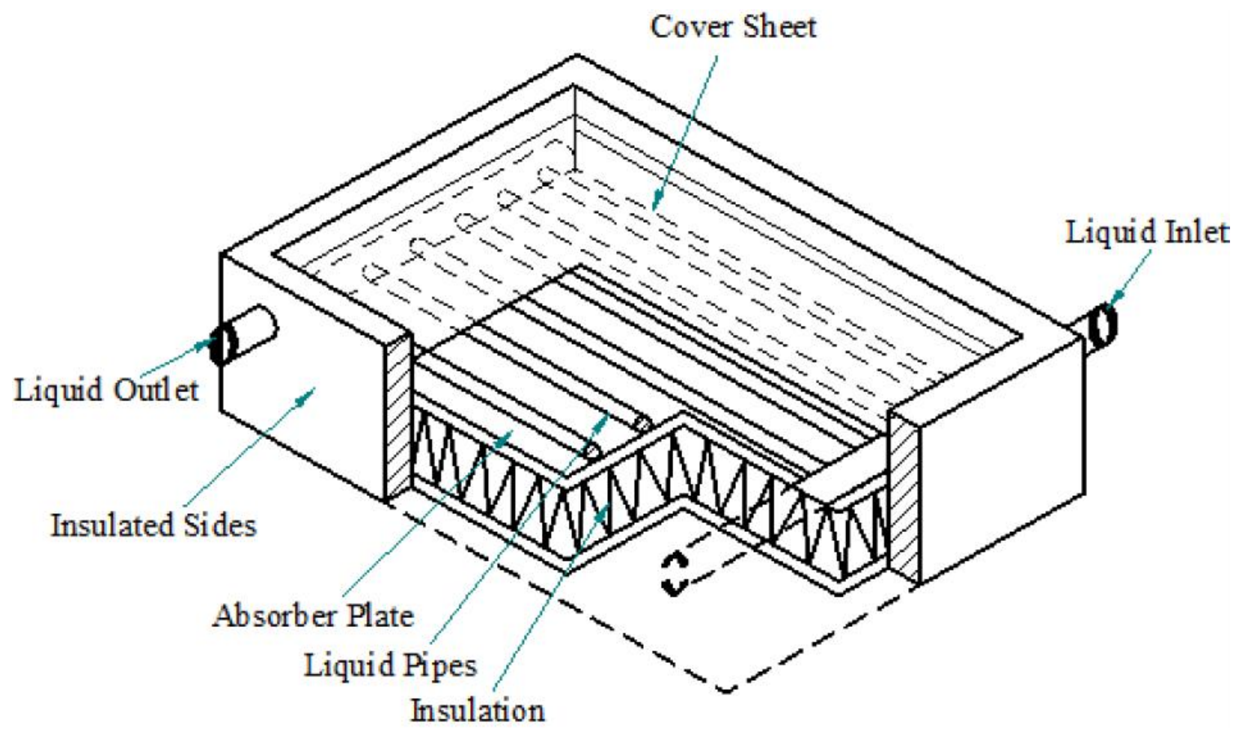
Keywords: Nano materials, Solar energy, Nano coatings, Collectors, Absorbtance

INTRODUCTION

Solar energy has always been a viable option for the energy problems faced by the world. Solar energy can give enough power to supply the earth to meet its needs. This solar radiation can be directly converted into heat energy. Many different kinds of equipment are available for this conversion. These can help lessen the impact of domestic sector on the environment. Flat plate collectors have been in service for a long time. The collector is the key element in solar energy systems which absorbs the radiation and converts into a useable form of energy that is utilized to meet a specific demand. A sophisticated system of different design models for collectors either stationary or concentrating types were developed which include Flat Plate Collectors (Figure 1), Evacuated Tube Collectors and Compound Parabolic Collectors, Parabolic and Cylindrical Trough Collectors, Parabolic Dish Reflector and Heliostat Field Collector. Among these, liquid Flat Plate Collectors are finding wide applications.

[1] Department of Mechanical Engineering, Ballari Institute of Technology and Management, Bellary 583104, Karnataka, India.

Figure 1: A Typical Liquid Flat Plate Collector



Liquid flat plate collectors are used as pre-heaters for concentrating collectors in high temperature industrial process as well residential heating systems. These are the most common water heating and space heating installations and coatings made on these collectors are of major importance. Normally the coatings are of Al, Cu, Al, Fe, Zn, Cr, etc., based which are now rapidly replacing by high performance nano coatings.

LITERATURE REVIEW

Nidal (2012), in their work on Nano paints for flat plate collectors, used Nano chromium particles with black paint, which resulted in increase of optical collector efficiency by 4.5%, efficiency slope improved by 15%, and the annual thermal performance for the modified collector improved by 11% over the existing local manufactured collector.

Bostrom *et al.* (2007) presented results on Solution chemical derived nickel alumina coatings for thermal solar absorbers, the optimal coating with nickel content of 65%, thickness of 0.1 μm and particle size of 10 nm. The absorbing layer attained a normal solar absorptance, ~ sol, of 0.83 and a normal thermal emmitance of 0.03. Adding an anti reflection layer on top of the first absorbing layer further enhanced the performance of the absorber. The optimum antireflection coated sample reached a solar absorptance of 0.93 and a thermal emmitance of 0.04.

Katumba *et al.* (2008), in their report on Solar selective absorber functionality of carbon Nano particles embedded in SiO_2, ZnO and NiO matrices, fabricated by a solgel technique. The coatings were tested on aluminum substrates. UV VIS and FTIR spectroscopies were used to determine the spectral response of the composite coatings, from which the solar absorptance and thermal emmitance were determined. The NiO matrix samples showed the best solar selective behaviour, and suggested a theoretical evaluation framework for future comparison of such materials.

Mehdi Baneshi *et al.* (2011) worked on "Comparison between aesthetic and thermal performances of copper oxide and titanium dioxide Nano particulate coatings". The authors introduced a new optimization method in designing pigmented coatings which considers both thermal and aesthetic effects. The optimization is possible by controlling the material, size and concentration of pigment particles. The proposed coatings maximize the reflectance of near infrared (NIR) region to care the thermal effects and minimize the visible (VIS) reflected energy to keep the dark tone because of aesthetic appeal. Two different types of copper oxide pigment particles namely cupric oxide (CuO) and cuprous oxide (Cu_2O) were studied. The optimum characteristics and performances obtained are compared with titanium dioxide (TiO_2) particle. The results show that cupric oxide has much better performance.

Selvakumar *et al.* (2013), in their review of Physical Vapor Deposited (PVD) spectrally selective coatings for mid and high temperature solar thermal applications, presented the state of the art of the physical vapor deposited solar selective coatings used for solar thermal applications with an emphasis on sputter deposited coatings for high temperature applications. A detailed survey has been made for the PVD deposited solar selective coatings with high absorptance and low emmitance. This review article also describes in detail about the commercially available PVD coatings for flat plate/ evacuated tube collectors and solar thermal power generation applications.

Ehab AlShamaileh (2010) proposed a selective coating composed of a nickel-aluminum (NiAl) alloy into the black paint having higher solar absorption efficiency compared to the commercial black paint coating. Optimum composition was 6% NiAl alloy by mass.

From the above discussion it can be understood that many enthusiastic researchers have done several experimentations and documented findings with Nano materials. The overall inference of the studies is Nano materials like Ni Al alloy, cupric oxide, SiO_2, ZnO and NiO matrices, chromium particles with black paint are the important metal alloys used in solar systems. But only few researchers have experimented with Nano coatings and methods or techniques used for coatings which can be addressed further. Now the purpose of this research study is to identify and analyze the Nano coatings like TiO_2 with PVD, sputtering, ECP techniques and also study the economics of the system and give a comparative statement in a meaningful manner.

OBJECTIVE

In order to carry out this proposed research work few objectives have to be framed. First of all identify the problem and develop an experimental set up accordingly. Next step is to select different Nano particle compositions for appropriate coatings and its application technique (such as Physical Vapour

Table 1: Properties of Coatings

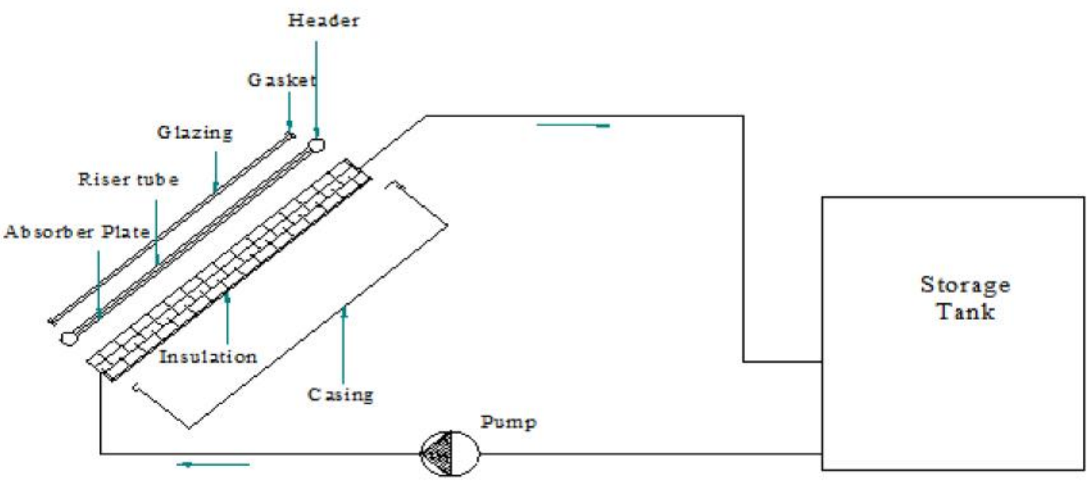
Optical Properties of Selective Coatings	Absorbtivity (~)	Emissivity (£)	~/£
Black Chrome	0.93	0.10	9.30
Black Nickel on Polished Nickel	0.92	0.11	8.40
Black Nickel on Galvanized Iron	0.89	0.12	7.40
CuO on Nickel	0.81	0.17	4.70
Co_3O_4 on Silver	0.90	0.27	3.30
CuO on Aluminium	0.93	0.11	8.50
CuO on Anodized Aluminum	0.85	0.11	7.70
Solchrome	0.96	0.12	8.00
Black Paint	0.96	0.88	1.09

Deposition (PVD) Electrochemical Methods (Evaporation and Sputtering), Painting, and Sol-Gel Process on the collector. The third step is to study the performance or efficiency of the coatings theoretically (with suitable tools) along with conduction of experiments. Further, to tabulate the results and make a comparative analysis of the collected data. Finally, establishing the efficient Nano material and technique of applying the coating for cost effectiveness and performance. Few of the selective coatings with their properties are listed in Table 1.

STATEMENT OF PROBLEM

The research study is focused to improve the performance of liquid flat plate solar collectors using novel high performance Nano coatings. The research work aims at the process of energy conversion from the collector to the working fluid which is accomplished by employing Nano coatings such as oxides of titanium, nickel, aluminum etc on the collectors. Different types of Nano coatings are selected for application on the collectors for the comparative performance analysis based on the properties exhibited by these Nano

Figure 2: Experimental Setup



materials along with cost criteria. It is learnt that the technique used for application of coatings will influence the performance of the coatings to a large extent. Therefore there is every need to address this as well.

EXPECTED OUTCOMES

It is recommended that TiO_2, with PVD, ECP, coatings can be selected for experimentation which will result in

- Both theoretical and experimental analysis may show enhancement in the performance of the collector.
- Absorbatance capacity is expected to enhance by Nano Particles.
- Nano coatings will show a positive influence on the absorbtivity and emissivity of absorber.
- Increase in the output temperature of the working fluid in the collector with the metallic coatings is expected.
- Nano coatings may allow in reduction of cost.

CONCLUSION

This article is a proposed work outlining the use of Nano coatings with different techniques which is a latest and novel approach in the field of solar systems to enhance the absorbtivity and minimize the emissivity in a liquid flat plate solar water collector using a cost effective coating techniques that could be easily applied. The requirements for the experimental set up, methods of coating the Nano materials are discussed along with possible outcomes of the study. On an overall, from the research work undertaken is that using such Nano coatings on the liquid flat plate collectors may considerably improve the performance of the solar collector.

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