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A simplified heat pump model for use in solar plus heat pump system simulation studies

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Abstract

Solar plus heat pump systems are often very complex in design, with sometimes special heat pump arrangements and control. Therefore detailed heat pump models can give very slow system simulations and still not so accurate results compared to real heat pump performance in a system. The idea here is to start from a standard measured performance map of test points for a heat pump according to EN 14825 and then determine characteristic parameters for a simplified correlation based model of the heat pump. By plotting heat pump test data in different ways including power input and output form and not only as COP, a simplified relation could be seen. By using the same methodology as in the EN 12975 QDT part in the collector test standard it could be shown that a very simple model could describe the heat pump test data very accurately, by identifying 4 parameters in the correlation equation found.

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Keywords: Heat pump; correlation model; simulation

1. Introduction

Solar plus heat pump systems are often very complex in design, with sometimes special heat pump arrangements and control. Therefore detailed heat pump models can give very slow system simulations and still not so accurate results, compared to real heat pump performance in a system. The idea here is to start from a standard performance map of measured test points according to EN 14825 [1] for a heat pump and then determine characteristic parameters for a simplified correlation based model of the heat pump.

No model variant of this kind is known to the authors so far, in spite of the accuracy found in the example tried now for a brine to water heat pump. The model is so simple that it can also be used in

calculation tools as Excel for performance estimations. If programmed for TRNSYS [2] it could be advantageous to speed up system simulations.

One aim with the paper is also to present a possibility to model a heat pump in this way during dynamic testing in the same way as the QDT method for solar collectors. This could shorten the testing time and also give a model validation in each test as for the QDT method in EN 12975 [3].

2. Method

By plotting heat pump test data in different ways including power input and output form and not only as COP, a simplified relation could be seen with Power output and Power input on the Y-axis. By using the same modeling and parameter identification methodology, as in the EN 12975 QDT part in the collector test standard, it could be shown that a very simple model could describe the heat pump test data very accurately.

- The Analyze and Results were based on Thermal and Electrical Heat Pump test data.
- Multiple Linear Regression (MLR) was used to find two simplified *Power* Equations.
- One equation for Thermal Output Power (Condenser thermal power output to system)
- One equation for Electricity Consumption (Compressor and Motor)
- By combining these correlation equations, the COP could also be modeled very accurately.

3. Results

The correlation equations found: One for thermal power output and one for electric power consumption.:

$$\text{Electric Power Input} = p_1 + p_2 * T_{\text{in_cold}} + p_3 * T_{\text{in_hot}} + p_4 * T_{\text{in_hot}} * T_{\text{in_cold}} \quad (1)$$

$$\text{Thermal Power Output} = p_5 + p_6 T_{\text{in_cold}} + p_7 * T_{\text{in_hot}} + p_8 * T_{\text{in_hot}} * T_{\text{in_cold}} \quad (2)$$

Nomenclature

Electric Power Input	Power used by the heat pump electric motor
Thermal Power Output	Thermal Power delivered from the heat pump condenser to the system
$T_{\text{in_cold}}$	Inlet temperature to the heat pump evaporator
$T_{\text{in_hot}}$	Inlet temperature to the heat pump condenser

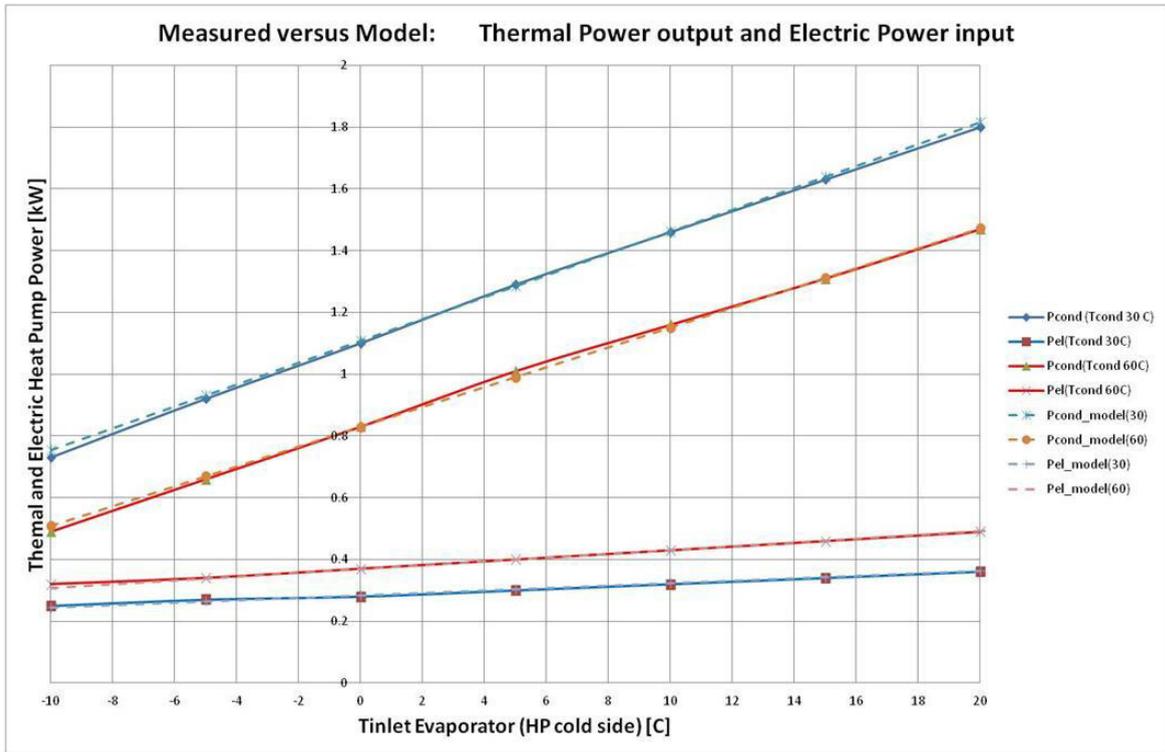


Fig. 1. Heat pump Thermal Power output and Electric Input as a function of T_{in} cold evaporator and T_{in} hot condenser

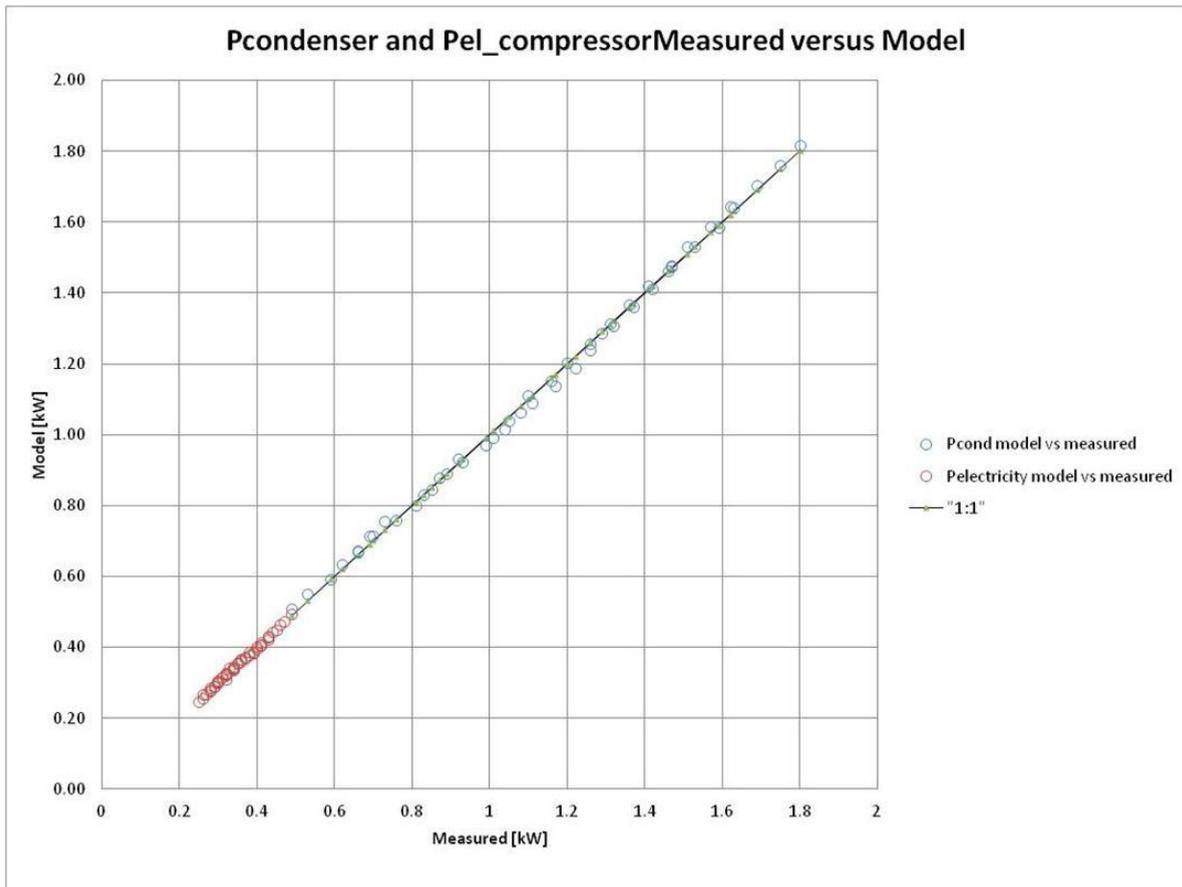


Fig. 2. Measured versus Modeled Thermal Power out and Electricity in

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References

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- [3] CEN, European committee for standardization. (2006) “EN 12975-2:2006, Thermal solar systems and components - Collectors - Part 2: Test methods”