Solar thermal collectors and applications

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As solar collector designs have improved two main classifications for solar thermal collectors have emerged. These are non-concentrating collectors and concentrating collectors [12]. Figure 1 shows the various classification of solar collectors.

Classification of solar collectors

The remainder of this section will present the working principles of the various collectors investigated in this study along with the recent advances by researchers to improve the thermal efficiency of these collectors.

Flat plate solar collectors (FPC) are the most widely used solar thermal collectors [15]. The collector, first designed by Hottel [16], is primarily composed of an absorber surface, a transparent cover, risers, and insulation. The absorber surface is a black surface intended to collect as much thermal energy as possible [12]. Thermal energy received on the absorber plate is transferred to the working fluid (air, water, etc.) in the risers (pipes) by convective heat transfer. The schematic of the flat plate collector is shown in Fig. 2.

The glazing on the top of the flat plate collector primarily functions to reduce convective and radiative losses from the absorber, transmit the incident solar radiation into the absorber plate, and protect the system from environmental damage. Effective glazings have low reflection and absorption properties while having high transmission properties [23]. Glazing materials are doped with transparent conductive oxides (TCO) like aluminum-doped zinc oxide and tin-doped indium oxide [24] to improve the glazing transmittance performance.

Recently, a growing number of studies have focused on enhancing the overall thermal efficiency of collectors by improving the properties of their heat transfer fluids (HTF). These working fluids have been improved by replacing the conventional HTF with a mixture of glycol, propylene, and water. These mixtures have been proven to slightly improve the thermal performance of the collectors [25], however, the potentials of nanofluids in improving the thermal efficiency of solar thermal collectors are enormous.

The useful energy (Qu) of an FPC with a collector area At can be defined as [17]:

where It is solar radiation on the absorber surface, At is collector surface area, ((tau alpha))eff is the product of the cover transmittance, and absorber surface absorptance, and Ul is the collector"s heat loss to the surroundings.

In experiments, useful energy is calculated with Eq. 3 [17]:

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