Review on Solar Water Heating System

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Abstract. *Solar water heating is a promising application of solar energy. It utilizes this renewable energy to produce hot water that can be used for several purposes and in different places (houses, hotels, hospitals, etc.). Such application serves in mitigating the dependence on conventional energy sources that are depleting day after day and replace it by using renewable source of energy which is environmentally friendly. The aim of this paper is to present a brief review on solar water heating systems. The review includes demonstration of the principle of solar water heating systems. Also, classification of such system is exposed in addition to the mode of operation of each type.*

1. Introduction

The continues aggravation of environmental problems in addition to the persistent increase in the cost of conventional sources of energy motivated scientific researchers to exploit heat recovery systems or renewable energy sources as effective solutions. Heat recovery systems [1-11] are defined as the reuse of the dissipated energy from distinct application leading to the increase of energy usage efficiency. On the other hand, renewable sources of energy mainly comprise geothermal [12], wind [13], biomass [14] and solar energy [15-20]. Solar energy is a distinguished type of renewable energy sources where several applications are derived from it. Solar water heating system [21-23] is a fascinating idea to exploit solar energy. It absorbs solar energy and transforms thermal energy into heat to generate hot water which can be used for domestic and industrial purposes.

The target of this paper is to expose a brief review on solar water heating system regarding its principle of work, classification and the mode of operation of each type of this application. Hence, the rest of the paper is organized as follows: section 2 explains the principle of solar water heating system, section 3 presents the classification of such system and investigates the mode of function of each type and section 4 summarizes the main conclusions of this paper.

2. Principle of solar water heating application

Solar water heating system is composed of solar collector, tank, pipelines, and working fluid. In such system, fluid is heated by transporting it in contact with dark surface which is imposed to solar radiation. This dark surface is the solar collector in which its role to absorb solar radiation and reduce heat loss. In solar water heating systems, the fluid may be either water which will be heated and utilized directly, or heat transfer fluid such as glycol/water that will pass through form of heat exchanger and heat water to be used. Fig. 1 shows a schematic that summarizes the process of heating water using solar energy.

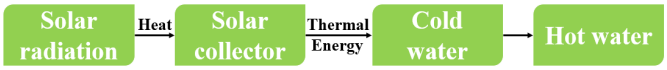

Fig. 1. Process of heating water using solar energy.

3. Classification of solar water heating system

Solar water heating system is generally classified into two systems; passive and active systems. Fig.2 illustrates the technologies of each type of solar water heating systems [24].

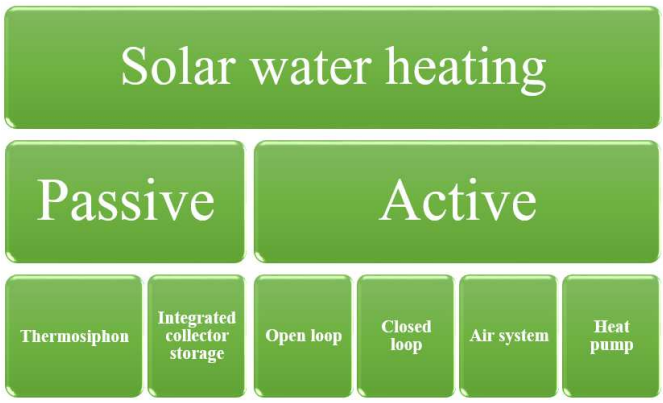

Fig. 2. Classification of solar water heating system.

3.1. Passive solar water heating

Passive systems are the systems in which they doesn't depend on pumps to circulate the flow between the storage tank and collector. They are less expensive compared to active systems and have low maintenance cost due to the absence of moving parts in the system (pumps).

Thermosyphon system [25] depends on the natural convection in which water in collector is heated and expand, becoming less dense. Water in the tank which is above the collector is cooler having higher density, so it flows down to the collector forcing hot water to go up to the storage insulated tank. The water will remain circulating as longer as the sun is shining. Fig.3 shows schematic of Thermosyphon solar water heating system.

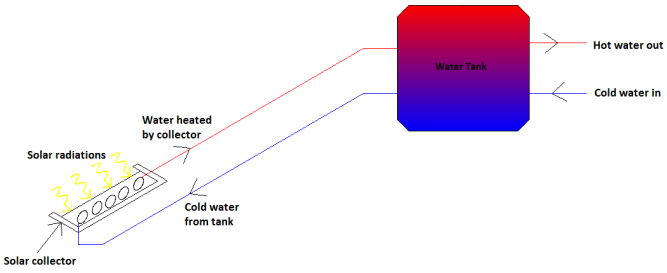

Fig. 3. Thermosiphon solar water heating system.

Integrated collector storage system [26] is also known as batch system. This system works as thermosyphon system work but the main difference is that the storage tank is used also as a collector. The storage tank is placed in an insulated box having a glazed side which allows solar radiation to heat the tank. Fig.4 shows schematic of integrated collector storage system.

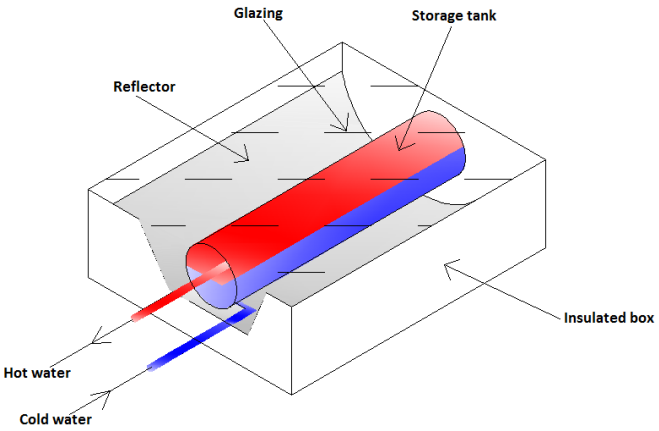

Fig. 4. Integrated collector storage system.

3.2. Active solar water heating

Active solar water heating requires some mechanical forces in order to circulate fluid through the system. It utilizes one or more pumps, valves and controllers to circulate the heat transfer fluid through the collector.

In the direct active system, water is directly circulated by a pump from the storage tank to the collector to be heated by solar energy, and then returned to the storage tank to be used when needed. The storage tank can be mounted above or below the collector. Direct circulation systems typically utilizes single storage tank with an auxiliary water heater, but it can also use two-tank storage systems. Also, this system can be used with water supplied from a cold water storage tank or connected directly to service water. Fig. 5 shows a schematic of open loop system.

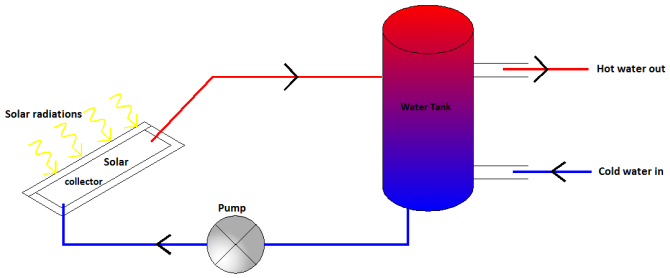

Fig. 5. Open loop system.

In the closed loop active system, potable water is heated in an indirect way by circulating a heat transfer fluid through the collector where it rejects its heat via a heat exchanger to the water in the storage tank. Water/ethylene glycol solution is the most utilized heat transfer fluid, although silicone oils and refrigerants can be also used. The heat exchanger can be placed inside the storage tank, around it, or it can be external. Fig. 6 illustrated a schematic of closed loop system.

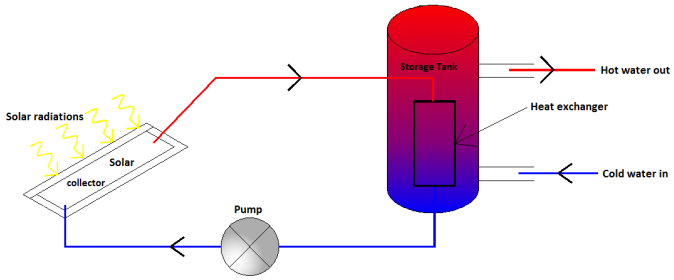

Fig. 5. Open loop system.

Air system is an indirect system using air as a circulating fluid. It needs a heat exchanger to transfer heat from air to water. Fig. 6 shows air system which uses two storage tanks, since such system is used to

preheat domestic water and the auxiliary heater is used in the second tank.

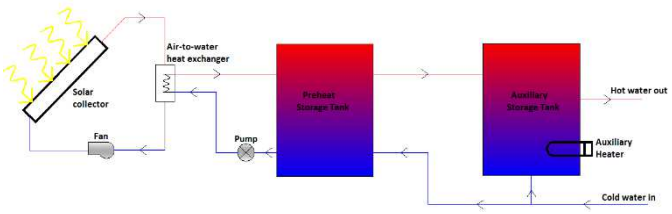

Fig. 6. Air system.

Carnot cycle is utilized in heat pump machines which transfer heat from a heat source to a heat sink using vapor compression cycle. Heat pumps [27] improve the overall efficiency of the system especially collector by which it sends colder fluid to it which maximize the usage of solar radiation, thus increase the efficiency of the collector. Heat pump can be connected to the collector in series or parallel configuration [pdf68]. For the parallel connection, auxiliary heat source should be connected at the evaporator and it may be warm ambient air or ground heat exchanger, shown in Fig. 7. For series Connection, solar energy heat the evaporator of the system. It may be direct or indirect solar heat pump. Direct systems use the collector to be the evaporator whereas indirect systems have two circulating loops which are shown in Fig. 8 and 9 respectively.

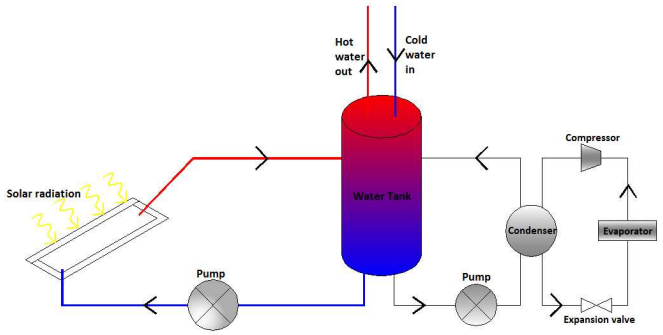

Fig. 6. Parallel solar heat pump.

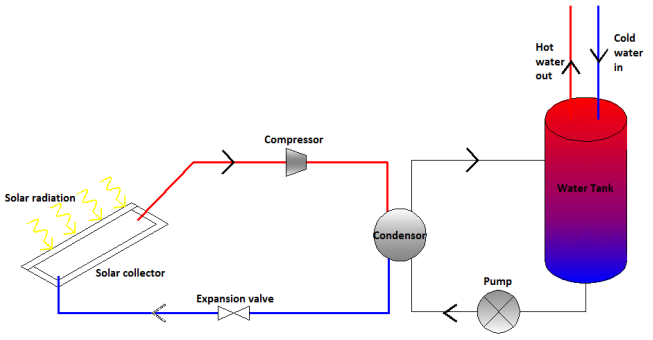

Fig. 6. Direct series solar heat pump.

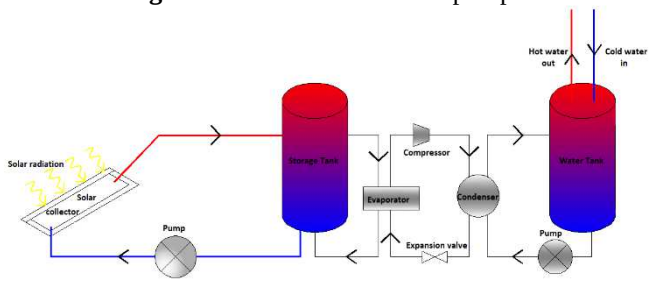

Fig. 6. Indirect series solar heat pump.

4. Conclusions

Solar energy is a successful feasible alternative source of energy. It can be exploited in various applications in which it decreases nonrenewable energy dependence and preserves environment. Solar water heating application is a great idea derived from the usage of solar energy to produce hot water for domestic and industrial uses.

In this work, a short review on solar water heating and is presented. The principle and the classification and sub categories are carried with a brief description including their mode of operation.

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