**TRNSYS-Type 983**

**Dual sink heat pump with start losses and defrosting based on Curve-Fit of COP and condenser heat**

**V1.00**

Martin Neugebauer, 04.08.2021

Thibault Péan, 30.08.2021

# Introduction

This TRNSYS Type simulates a heat pump (typically air-water or water-water) with its COP calculated based on biquadratic curve fits that use the evaporator inlet temperature and the condenser outlet temperature as independent variables. The model follows to a large extent the basic concepts of the model by Wetter & Afjei (1996), with the difference that the bi-quadratic curve-fits are done for COP and heat output instead of electricity consumption and heat output. Defrosting losses of air-source heat pumps are assumed to be either already included in the curve fits, or they can be calculated based on the same approach of defrosting efficiency, relative humidity of the air, and air inlet temperature, as in the semi-physical heat pump model type 877. The reference temperature for COP and Power has been changed to average of inlet and outlet (instead of inlet for evaporator and outlet for condenser).

# Parameters, Inputs and Outputs

## Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Nr.*** | ***short*** | ***explanation*** | ***unit*** | ***range*** |
| 1 |  | start time constant | s | [0;+inf] |
| 2 |  | stop time constant | s | [0;+inf] |
| 3 |  | temperature of ambient air (inlet) below which defrosting takes place | °C | [-inf;+inf] |
| 4 |  | Efficiency of defrosting | - | [0;1] |
| 5 |  | electricity consumption of ventilator | kW | [0;+inf] |
| 6 |  | electricity consumption of controller | kW | [0;+inf] |
| 7 |  | minimum temperature for condenser outlet | °C | [-inf;+inf] |
| 8 |  | maximum temperature for condenser outlet | °C | [-inf;+inf] |
| 9 |  | specific heat of the heat sink | kJ/kgK | [0;+inf] |
| 10 |  | Number of hours heat pump stays on error (compressor and ventilator OFF) if it has been tried to run it with outlet temperature of the condenser above maximum or inlet temperature of the evaporator below minimum. | h | [0;+inf] |
| 11 |  | heat loss and startup calculation mode: 0: no losses; 1: based on start and stop time constants; 2: based on thermal capacity and UA-value only during standby; 3: thermal cap. + UA-losses during standby AND during operation; | - | [0;3] |
| 12 |  | thermal capacity of the heat pump | kJ/K | [0;+inf] |
| 13 |  | UA-value for thermal losses of the heat pump | W/K | [0;+inf] |
| 14 | MoCtrl | Control mode of the heat pump  1: Control by temperature set-point (ref case)  2: Control by capacity (AEMS) | - | [0 ; 2] |
| 15-17 | frCOP0, frCOP1, frCOP2 | Coefficients for the frCOP = f(frCond) curve | - | [-inf;+inf] |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Inputs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Nr.*** | ***short*** | ***explanation*** | ***unit*** | ***range*** |
| 1-10 | - | 1st to 10th coefficient for bi-quadratic polynomial function for the dhw power | kW | [-inf;+inf] |
| 11-20 | - | 1st to 10th coefficient for bi-quadratic polynomial function for the sh power | kW | [-inf;+inf] |
| 21-30 | - | 1st to 10th coefficient for bi-quadratic polynomial function for the COP | - | [-inf;+inf] |
| 31 |  | temperature of evaporator inlet | °C | [-inf;+inf] |
| 32 |  | mass flow rate of evaporator inlet | kg/h | [0;+inf] |
| 33 |  | temperature of dhw condenser inlet | °C | [-inf;+inf] |
| 34 |  | mass flow rate of dhw condenser inlet | kg/h | [0;+inf] |
| 35 |  | temperature of sh condenser inlet | °C | [-inf;+inf] |
| 36 |  | mass flow rate of sh condenser inlet | kg/h | [0;+inf] |
| 37 |  | Control switch for turning heat pump (compressor / working fluid cycle) on | - | [0;1] |
| 38 |  | Relative humidity of air inlet | - | [0;1] |
| 39 |  | Temperature of the room for thermal loss calculation | °C | [-inf;+inf] |
| 40 |  | Factor for multiplication with Condensor heat output for modulating / inverter controlled heat pumps | - | [-inf;+inf] |
| 41 |  | Factor for multiplication with COP for modulating / inverter controlled heat pumps | - | [-inf;+inf] |
| 42 |  | specific heat of the evaporator heat source | kJ/kgK | [0;+inf] |
| 43 |  | minimum temperature for evaporator outlet | °C | [-inf;+inf] |
| 44 |  | maximum temperature for evaporator outlet | °C | [-inf;+inf] |
| 45 | QthSet | Set-point of capacity (when MoCtrl = 2) | kW |  |

## Outputs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Nr.*** | ***short*** | ***explanation*** | ***unit*** | ***range*** |
| 1 |  | temperature of evaporator outlet | °C | [-inf;+inf] |
| 2 |  | mass flow rate of evaporator outlet | kg/h | [0;+inf] |
| 3 |  | temperature of dhw condenser outlet | °C | [-inf;+inf] |
| 4 |  | mass flow rate of dhw condenser outlet | kg/h | [0;+inf] |
| 5 |  | temperature of sh condenser outlet | °C | [-inf;+inf] |
| 6 |  | mass flow rate of sh condenser outlet | kg/h | [0;+inf] |
| 7 |  | electric power consumption compressor | kW | [0;+inf] |
| 8 |  | electric power consumption total (including controller and ventilation) | kW | [0;+inf] |
| 9 |  | evaporator heat transfer | kW | [0;+inf] |
| 10 |  | Dhw condenser heat transfer | kW | [0;+inf] |
| 11 |  | Sh condenser heat transfer | kW | [0;+inf] |
| 12 |  | coefficient of performance in steady state, without start losses and without defrosting losses | - | [0;+inf] |
| 13 |  | start losses (for Moloss 1) or heat losses to ambient (mode 2,3) | kW | [0;+inf] |
| 14 |  | defrosting losses | kW | [0;+inf] |
| 15 |  | error low pressure in evaporator | - | [0;1] |
| 16 |  | error high pressure in evaporator | - | [0;1] |
| 17 |  | error low pressure in condenser | - | [0;1] |
| 18 |  | error high pressure in condenser | - | [0;1] |
| 19 |  | steady state condenser power (before subtraction of losses to ambient and for defrosting) | kW | [0;+inf] |
| 20 |  | heat exchange rate with thermal capacitance | kW | [0;+inf] |
| 21 | HpIsBlock | Boolean to know if the heat pump is block or not | - | [0,1] |

# Calculation

The steady state condenser powers and of the heat pump and the overall COP are calculated as a function of the normalized inlet temperatures of the evaporator and the outlet temperatures of the condensers and :

with



because the outlet temperatures of the condensers and are themselves functions of , and the respective inlet temperatures, they have to be found iteratively.

***Defrosting losses***

For cases where  losses are calculated as:



Where  and  are the inlet and outlet water vapor load of the air. The outlet water vapor load is calculated as the water vapor load that corresponds to saturated air at the outlet temperature  and is thus dependent also on the term .

***Overall condenser side***

The overall power on the condenser side is calculated as

The overall inlet temperature on the condenser (sink) side is calculated as

***Mode 1 loss calculation***

Start losses during a particular timestep are calculated as:





Where  is the length of the timestep,  is the time elapsed between start of the compressor and the beginning of the timestep,  is the time elapsed at the end of the timestep,  is the off-time before the heat pump is starting to operate again, and  is the stop time constant.

***Mode 2 and 3 loss and thermal capacity calculation***

It is assumed that thermal capacitance of the heat pump can be represented with one thermal node, whose temperature is at the same time the supply temperature. The node temperature  is dependent on time  and can be calculated by an exponential approach:



The average outlet temperature over one timestep  is:



With  (temperature after an infinite time), , and :







 is the steady state heating power of the heat pump after subtraction of the defrosting losses,  is the capacity flow rate, and  the return temperature. Heat losses, outlet heating power, and the heat charged to or released from the thermal capacitance are:







***Final outputs***

The other outputs are calculated as:









Literature

Wetter, M. & Afjei, T., 1996. *TRNSYS TYPE 410 - Kompressionswärmepumpe inklusiv Frost- und Taktverluste - Modellbeschreibung und Implementation in TRNSYS*. Zentralschweizerisches Technikum Luzern.