Hungarian University of Agriculture and Life Science
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Mechanical engineering Course

SOLAR ENERGY UTILISATION WITH THE HEAT PUMPS

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Summary

The recent gas crisis has highlighted the importance of alternative sources of energy for heating and cooling homes and buildings. One promising technology that can help reduce reliance on fossil fuels is the solar-assisted heat pump (SAHP). SAHP systems combine solar energy with heat pump technology to provide efficient and sustainable heating and cooling solutions. Bas well as reducing energy bills and lower carbon emissions, making them an attractive option for homeowners and businesses. The work presented aims to construct a double-source solar-assisted heat pump (solar energy and ambient temperature) with a storage tank and investigate the impact of controlling the inlet temperature by comparing the results of the solar collector's outlet temperature under identical solar irradiance conditions and the same mass flow of the heat transfer medium over three days. Therefore, my hypothesis is that the lower the temperature of the heat transfer medium entering the collector, the greater the efficiency of the system, resulting in a greater amount of extracted heat to assist the heat pump evaporator over a longer period of time, where the refrigerant in the heat pump side is working with low-temperature ranges, therefore, to heat up a circulated fluid from -5 °C to 0°C is more degrees will be much significant than heating up a high-temperature fluid.

The execution of the system was carried out at the energetic building's laboratory of the Hungarian University of Agriculture and Life Sciences. The main component of the system is the heat pump which is assisted by a flat plate solar collector placed outside on the roof of the mentioned building, forming two main circuits the antifreeze circuit and the refrigerant circuit; in this study, I am going to focus on the antifreeze circuit where the investigation of the change of the outlet temperature in function of external conditions and the inlet temperature of the solar collector. The experiments take place over three days, in each day we set different inlet temperatures of the solar collector and we see how the outlet temperature is changing in almost the same values of solar radiation in each day. In the experiments we also investigate the change of the extracted heat according to the inlet temperature and the external conditions during the day, then the coefficient of performance of the whole system including the heat pump, the heat pump during the whole system running period change phase ON/OFF, when the inlet temperature drops below the fixed value, the heat pump shuts off, the start of the next heat pump cycle will be when the inlet temperature reaches again the previously set temperature point. Therefore, the tank during the OFF phase of the heat pump continues charging by the solar collector increasing by that the performance of the system.

A digital thermostat was used to control the inlet temperature during the day. The thermostat was equipped with a temperature's sensors to measure the outlet and inlet temperature, both of them were connected to the ALMEMO system in order to instantly record the collected data. The ambient temperature, solar irradiation and the instantly consumed current in the compressor were also measured during the experiments and recorded in the ALMEMO system in order to calculate the COP of the whole system.

The obtained results after analyzing the data record:

(1) In high solar irradiation ranges the extracted heat by the heat transfer medium is more significant when the inlet temperature is low.

(2) During the experiments it was noticed that the amount of increase in the outlet temperature is more significant when the inlet temperature is much low than when it is close to the ambient temperature.
(3) That is very useful in the heat pump systems with a storage tank, where is known the refrigerant is working with low-temperature ranges therefore, it is more significant to heat up the heat transfer medium circulating inside the collector from -5°C to 0°C, than from +30 to +33°C. The storage tank is added to the system to increase the efficiency of solar energy usage and increase operating time.
(4) Solar irradiation has a strong and direct effect on the variation of the outlet temperature of the solar collector.
(5) When the absence of solar irradiation the heat pump system can be assisted by the ambient temperature as a heat source making a double source solar-assisted heat pump.
(6) In high solar irradiation ranges (in my experiments) the ambient temperature has a neglected effect on increasing the outlet temperature of the solar collector.

To simulate the outlet temperature of the solar collector change under the measured external condition and the measured inlet temperature of the solar collector, MATLAB Simulink software was used, The obtained results from the MATLAB calculation shows that for the same initial conditions, the change in the calculated outlet temperature of the solar collector by MATLAB Simulink is changing approximately in the same way as the measured values with (+2 to 3 °C) of difference, As the Simulink values predict in all cases an outlet temperature that's is greater than the measured values and we can demonstrate this difference with the following assumptions.

- In the real measurements the position of the position of temperature sensors in the inlet and outlet of the solar collector was 4 meters far from the exact outlet and inlet of the solar collector.
- The bad insulation of the pipes in the whole system.
- MATLAB model may not be accurate for this temperature range.

To advance the state of knowledge regarding this topic, the following future research is suggested to enhance this study:

(1) Look for correlations to determine the optimum interconnection parameters for solar panels, collectors, and heat pump systems, focusing more on energy storage issues, taking into consideration that battery banks and thermal storage are promising components for improving energy conservation and reliability of power systems.
(2) Research limitations on exergy analysis. The exergy analysis evaluates the efficient use of solar energy by calculating the sources and magnitude of irreversibility; consequently, this analysis can be used to enhance the performance of the system, particularly the PV/T-assisted heat pump system.
(3) Developing the optimal operation control strategies, that could aim to reduce the cost of investments, and life cycle costs.
(4) Adding other renewable energy sources, such as wind energy and biomass energy, to enhance the efficiency of the systems (double or more source solar assisted heat pump).