TYPE 696: AIR STREAM CONDITIONING DEVICE

General Description

Type696 models a simple air conditioning device that adds or removes sensible and latent energy from an air stream to meet user-specified set point conditions of temperature and / or humidity. In this device the sensible condition controls the latent decisions. In other words the device cannot heat and dehumidify or cool and humidify the air stream. It can, however, heat and humidify or cool and dehumidify. To use the component effectively as a dehumidifying coil, set the set point temperature in cooling to the inlet air temperature and the humidity set point to desired level, then set the IREHEAT parameter value to 1 so that the air is returned (through reheat after dehumidification) to its inlet condition or set IREHEAT to 0 allow for a free-floating outlet temperature. To operate this component as a temperature controlled device only, choose the RH input mode and set the RH set point to 100% in cooling and to 0% in heating.

Nomenclature

$\dot{m}_{air}$	[kg/hr]	The mass flow rate of air entering the conditioning device
P_{out}	[atm]	The pressure of air exiting the conditioning device
P_{in}	[atm]	The pressure of air entering the conditioning device
ΔP	[atm]	The pressure drop of air as it passes through the conditioning device
h_{in}	[kJ/kg]	The enthalpy of air entering the conditioning device
h_{out}	[kJ/kg]	The enthalpy of air exiting the conditioning device before any possible reheating
h_{reheat}	[kJ/kg]	The enthalpy of air exiting the conditioning device after possible reheating.
$\dot{Q}_{sens,heat}$	[kJ/hr]	The sensible heating energy transferred to the air stream
$\dot{Q}_{sens,cool}$	[kJ/hr]	The sensible cooling energy transferred from the air stream.
$\dot{Q}_{lat,heat}$	[kJ/hr]	The latent heating energy transferred to the air stream
$\dot{Q}_{lat,cool}$	[kJ/hr]	The latent cooling energy transferred from the air stream.
$\dot{Q}_{tot,heat}$	[kJ/hr]	The total heating energy transferred to the air stream
$\dot{Q}_{tot,cool}$	[kJ/hr]	The total cooling energy transferred from the air stream.
$\dot{Q}_{reheat}$	[kJ/hr]	The energy used to reheat the air stream after dehumidification.
ω_{in}	[kgH_2O/kgAir]	The humidity ratio of air entering the conditioning device.
ω_{out}	[kgH_2O/kgAir]	The humidity ratio of air exiting the conditioning device.
HFG		The latent heat of vaporization for water.

Detailed Description

The basic idea of Type696 is quite simple: an inlet air stream is conditioned to meet a heating temperature set point, a cooling temperature set point, a humidification set point and a dehumidification set point. The device is not outfitted with any capacities but simply reports the required amounts of sensible and latent heating and cooling energy required to bring the air stream into the set point range. The model is limited in that the sensible energy requirement dictates the latent energy requirement. In

other words, if sensible heating energy is required, the model cannot then allow for dehumidification of the air stream. Likewise if sensible cooling energy is required to bring the air temperature down, dehumidification but not humidification of the air stream is then possible.

Three other important features are included in the model. First, PARAMETER 4 allows the user to set the relative humidity of the air exiting the device when it is in cooling mode. This feature can be used to account for the fact that air often does not exit a cooling coil exactly at its saturated condition. PARAMETER 5 allows the user to control whether or not the air stream should be reheated to its set point temperature after being cooled for dehumidification. Thirdly, PARAMETER 6 can be used to determine whether humidification can only occur when heating is on or whether it can occur independently of heating. Likewise, PARAMETER 7 is used to determine whether dehumidification can only occur when cooling is on or whether it can occur independently.

At each time step, Type696 performs a call to the TRNSYS Psychrometrics routine in order to obtain those air properties for the inlet air stream not specified by the user among the component's inputs. The user is required to specify inlet air pressure, temperature and either relative humidity or humidity ratio depending upon the value of PARAMETER 1. If the dry bulb temperature and humidity ratio are inputs to the model and a humidity ratio higher than the saturation humidity ratio for that dry bulb temperature is specified, the Psychrometrics routine will reset the humidity ratio to its saturated condition and print a warning in the TRNSYS list file.

No Flow Condition

If air is not flowing through the conditioning device or if the temperature and humidity of the air stream are already within the user specified set point ranges, Type696 sets the outlet air temperature to the inlet temperature, sets the outlet air pressure to the inlet air pressure and sets the outlet air humidity ratio to the inlet air humidity ratio. The sensible, latent and total heating and cooling energies as well as the reheat energy are set to zero.

Zero Outlet Pressure Condition

Among Type696 inputs, the user is required to provide the pressure drop of the air flowing through the device. If for some reason, the user specifies a pressure drop greater than the inlet air pressure (also specified as an input) then Type696 sets the outlet air pressure to zero, sets the outlet air temperature and humidity ratio to their respective inlet values and again sets all energy transfers to and from the air stream to zero.

Flow Condition 1 (Heating and Possible Humidification)

If air is flowing through the conditioning device and the entering air temperature is lower than the heating set point temperature, Type696 sets the air outlet pressure according to equation 696.1

$$P_{out} = P_{in} - \Delta P \qquad \text{(Eq. 696.1)}$$

Type696 then sets the outlet air humidity ratio equal to the inlet air humidity ratio and sets the outlet air temperature equal to the air heating set point temperature. It performs a call to the TRNSYS

Psychrometrics routine to fully determine the air outlet state, including the air outlet enthalpy h_{out} and computes the sensible energy transfer to the air stream according to equation 696.2

$$\dot{Q}_{sens,heat} = \dot{m}_{air}\left(h_{out} - h_{in}\right) \quad \text{(Eq. 696.2)}$$

If Type696 is in mode 1 then air humidities (whether inlet conditions or set points) are specified as relative humidities on a percent basis. If heating has occurred and Type696 is in mode 1, it checks whether the inlet air relative humidity is below the humidification set point. If it is, then Type696 calls the Psychrometrics routine, this time with the set point air temperature and set point air relative humidity. Psychrometrics again returns the full air state, including the outlet air enthalpy h_{out}, which will have a different value than the one returned assuming no change in air humidity. The total energy transfer to the air stream is given by equation 696.3

$$\dot{Q}_{tot,heat} = \dot{m}_{air}\left(h_{out} - h_{in}\right) \quad \text{(Eq. 696.3)}$$

Equation 696.3 has exactly the same form as equation 696.2 but again, the outlet air enthalpy is different. The latent energy added to the stream is then

$$\dot{Q}_{lat,heat} = \dot{Q}_{tot,heat} - \dot{Q}_{sens,heat} \quad \text{(Eq. 696.4)}$$

If Type696 is in mode 2 then air humidities (whether inlet conditions or set points) are specified as absolute humidity ratios. If heating has occurred and Type696 is in mode 2, it checks whether the inlet air humidity ratio is below the humidification set point. If it is, then Type696 calls the Psychrometrics routine, this time with the set point air temperature and set point air humidity ratio. Psychrometrics again returns the full air state, including the outlet air enthalpy h_{out}, which will have a different value than the one returned assuming no change in air humidity (equation 696.2). The total and latent energy transfers to the air stream are given by equation 696.3 and 696.4 as they were for the relative humidity mode.

Flow Condition 2 (Cooling and Possible Dehumidification)

If air is flowing through the conditioning device and the entering air temperature is higher than the cooling set point temperature, Type696 again sets the air outlet pressure according to equation 696.1. It then sets the outlet air humidity ratio equal to the inlet air humidity ratio and sets the outlet air temperature equal to the air cooling set point temperature. It performs a call to the TRNSYS Psychrometrics routine to fully determine the air outlet state (including the air outlet enthalpy h_{out}). As with other calls to the Psychrometrics routine if the air is over the saturation line based on the set point temperature, the humidity ratio returned will be that of saturation for the given temperature. If the air was determined to have saturated, Psychrometrics is recalled, this time with outlet pressure (equation 696.1), cooling set point temperature, and the value of PARAMETER 4. This parameter contains the relative humidity for air exiting the coil and accounts for the physical reality that air does not exit a cooling coil exactly at its saturation point. With the fully determined exiting air state, Type696 computes the sensible energy transfer from the air stream according to equation 696.5

$$\dot{Q}_{sens,cool} = \dot{m}_{air}\left(h_{in} - h_{out}\right) \quad \text{(Eq. 696.5)}$$

The latent energy removed from the air stream due to condensation is given by 696.6.

$$\dot{Q}_{lat,cool} = \dot{m}_{air}\left(\omega_{in} - \omega_{out}\right) \quad \text{(Eq. 696.6)}$$

If Type696 is in mode 1 then air humidity (whether an inlet condition or a set point) is specified as a relative humidity on a percent basis. If cooling has occurred and Type696 is in mode 1, it checks whether the inlet air relative humidity is above the dehumidification set point. If it is, then Type696 calls the Psychrometrics routine this time with the air pressure and set point air relative humidity. The third property (outlet air enthalpy) is set to zero and is reset by Psychrometrics. The total energy transfer to the air stream is given by equation 696.7

$$\dot{Q}_{tot,cool} = \dot{m}_{air}\left(h_{in} - h_{out}\right) \quad \text{(Eq. 696.7)}$$

The latent energy removed from the stream through dehumidification is then

$$\dot{Q}_{lat,cool} = \dot{m}_{air}\ HFG\left(\omega_{in} - \omega_{out}\right) \quad \text{(Eq. 696.8)}$$

Where HFG is the latent heat of vaporization for water (specified as a parameter). If Type696 is in mode 2 then air humidity is specified as absolute as humidity ratio. If cooling has occurred and Type696 is in mode 2, it checks whether the inlet air humidity ratio is above the dehumidification set point. If it is, then Type696 calls the Psychrometrics routine, this time with the set point air humidity ratio. The third property (outlet air enthalpy) is set to zero and is reset by Psychrometrics. The total and latent energy transfers to the air stream are given by equation 696.7 and 696.8 as they were for the relative humidity mode.

If reheating is allowed based on user specified parameter values, Psychrometrics is called once again, this time with outlet air pressure and both the dehumidification and temperature set points. The energy required to reheat the dehumidified air is given by 696.9.

$$\dot{Q}_{reheat} = \dot{m}_{air}\left(h_{reheat} - h_{out}\right) \quad \text{(Eq. 696.9)}$$

Flow Condition 3 (Humidification Only)

If Type696 is allowed to operate in a mode where humidification can occur without simultaneous heating, it checks whether the inlet air relative humidity is below the humidification set point without first looking at the inlet air temperature. If the inlet relative humidity is below the relative humidity set point, Type696 calls the Psychrometrics routine with the inlet air temperature and set point air relative humidity. Psychrometrics returns the full air state, including the outlet air enthalpy h_{out}. The total energy transfer to the air stream is given by equation 696.10.

$$\dot{Q}_{lat,heat} = \dot{m}_{air}\left(h_{out} - h_{in}\right) \quad \text{(Eq. 696.10)}$$

If Type696 is in mode 2 then humidity ratios for the air inlet and humidification set points are used in place of relative humidity in calls to the Psychrometrics routine.

Flow Condition 2 (Dehumidification Only)

If Type696 is allowed to operate in a mode where dehumidification can occur without simultaneous cooling, it checks whether the inlet air relative humidity is above the dehumidification set point without first checking the inlet air temperature. If the inlet air is above the set point, Type696 sets the air outlet pressure according to equation 696.1, sets the outlet air temperature equal to the inlet air temperature and sets the outlet air relative humidity equal to the set point relative humidity (mode 1) or the set point humidity ratio (mode 2) and calls Psychrometrics. Type696 computes the total energy transfer from the air stream according to equation 696.11

$$\dot{Q}_{tot,cool} = \dot{m}_{air}\left(h_{in} - h_{out}\right) \quad \text{(Eq. 696.11)}$$

The latent energy removed from the air stream is given by 696.12.

$$\dot{Q}_{lat,cool} = \dot{m}_{air}\ HFG\left(\omega_{in} - \omega_{out}\right) \quad \text{(Eq. 696.12)}$$

Where HFG is the latent heat of vaporization for water (specified as a parameter).

If reheating is allowed based on user specified parameter values, Psychrometrics is called once again, this time with outlet air pressure and both the dehumidification and temperature set points. The energy required to reheat the dehumidified air is given by 696.13.

$$\dot{Q}_{reheat} = \dot{m}_{air}\left(h_{reheat} - h_{out}\right) \quad \text{(Eq. 696.13)}$$