TYPE 504: WATER SOURCE HEAT PUMP

General Description

This component models a single-stage liquid source heat pump with an optional desuperheater for hot water heating. The heat pump conditions a moist air stream by rejecting energy to (cooling mode) or absorbing energy from (heating mode) a liquid stream. This heat pump model was intended for a residential ground source heat pump application, but may be used in any liquid source application.

The heat pump has a desuperheater attached to a secondary fluid stream. In cooling mode, the desuperheater relieves the liquid stream of some of the burden of rejecting energy. However, in heating mode, the desuperheater requires the liquid stream to absorb more energy than is just required for space heating.

This model is based on user-supplied data files containing catalog data for the capacity (both total and sensible in cooling mode), and power, based on the entering water temperature to the heat pump, the entering water flow rate and the air flow rate. Other curve fits are used to modify the capacities and power based on off-design indoor air temperatures. Type504 takes either air relative humidity or absolute humidity ratio as an input. It is identical to Type505 in the TESS HVAC Equipment Library. Formerly, Type504 took air humidity ratio as an input while Type505 took air relative humidity.

Detailed Description

A heat pump is a device that transfers energy from a low temperature source to a higher temperature sink. It differs from a pure refrigeration cycle in that the end result of the application could be either to heat or cool depending upon the direction that the refrigerant is currently flowing through the system. [1] Figure 1 shows a schematic diagram of a heat pump system.

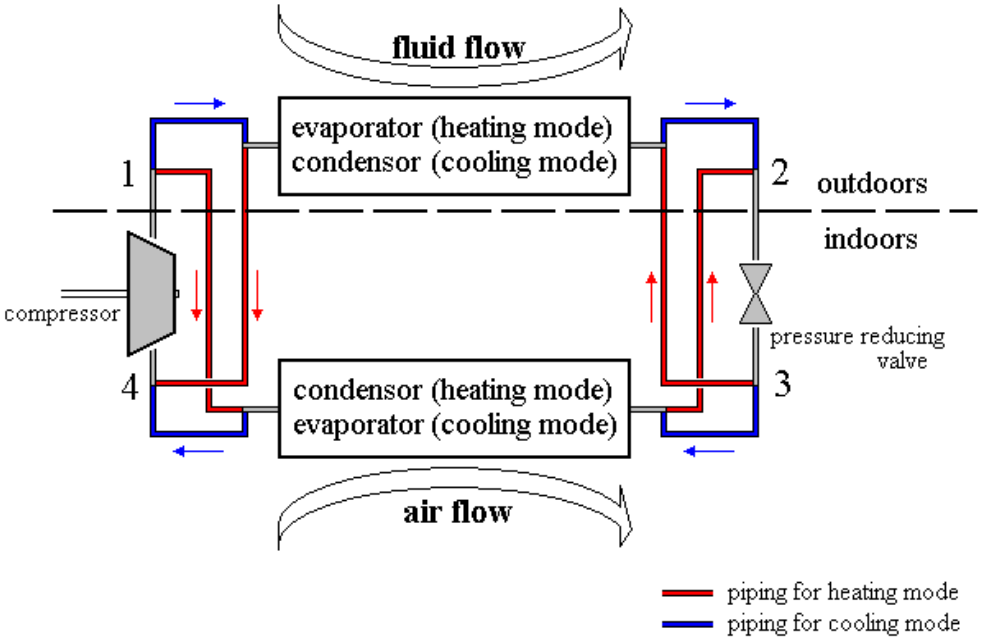


Figure 1: Heat Pump Schematic

Normally, a fan is included on the air side of the heat pump unit. It is not pictured in the schematic for clarity purposes. The numbered points on the diagram correspond to the refrigerant states shown on the psychrometric chart in Figure 2.

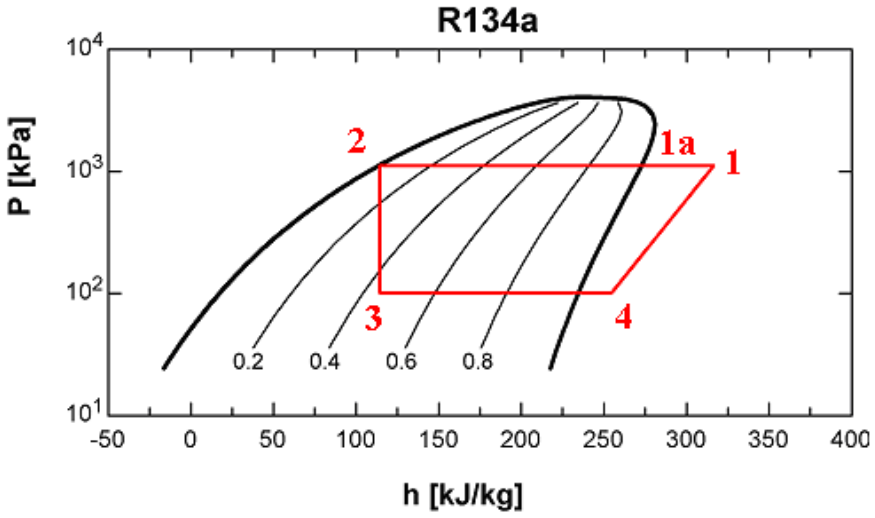


Figure 2: A Generic Heat Pump Cycle

The addition of a desuperheater (an extra heat exchanger between the compressor and condenser (in cooling mode) or evaporator (in heating mode)) to a heat pump causes the refrigerant exiting the compressor to move from the point labeled 1 toward the point labeled 1a in Figure 2.

Type504 is not a first principals model but relies instead upon catalog data readily available from heat pump manufacturers. At the heart of the component are four data files: a file containing cooling performance data, a file containing heating performance data, a file containing cooling correction data and a file containing heating correction data.

All four files use the standard format for TRNSYS data files as outlined in Section 3.4.2 of Volume 1 of the TRNSYS documentation set.

Cooling Performance Data

Three measures of cooling performance must be provided in the cooling performance data file. These are: total cooling (in kW), sensible cooling (in kW), and power consumed (in kW). The power consumed should include the power associated with the indoor fan as well as the power associated with the compressor. Type504 linearly interpolates between cooling performance measures based on the current values of the air flow rate (in l/s), fluid flow rate (in l/s) and entering fluid temperature (in ºC). It should be noted that the component does not extrapolate beyond the data range provided. If values outside the data range are provided, the maximum or minimum cooling performance values will be returned and a warning will be written to the TRNSYS listing file and to the simulation log file.

An example cooling performance data file is provided for use with Type504. The file can be found in ..\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_C.dat. Users creating their own performance data must adhere closely to the syntax of the sample file. The values of air flow must all

appear on the first row of the data file. The values of fluid flow rate must all appear on the second row of the data file, the values of the entering fluid temperature must all appear on the third row of the data file. Users may specify more or fewer values of each of the three variables than are shown in the sample file but must also remember to modify the corresponding PARAMETER in the TRNSYS input file. For example, the sample file contains two values of air flow rate. Consequently the value of the parameter 11 (number of airflow steps – cooling) would be set to 2. The values of all three cooling performance measures must then appear, each group on its own line.

Heating Performance Data

The specification of heating performance data is much the same as for cooling performance data. Two measures of heating performance must be provided in the heating performance data file. These are: total cooling (in kW), and power consumed (in kW). The power consumed should include the power associated with the indoor fan as well as the power associated with the compressor. Type504 linearly interpolates between heating performance measures based on the current values of the air flow rate (in l/s), fluid flow rate (in l/s) and entering fluid temperature (in ºC). It should be noted that the component does not extrapolate beyond the data range provided. If values outside the data range are provided, the maximum or minimum cooling performance values will be returned and a warning will be written to the TRNSYS listing file and to the simulation log file.

An example heating performance data file is provided for use with Type504. The file can be found in ..\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_H.dat. Users creating their own performance data must adhere closely to the syntax of the sample file. The values of air flow must all appear on the first row of the data file. The values of fluid flow rate must all appear on the second row of the data file, the values of the entering fluid temperature must all appear on the third row of the data file. Users may specify more or fewer values of each of the three variables than are shown in the sample file but must also remember to modify the corresponding PARAMETER in the TRNSYS input file. For example, the sample file contains two values of air flow rate. Consequently the value of the parameter 12 (number of airflow steps – heating) would be set to 2. The values of both heating performance measures must then appear, each group on its own line.

Cooling Correction Data

The performance data specified in the cooling file is given for some nominal air condition (typically 21.1 ºC (80 ºF) and 50% RH). Consequently a correction factor file must also be provided so as to adjust the performance data for other air conditions. For cooling, three correction values must be provided: a multiplier for total capacity, a multiplier for sensible capacity and a multiplier for total power. All three multipliers are dimensionless. A linear interpolation is performed based on the current value of entering air dry bulb and wet bulb temperatures. Again no extrapolation is performed for entering conditions that lie outside the data range and the same rules for syntax apply to the cooling correction data file. A sample file is provided:
..\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_CT.dat

Heating Correction Data

The performance data specified in the heating file is also given for some nominal air condition and so must be corrected for other air conditions. For heating, two correction values are provided: a multiplier for total capacity and a multiplier for total power. Both multipliers are again dimensionless. A linear

interpolation is performed based on the current value of entering air dry bulb and wet bulb temperatures and no extrapolation is performed for entering conditions that lie outside the data range. The same rules for syntax apply again to the heating correction data file. A sample file is provided:
..\TESS Models\SampleCatalogData\GeothermalHeatPump\Samp_HT.dat

Auxiliary Heating Capacity

Should the heating capacity of the heat pump device be insufficient to meet the load at some time during the simulation, it is possible to specify two stages of additional capacity so as to meet the load. No assumption is made about the nature or efficiency of this additional capacity and as with the base heating and cooling control signals, the auxiliary heating stages are controlled independently and externally (by equations or another component in the TRNSYS input file).

Heat Pump Capacity Scaling

The process of creating data files for the heat pump model is time consuming. Type504 contains a feature to allow for the quick resizing of a heat pump within a simulation. On a normalized basis, heat pump performance is not heavily dependent upon equipment size. Thus four dimensionless multiplier inputs (17 through 20) are available to individually scale the cooling power, cooling capacity, heating power and heating capacity of the heat pump.

Heat Pump Desuperheater

Lastly, the model includes an optional desuperheater feature that allows for the heating of a secondary (usually domestic hot water) stream. To disable the feature, it suffices to set the desuperheater inlet flowrate (INPUT 8) to zero. To use the feature, the user must provide the conditions of the fluid stream entering the desuperheater and must specify a heat transfer coefficient between the refrigerant and the fluid stream for both heating and cooling modes.

References

[1] Mitchell, J.W. and J.E. Braun, Design Analysis, and Control of Space Conditioning Equipment and Systems, Solar Energy Laboratory, University of Wisconsin – Madison. 1997