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Thermal Analysis On Solar Collector For Supplementary Heating Of Hot Fluid

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Abstract-Stagnation temperature, temperature enhancement of fluid and thermal performance are the key parameters and so these parameters are to be monitored in solar collector applications in connection with supplementary heating of hot fluid. In this connection, the present research was devoted to have studies on solar absorber, solar collector in stagnant conditions and solar collector in operative conditions. The research results showed that the crystallite size in absorptive coating effected on solar absorber was 36 nm. The research results also showed that the stagnation temperature of solar collector with nano structured absorber was 85.0 ^oC. The observation on research results revealed not only the termperature enhancement of fluid that varied from 5.3 to 5.7 ^oC but also the instantaneous performance of collector that ranged between 53.0 to 54.0%. It could be concluded that the solar collector with nano-structured absorber would be used for supplementary heating of hot fluid with improved thermal performances.

Index Terms- Solar collector, Stagnation temperature, Temperature of fluid, Thermal performance.

1. INTRODUCTION

The physical properties of solar absorbers determine the instantaneous thermal performances of solar collector [1]. It has been reported that the physical properties can be improved by using suitable chemical constituents in the absorptive coatings effected on solar absorbers [2]. It has also been reported that the physical properties can also be improved by using suitable sizes of chemical constituents in absorptive coatings effected on absorbers [3]. In these perspectives, the present research work was devoted (i) to estimate the crystallite sizes in the absorptive coating effected on solar absorber, (ii) to evaluate the thermal enhancements in solar collector at stagnant conditions and (iii) to assess the instantaneous thermal performances of solar collector for supplementary heating of hot fluid. The standard materials, standardized methodology and calibrated instruments were used for materializing all these objectives of the present research [4]. The research outcomes have been documented in this research paper for the benefits of researchers, manufacturers and end users of solar thermal gadgets worldwide.

2. MATERIALS AND METHODS

In the present research work, the nano structured absorber and solar collector were tested. The structural and thermal properties of nano structured absorber were studied through characterization and outdoor testing techniques respectively. The instantaneous thermal performances of the solar collector were calculated by using the formula $\eta = m_f C_p (T_o - T_i)/A_g G$ where η = efficiency (%), m_f = mass flow rate of working fluid (Kg/s), Cp = specific heat capacity (J/kg°C), T_o = outlet temperature of the working fluid (°C), T_i = inlet temperature of the working fluid (°C), A_g = gross area of collector (m^2) and G = incident solar radiation (W/m^2) [5].

3. RESULT AND DISCUSSION

The present research was conducted to study the physical properties with special reference to structural and thermal properties of solar absorber and collector. While the stagnation temperature has been presented in Table 1, the temperature enhancement of hot fluid and thermal performances of solar collector for supplementary heating of hot fluid have been presented in Table 2 and Table 3 respectively.

Table 1. Stagnation temperature in solar collector.

Time	Solar radiation (W/m^2)	Stagnation temperature (^oC)	Time	Solar radiation (W/m^2)	Stagnation temperature (^oC)
08:30	321.6	37.2	12:30	795.6	82.0
09:00	346.7	40.5	13:00	798.3	85.0
09:30	380.5	46.8	13:30	720.4	85.0
10:00	461.8	54.1	14:00	682.2	85.0
10:30	510.5	65.9	14:30	534.6	84.1
11:00	622.3	72.0	15:00	428.7	82.0
11:30	680.9	79.7	15:30	361.9	81.8
12:00	730.2	81.6	16:00	310.1	81.0

Table 2. Increase in temperature of hot fluid in solar collector

Time	Solar radiation (W/m^2)	Ambient temperature (^oC)	Wind speed (m/s)	Temperature of fluid (^oC)	
				Inlet	outlet
11:00	790.8	30.0	1.6	60.0	65.3
11:30	798.6	30.2	1.3	60.0	65.5
12:30	809.7	30.5	0.8	60.0	65.6
13:00	821.8	30.6	0.6	60.0	65.7

Table 3. Instantaneous thermal performances of solar collector for supplementary heating of hot fluid

Inlet temperature of working fluid (^oC)	Instantaneous thermal performance of solar collector (%)
60.0	54.0
60.0	53.4
60.0	53.2
60.0	53.0

The solar absorber was characterized through X-ray diffractometer and the crystallite size was estimated to be 36 nm. As the crystallite size was in nano range, the enhanced absorption of solar radiation and hence increased stagnation temperature of solar collector and improved instantaneous thermal performances of solar collector for supplementary heating of hot fluid would be harvested.

The developed solar collector was tested in stagnant conditions. It was tested at equal intervals of time during sunshine hours. The stagnation temperature of the solar collector was found to be 85.0 ^oC. The developed solar collector was also tested with high temperature fluid of 60.0 ^oC. It was tested at equal intervals of time before and after solar noon. The increase in temperature of fluid varied from 5.3 to 5.7 ^oC. Subsequently the thermal efficiency was calculated by using the measured parameters such as increase in temperature of fluid, mass flow rate of fluid and incident solar radiation. The average instantaneous thermal efficiency for supplementaty heating of hot fluid was calculated to be 53.4%. The acquired stagnation temperature, attained thermal enhancement of fluid and apprehended instantaneous thermal performances of solar collector could be attributed with absorptive properties of components, heat transfer characteristics of components and physical efficacy of components [6]. They could also be attributed with chemical constituents of the absorptive coating, sizes of constituents of absorptive coating and structural characteristics of the absorptive coating effected on solar absorbers used in solar collector [7].

4. CONCLUSION

It could be concluded that the solar collector with nano-structured absorber would be used for supplementary heating of hot fluid with improved thermal performances.

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