Thermal Analyses On Solar Collector With Heat Transfer Configurations

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Abstract: The solar collectors with heat transfer configurations can be developed for their effective utilization in application sectors. In this connection, the present research work was conducted not only to prepare and incorporate heat transfer configurations with solar collector but also to experimentally assess the thermal characteristics of solar collector with the same heat transfer configurations. The research results revealed that heat transfer configurations with ribs, baffles and nano structured fins could be effectively integrated in solar collector. The research results also revealed that the temperature rise of working fluid was in the range of 16.8 to 28.4ºC in solar collector with heat transfer configurations. It could be concluded that the thermal characteristics of solar collector would be substantially enhanced with rib, baffle and nano structured fin based heat transfer configurations.

Index Terms **– Heat transfer configurations, Temperature enhancement of fluid, Performance improvement of solar collector**

I. INTRODUCTION

Solar collector is the integral part of solar thermal devices [1]. Its efficiency is to be improved so as to match partially the demand and supply of hot fluids in photo thermal application sectors. It is reported that the efficiency of solar thermal device can be improved by improving the optical absorption of incident radiation through nano structured fins [2]. It is also reported that the efficiency of solar thermal device can be enhanced by improving the heat transfer from fin to fluid through ribs and baffles [2]. In this connection, the present research work was conducted not only to develop and incorporate heat transfer configurations with solar collector but also to experimentally assess the thermal characteristics of solar collector with the same heat transfer configurations. The standard materials, methods and test instruments were used for materializing these objectives [3]. The research outcomes along with their scientific interpretation have been documented in this research paper for the benefits of producers, researchers and end users of solar thermal devices.

II. MATERIALS AND METHODS

The conventional solar collector was taken. It was attached with heat transfer configurations such as ribs, baffles and nano structured fins. In fact, the 'V' shaped metal ribs were separately prepared and they were integrated on the fin of the solar collector. The rectangular shaped metal baffles were also separately prepared and they were integrated on the fin of the same solar collector. The metal substrate of the solar collector was spray coated with nano carbon and metal carbide based nano composite. It is worth mentioning that the ribs and baffles were also coated with the same nano composite so as to reap the enhanced optical and thermal benefits.

The developed collector with heat transfer configurations was kept in the test set up and it was tested in field conditions as per specifications. It is to be noted that the parameters such as incident solar radiation, inlet temperature of fluid, outlet temperature of fluid and flow rate of fluid were periodically measured during sun shine hours. It is also to be noted that the thermal performance of solar collector was calculated by substituting the measured parameters in the formula of thermal performance [4].

III. RESULT AND DISCUSSION

The present research work was conducted not only to prepare and incorporate heat transfer configurations with solar collector but also to experimentally assess the thermal characteristics of solar collector with the same heat transfer configurations. The results of thermal analyses on solar collector have been presented in Table 1 and Table 2 respectively.

Table 1: Temperature enhancement of working fluid in solar collector

Test day	Solar radiation (W/m^2)	Ambient temperature (°C)	Wind speed (m/s)	Temperature enhancement of fluid (°C)			
				In collector without heat transfer configurations		In collector with heat transfer configurations	
				Inlet	Outlet	Inlet	Outlet
1	501 - 600	31.8	0.5	31.4	46.3	31.6	48.4
2	601 - 700	32.6	0.4	32.4	44.4	32.4	53.4
3	701 - 800	32.8	0.4	32.4	48.0	32.0	60.4
4	801 - 900	32.8	0.2	32.6	60.8	32.8	56.8

Table 2: Thermal performances and losses of solar collector

Solar collector	Values
Solar collector without heat transfer configurations	
Thermal performance	46.2%
Heat loss	4.52 W/m^2 °C
Solar collector with heat transfer configurations	
Thermal performance	49.6%
Heat loss	3.59 W/m^2 °C

In the present research, the solar collector was fabricated as per empirical specifications. The tempered glass cover of 4.0 mm thickness, 2100×1100 mm size and 82% transmittance was fixed as the top component of the collector. The absorber of 8 baffles, 40 ribs and 58 nm carbon based nano structured coating was integrated as the middle component of the collector. The rockwool of thin layers of 35 mm and 70 mm was fixed as the side and bottom component of the collector. These primary components were fixed with the support of secondary components such as channel section made of aluminium of thickness of 1.8 mm, angle section made of aluminium of thickness of 1.4 mm and bottom sheet made of aluminium of thickness of 1.0 mm. The gaskets and grommets made of EPDM were fixed in the connecting points and leakage test was conducted to ensure that there was no fluid and heat leakage from the developed collector.

In the present research, the solar collector without baffles, ribs and nano structured fins was tested at the optimized fluid flow rate in field conditions. In continuation, the solar collector with baffles, ribs and nano structured fins was tested as the same optimized fluid flow rate in outdoor conditions. The observation on test results showed that the temperature rise of working fluid was in the range of 12.0 to 18.2ºC in the solar collector without heat transfer configurations. The observation on test results also showed that the temperature enhancement of working fluid was in the range of 16.8 to 28.4ºC in the solar collector with heat transfer configurations. The temperature enhancement of working fluid in the later collector could be correlated to the presence of baffles that improved the channel length of fluid, thermal contact of fluid and also heat transfer from the fin to fluid [5][6][7]. It could also be correlated to the presence of ribs that increased the time of retention of fluid on fin, period of thermal contact of fluid and also time duration of heat transfer to the fin to fluid [5][6][7]. It could as well be ascribed with the presence of nano structured fins that enhanced the optical absorption of radiation, heating effect on fins and heat transfer to fluid [5][6][7].

IV. CONCLUSION

It could be concluded that the thermal characteristics of solar collector would be substantially enhanced with rib, baffle and nano structured fin based heat transfer configurations.

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