INFLUENCE OF OPERATIVE TEMPERATURE OF NANO COBALT AND CHROMIUM COATED ABSORBER ON THERMAL PERFORMANCE OF SOLAR COLLECTOR

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doi: 10.48047/ecb/2023.12.si4.1008

Abstrat:

Thermal investigation on solar absorber and collector is necessitated for optimizing their utilization in application sectors. Temperature enhancement of fluid, thermal performance and Stagnation temperature are the key parameters and so these parameters are to be absorbed in solar collector applications in connection with supplementary heating of air as hot fluid .The research results showed that the operative temperature of nano cobalt and nano chromium coated absorber varied from 28.6 ^{o}C to 31.4 ^{o}C.. The research results also showed that the stagnation temperature of the solar collector was 213.4^{o}C and the range of increase of temperature of fluid was from 4.2 to 5.3^{o}C. The observation on research results showed that the instantaneous thermal performance of solar collector ranged between 57.5 and 59.5% for the inlet fluid temperature of 35.9^{o}C. As the thermal performance of the solar collector was directly proportional to operative temperature of solar absorber, it could be concluded that nanocobalt and chromium coated solar absorber would be integrated in solar collector so as to reap improved thermal performances.

Keywords: Operative temperature of absorber – Thermal performance of solar collector

Introduction:

The absorber is the central component of any solar collector. Solar absorbers physical properties 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].In this connection, the present research work was devoted (i) to estimate the operative temperature of solar absorber, (ii) to evaluate the stagnation temperature of solar collector and (iii) to assess the instantaneous thermal performances of solar collector.

Materials and methods

The test samples of the present research investigation included (i) nano structured absorber and (ii) solar collector integrated with the nano-structured absorber. While the physical parameters of absorber were measured, the thermal parameters of the absorber were monitored in outdoor conditions. The solar collector was tested as per BIS specifications [2] and 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) [3].

Result and discussion

The present research was conducted not only to study the thermal properties of solar absorber but also to study the thermal performances of solar collector. In this connection, the technical specifications of the nano- structured absorber have been tabulated in Table 1 and thermal properties of the nano-structured absorber in outdoor conditions have been tabulated in Table 2. At the same time, the stagnation temperature, thermal enhancement of working fluid and instantaneous thermal performances of solar collector have been tabulated in Table 3.

Table 1: Specifications of solar absorber

Parameters	Material, chemicals and sizes
Material	Mild steel
Coating composition	Nano cobalt and nano chromium
Thickness	0.5 mm
Size of absorber (Pilot scale)	965 mm x 1806 mm

Table 2: Thermal properties of solar absorber

Time	Solar radiation (W/m^2)	Temperature (^oC)	
		Operative temperature	Stagnation temperature
10.00 am	472.9	32.5	141.1
10.15 am	522.4	33.1	144.5
10.30 am	536.7	34.5	147.3
10.45 am	555.1	34.4	155.4
11.00 am	593.3	34.5	164.4

11.15 am	617.1	34.6	182.2
11.30 am	636.8	34.8	195.6
11.45 am	634.7	35.2	198.7
12.00 noon	655.5	35.3	203.6
12.15 pm	666.9	35.5	204.3
12.30 pm	682.4	35.7	207.2
12.45 pm	715.4	35.8	208.7
13.00 pm	728.6	33.8	212.1
13.15 pm	662.2	31.9	214.7
13.30 pm	680.1	31.6	217.9
13.45 pm	582.5	31.4	213.4
14.00 pm	527.2	30.5	213.4
14.15 pm	538.6	30.6	213.4
14.30 pm	475.4	29.2	213.4
14.45 pm	472.2	29.5	213.4
15.00 pm	465.9	28.3	213.4

Table 3: Thermal performances of solar collector

Time	Solar radiation (W/m^2)	Ambient temperature(^oC)	Temperatureof fluid (^oC)		Instantaneous thermal performance(%)
			Inlet	outlet	
12.30 pm	702.2	36.9	35.9	104.9	59.5
13.00 pm	544.2	35.7	35.3	101.7	
13.30 pm	417.3	34.5	35.1	98.7	
14.00 pm	504.1	33.7	33.7	93.9	
14.30 pm	561.1	32.4	32.5	90.5	
15.00 pm	428.3	30.4	31.1	86.9	

The nano cobalt and nano chromium coated absorber was characterised. By using the characterisation results and Debye Scherrer formula, the crystallite size was calcuated. The calculated crystallite size was 22 nm. As the crystallite size was in nano range, the number of crystallites in coating that had been effected on aperture area of absorber. This would have caused enhanced absorption of solar radiation and so there would be increased operative temperature of solar absorber, improved stagnation temperature of solar collector and improved fluid temperature in solar collector [2].

The nano cobalt and nano chromium coated absorber was tested. It was tested at equal intervals of time with variations in meteorological conditions. The operative temperature of solar absorber was observed to vary from 28.6^{o}C to 31.4 ^{o}C. The developed solar collector with nano cobalt and nano chromium coated absorber was also tested in stagnant and working conditions during sunshine hours. The stagnation temperature of the solar collector was noted to be 213.4^{o}C and the increase in temperature of fluid was noted to vary from 4.2 to 5.3^{o}C. All these operative, stagnant and fluid temperatures were found to be higher than those of the conventional solar collectors. The instantaneous thermal efficiency of solar collector was calculated. It was noted to range between 57.5 and 59.5 % for the inlet fluid temperature of 35.9 ^{o}C. The noted operative temperature, obtained stagnation temperature and obtained fluid temperature could be correlated with increased absorption of incident radiation, improved radiation to heat conversion and improved efficacy of components [3]. They could also be attributed with chemical constituents in absorptive coating, sizes of crystallites in absorptive coating and efficacy of absorptive coating effected on solar absorber used in solar collector [4]. As the thermal performance of the solar collector was diretly proportional to operative temperature of solar absorber, it could be concluded that nanocomposite coated solar absorber would be integrated in solar collector so as to reap improved thermal performances.

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