THERMAL INVESTIGATIONS ON CONVENTIONAL AND NANO FLUIDS IN SOLAR COLLECTOR

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Abstract

Performance of direct absorption solar collector is to be improved either by component modification in solar collector or by fluid alteration flowing in solar collector. In the present research, the fluid alteration was chosen and the conventional and altered nano fluids were used as working fluid in the specially developed solar collector. The research results showed that the temperature enhancement of conventional fluid was 4.7^{0}C in operative conditions. They also showed that the temperature enhancement of nanofluid was 5.3^{0}C in operative conditions. They as well showed that the stagnant temperature was 60.8^{0}C and 62.5^{0}C in conventional and nano fluids respectively. It could be concluded that the sizes, shapes and masses of nano particles would be carefully chosen so as to have effective application of nano fluids in solar collectors. It could also be concluded that the nano fluids would be exclusively utilized in solar collectors so as to have effective heating of fluid and application of storage of hot fluid.

Keywords: *Solar collector, Nano fluid, Thermal characteristics*

Introduction

Conventional fluids are used in solar collector for heating applications. At the same time, nano fluids can be used in solar collector for effective heating applications (Sujit Kumar Verma and Arun Kumar Tiwari, 2015). It has been reported that the nano fluids have higher density and so they have relatively higher heat absorbing capacity. It has also been reported that the solar collectors that are operated with nano fluids have relatively higher thermal efficiency (Otacicar et al., 2009). In this connection, the present research was devoted to (i) design and develop a pilot scale solar collector, (ii) assess the thermal characteristics of solar collector with conventional fluid as working fluid and (iii) assess the thermal characteristics of solar collector with nano fluid as working fluid. All these objectives were materialized and the research outcomes have been documented.

Materials and Methods

In the present research, nano sized carbon was indigenously prepared. Its average size was 52nm and its shape was found to be mostly spherical in nature. The nano particles of required amount were taken in a container and they were mixed with water. The prepared nano particles mixed solution was sonicated for about two hours. The sonicated nano fluids was used for further applications.

The black coated metal absorbers were fixed in solar collectors those had plain glasses as top component and rockwool as bottom component. The developed solar collectors were tested in field conditions and the related parameters were recorded. The working fluids were flown through the collector and the inlet and outlet temperatures of working fluids along with influencing parameters were measured (BIS, 2003).

In the present research, two experimental works were conducted. The first experimental work was related to thermal studies on fluids in flow conditions. The fluids were allowed to flow through the fluid carriers at a specified mass flow rate. The inlet and outlet temperatures of the fluids were measured with variations in meteorological conditions. Subsequently, the temperature enhancements of fluids in operative conditions were recorded (MNRE, 2007).

The second experimental work was related to thermal studies on fluids in stagnant conditions. The fluids were allowed to be stagnant in fluid carriers at a specified period of time by closing the inlet and outlet of the fluid carriers. The stagnant temperature of the fluids was measured with variations over time. Subsequently, the temperature enhancement of fluids in stagnant conditions was recorded (MNRE, 2007).

Results and Discussion

The present research was devoted not only to design and develop a pilot scale solar collector but also to assess the thermal characteristics of solar collector with conventional and nano fluid as working fluid. While the temperature enhancement in conventional and nano fluids in operative conditions have been presented in Table 1 and Table 2 respectively, the temperature enhancement in conventional and nano fluids in stagnant conditions have been presented in Table 3.

Table 1 Temperature enhancement in conventional fluid in operative conditions

Range of solar radiation (W/m^2)	Temperature of conventional fluid (^0C)	
	Inlet	Outlet
600 to 700	29.3	33.8
700 to 800	29.5	34.1
800 to 900	29.5	34.4

Table 2 Temperature enhancement in nano fluid in operative conditions

Range of solar radiation (W/m^2)	Temperature of nano fluid (^0C)	
	Inlet	Outlet
600 to 700	29.3	34.6
700 to 800	29.4	34.7
800 to 900	29.5	34.8

Table 3 Temperature enhancement in conventional and nano fluid in stagnant conditions

Time (hrs)	Temperature of conventional and nano fluid (^0C)	
	Conventional fluid in stagnant conditions	Nano fluid in stagnant conditions
9.00 to 11.00	56.2	58.0
11.00 to 13.00	61.0	63.8
13.00 to 15.00	60.8	62.5

The present solar collector was designed in such a way that it could accommodate plain glass as top component, black coated copper absorber as middle component and rockwool as bottom component. The present solar collector was developed in such a way that it could accommodate the secondary components for holding the primary components properly. The developed collector was tested with conventional and nano fluids as working fluids in operative and stagnant conditions. It was found that the temperature enhancement of conventional fluid was 4.7^0C in operative conditions. It was also found that the temperature enhancement of nanofluid was 5.3^0C in operative conditions. It was as well found that the stagnant temperature was 60.8^0C and 62.5^0C in conventional and nano fluids respectively.

The research results showed that the nano fluid had relatively higher operative and stagnant temperatures in solar collector. These research results could be correlated to design of specifications of solar collector, developmental specifications of solar collector and deployment specifications of solar collector (Soteris Kalogirou, 2007). These research results could also be correlated to structural properties of materials, optical properties of materials and thermal properties of materials of components used in solar collector (Tiwari et al., 1985). These research results could as well be correlated to radiation parameters, wind parameters and other atmospheric parameters (Duffie and Beckman, 1980). As the used solar collectors had the equal sizes, shapes and materials of integral components, the difference in thermal enhancement of working fluid could be specifically attributed with the nano constituents of working fluid, density of nano constituents in working fluid and heat absorbing capacity of nano constituents used in working fluid. So, the materials of nano constituents and density of nano constituents in working fluid would be optimized for having effective heating and hot fluid storage applications (Pravin et al., 2014, Karami et al., 2014, Ladjevardi et al., 2013).

It could be asserted that the sizes of nano particles, shapes of nano particles and masses of nano particles would be carefully chosen so as to have effective application of nano fluids in solar collectors. It could also be asserted that the nano fluids would be specifically utilized in solar collectors so as to have effective heating of fluid and storage of hot fluid.

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