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Performance Analysis of a Thermoelectric Solar Collector Integrated with a Heat Pump

C. LERTSATITTHANAKORN,[1,4] J. JAMRADLOEDLUK,[1] M. RUNGSIYOPAS,[2] A. THERDYOTHIN,[3] and S. SOPONRONNARIT[3]

1.—Thermal Processes Research Laboratory, Faculty of Engineering, Mahasarakham University, Khantarawichai, Mahasarakham 44150, Thailand. 2.—Mechanical Engineering Department, Faculty of Engineering, Burapha University, 169 Long-Hard Bangsaen Road Saensuk, Muang, Chonburi 20131, Thailand. 3.—School of Energy, Environment and Materials, King Mongkut's University of Technology Thonburi, Bangmod, Thungkru, Bangkok 10140, Thailand. 4.—e-mail: freeconvect@hotmail.com

A novel heat pump system is proposed. A thermoelectric solar collector was coupled to a solar-assisted heat pump (TESC-HP) to work as an evaporator. The cooling effect of the system's refrigerant allowed the cold side of the system's thermoelectric modules to work at lower temperature, improving the conversion efficiency. The TESC-HP system mainly consisted of transparent glass, an air gap, an absorber plate that acted as a direct expansion-type collector/evaporator, an R-134a piston-type hermetic compressor, a water-cooled plate-type condenser, thermoelectric modules, and a water storage tank. Test results indicated that the TESC-HP has better coefficient of performance (COP) and conversion efficiency than the separate units. For the meteorological conditions in Mahasarakham, the COP of the TESC-HP system can reach 5.48 when the average temperature of 100 L of water is increased from 28°C to 40°C in 60 min with average ambient temperature of 32.5°C and average solar intensity of 815 W/m^2, whereas the conversion efficiency of the TE power generator was around 2.03%.

Key words: Coefficient of performance, conversion efficiency, solar-assisted heat pump

Abbreviations

COP	Coefficient of performance
C_{pw}	Specific heat of water (J/kgK)
E_{TEHP}	Net energy of the TESC-HP system (W)
h_2	Specific enthalpy of two-phase fluid at evaporating pressure (J/kg)
h_3	Specific enthalpy of superheated vapor at condensing pressure (J/kg)
I	Current of the TE modules (A)
M_w	Mass of hot water per day (kg)
m_r	Refrigerant mass flow rate (kg/s)
m_w	Water flow rate (kg/s)
P	Electrical output of the TE solar collector (W)
Q_c	Heating capacity of the condenser (W)
Q_w	Rate of heat transfer to water in the storage tank per day (W)
T_c	Cold-side temperature of TE module (K)
T_h	Hot-side temperature of TE module (K)
T_m	Average temperature (K)
T_{wi}	Inlet water temperature of condenser (K)
T_{wo}	Outlet water temperature of condenser (K)
V	Voltage of the TE modules (V)
W_{com}	Power input to the compressor (W)
W_p	Power input to the water pump (W)
Z	Figure of merit of the TE material (1/K)
η_c	Carnot efficiency
η_e	Conversion efficiency

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INTRODUCTION

Solar energy systems and heat pumps are two promising means of reducing consumption of fossil