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Experimental Analysis of the Influence of Water Mass Flow Rate on the Performance of a CO2 Direct-Expansion Solar Assisted Heat Pump

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Abstract : Energy use is one of the main indicators for the economic and social development of a country, reflecting directly in the quality of life of the population. The expansion of energy use together with the depletion of fossil resources and the poor efficiency of energy systems have led many countries in recent years to invest in renewable energy sources. In this context, solar-assisted heat pump has become very important in energy industry, since it can transfer heat energy from the sun to water or another absorbing source. The direct-expansion solar assisted heat pump (DX-SAHP) water heater system operates by receiving solar energy incident in a solar collector, which serves as an evaporator in a refrigeration cycle, and the energy reject by the condenser is used for water heating. In this paper, a DX-SAHP using carbon dioxide as refrigerant (R744) was assembled, and the influence of the variation of the water mass flow rate in the system was analyzed. The parameters such as high pressure, water outlet temperature, gas cooler outlet temperature, evaporator temperature, and the coefficient of performance were studied. The mainly components used to assemble the heat pump were a reciprocating compressor, a gas cooler which is a countercurrent concentric tube heat exchanger, a needle-valve, and an evaporator that is a copper bare flat plate solar collector designed to capture direct and diffuse radiation. Routines were developed in the LabVIEW and CoolProp through MATLAB software’s, respectively, to collect data and calculate the thermodynamics properties. The range of coefficient of performance measured was from 3.2 to 5.34. It was noticed that, with the higher water mass flow rate, the water outlet temperature decreased, and consequently, the coefficient of performance of the system increases since the heat transfer in the gas cooler is higher. In addition, the high pressure of the system and the CO₂ gas cooler outlet temperature decreased. The heat pump using carbon dioxide as a refrigerant, especially operating with solar radiation has been proven to be a renewable source in an efficient system for heating residential water compared to electrical heaters reaching temperatures between 40 °C and 80 °C.

Keywords : water mass flow rate, R-744, heat pump, solar evaporator, water heater
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