PERFORMANCE PROFILE OF PHOTO THERMAL COLLECTOR WITH NANO GRAPHITE AND TIO_2 COATED ABSORBER

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ABSTRACT

Improvement in thermal performance of photo thermal collector is necessitated for its effective utilization in the energy-intensive sectors. In this connection, the present research was devoted not only to develop nano composite coated absorber and nano composite based photo thermal collector but also to generate the performance profile of the developed collector. It was found that the crystallite size in the solar absorptive coating effected on the absorber was 51nm. It was also found that the thermal enhancement on the absorber was satisfactory. The research on performance of photo thermal collector revealed that the instantaneous thermal performances were found to vary from 63% to 65% for the inlet water temperature of 30^0 C. The research on performance of photo thermal collector also revealed that the instantaneous thermal performance were found to range between 58% and 60% for the inlet water temperature of 40^0 C. It could be concluded that photo thermal collector with nano graded glass cover, nano composite coated absorber and mixed wool insulator would be preferred in the application sectors due to its improved thermal performances.

Keywords: Photo thermal collector - Nano structured absorbers - Thermal performances.

1.INTRODUCTION

The absorber is the central component of photo thermal collector. It is designed not only to absorb incident solar radiation but also to transfer the heat by means of conduction to the working fluid (1). It is desirable to enhance its absorptance by having nano absorptive coating on the absorber. It is also desirable to enhance its heat transfer by having nano composite coating on the absorber. It is worth mentioning here that the photo thermal collector with the nano composite coated absorber can yield enhanced energy gain

and improved thermal performance in field conditions (2). In this connection, the present research work was devoted (i) to prepare nano composite coated absorber (ii) to characterize the nano composite coated absorber and (iii) to generate performance profile of photo thermal collector integrated with the prepared solar absorber. The standard material and methods were adopted and the obtained research outcomes have been documented in this research paper for the benefits of manufacturers of photo thermal collectors, users of photo thermal devices and researchers worldwide (3).

METERIALS AND METHODS

In the present research, nano graphite powder was commercially procured. This powder was mixed with nano sized TiO_2 in different mass compositions. The mixed powder was stirred thoroughly in solar emulsion. The developed absorptive emulsion was spray coated with suitable flow rate on the metal absorber (4).

In the present research, the developed absorber was characterized through X-ray diffractometer and the diffractogram was generated. The crystallite size in the coating on the absorber was calculated by using the Debye-Scherrer formula that has been presented in equation (1)

$$D = K \lambda / \beta \cos\theta \qquad \text{----- (1)}$$

Where D is crystallite size, K is correction factor, λ is wavelength of X-ray used, β is the FWHM of the observed peaks and θ is the diffraction angle (5).

The experimentation on photo thermal collector was carried out and the relevant meteorological and thermal parameters were recorded. Subsequently, the thermal performance of photo thermal collector was calculated by the equation that has been presented in equation (2)

$$\eta = \dot{m} C_p [T_{out} - T_{, in}] / I A_c \qquad \text{----- (2)}$$

where $\dot{m}$ is mass flow rate, C_p is specific heat capacity, T_{out} is outlet air temperature, T_{in} is inlet air temperature, I is Incident solar radiation and A_c is area of collector.

RESULTS AND DISCUSSION

Generation of performance profile of photo thermal collector with nano graphite and nano TiO_2 coated absorber is the present research. In this connection, the nanocomposite coated absorber was developed and it was characterised. In addition, the thermal performances of photo thermal collector with the developed absorber were experimentally estimated. While the generated diffractogram of TiO_2 coating has been presented in figure 1, the measured parameters and calculated performances of photo thermal collectors have been presented in Table 1 and Table 2 respectively.

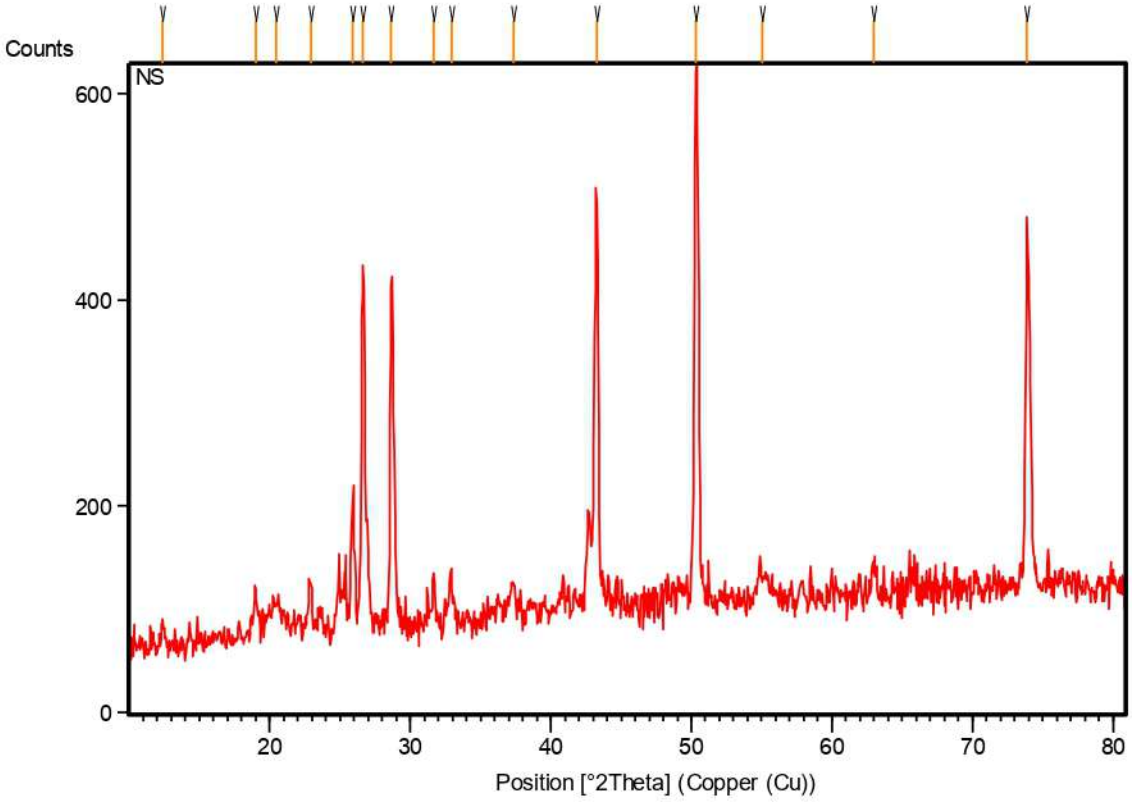

Figure: 1 Diffractogram of graphite and TiO_2 coated absorber.

Table 1 Measured parameters and calculated performances

Time (hr)	Solar radiation (W/m^2)	Wind speed (m/s)	Temperature (^0C)			Instantaneous Performances (%)
			Atmospheric temperature	Inlet water temperature	Outlet water temperature	
11:00	745.6	2.0	30.2	30.0	35.6	63 to 65
11:30	774.5	3.1	31.2	30.0	36.0	
12:30	812.5	2.4	32.4	30.0	36.2	
13.30	860.4	2.2	33.1	30.0	36.4	

Table 2 Measured parameters and calculated performances

Time (hr)	Solar radiation (W/m^2)	Wind speed (m/s)	Temperature (^0C)			Instantaneous Performances (%)
			Atmospheric temperature	Inlet water temperature	Outlet water temperature	
11:00	710.4	1.5	29.9	40.0	45.1	58 to 60
11:30	745.9	2.5	30.6	40.0	45.2	
12:30	790.6	1.0	31.2	40.0	45.6	
13.30	810.3	3.4	32.4	40.0	45.6	

In the present research, the nano composite coating was prepared and it was effected on metal plate. The crystallite size in the absorptive coating was found to be 51 nm. As the coating contained nanocrystallites, the enhanced optical absorptance and heat transfer would be expected (6). In the present research, the photo thermal collector with nano composite coated absorber was tested and the performance profile was generated. The generated performance profile revealed that the estimated performances adhered BIS specifications of photo thermal collector. The improved performances of photo thermal collector could be correlated to the enhanced transmittance due to the use of nano graded glass cover, improved absorptance due to the usage of nano composite coated absorber and improved thermal resistance due to the utilization of mixed wool in the photo thermal collector(7). It could be concluded that photo thermal collector with nano graded glass cover, nano composite coated absorber and mixed wool insulator would be preferred in the application sectors due to its improved thermal performances.

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