TYPE 754: HEATER / HUMIDIFIER

General Description

Type754 models a device that can heat and / or humidify an air stream. Depending upon the device control mode, the outlet air stream dry bulb temperature, dry bulb temperature and relative humidity, dry bulb temperature and humidity ratio, or humidity ratio only will be maintained by the device. Type754 is not capacity limited but reports the sensible and latent energy required to meet the requested outlet condition based on the air inlet conditions.

Nomenclature

$\dot{m}_{air}$	[kg/hr]	Mass flow rate of air entering the device.
P_{out}	[atm]	Outlet air pressure
P_{in}	[atm]	Inlet air pressure
ΔP	[atm]	Air pressure drop across the device.
$\dot{Q}_{hum}$	[kJ/hr]	The latent energy of humidifying the air stream.
$\dot{Q}_{tot}$	[kJ/hr]	The total energy transferred to the air stream.
ω_{in}	[kgH_2O/kgAir]	The inlet air humidity ratio
ω_{out}	[kgH_2O/kgAir]	The outlet air humidity ratio
h_{in}	[kJ/kg]	The enthalpy of air entering the device
h_{out}	[kJ/kg]	The enthalpy of air exiting the device
h_{vap}	[kJ/kg]	The enthalpy of water vapor exiting the device
h_{liq}	[kJ/kg]	The enthalpy of condensate exiting the device
HFG	[kJ/kg]	The latent heat of vaporization of water.

Detailed Description

At each time step, Type754 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. If 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 Type754 determines that it is unable to transfer energy to the air stream either because the air stream flow rate is equal to zero or because the device control signal is set to 0 (OFF) it sets the outlet air pressure equal to the inlet air pressure minus the device pressure drop (specified among the component's inputs) as shown in equation 754.1.

$$P_{out} = P_{in} - \Delta P \qquad \text{(Eq. 754.1)}$$

Under the OFF or no flow condition, Type754 sets the outlet air temperature, humidity ratio, enthalpy and relative humidity equal to the corresponding inlet values. The temperature of condensate is set to the air outlet temperature and the flow rate of condensate is set to zero. Type754 further sets both the total and latent energy transfer to the air stream to zero and exits.

Temperature Control

If the Type754 control signal is set to 1 (ON) and the air flow rate through the device is non zero, Type754 first sets the air pressure according to equation 754.1, sets the outlet enthalpy and humidity ratio equal to the corresponding inlet values and calls Psychrometrics. If the returned dry bulb temperature is greater than or equal to the user specified set point temperature, the sensible energy transfer is set to zero. The latent energy transfer is calculated based on equation 754.2

$$\dot{Q}_{hum} = \dot{m}_{air}\left(\omega_{out} - \omega_{in}\right) \quad \text{(Eq. 754.2)}$$

The latent energy transfer may be non zero if the inlet air humidity ratio, outlet pressure and inlet air enthalpy result in saturated conditions. As with the call to fully determine the air inlet state, the Psychrometrics routine may reset the humidity ratio to the saturation value.

If the air dry bulb temperature returned by Psychrometrics is below the user defined set point, Psychrometrics is recalled, this time with the outlet pressure, inlet humidity ratio and desired dry bulb temperature. Psycrhoetrics returns (among other values) the outlet air enthalpy. The total energy transfer to the air stream is given by equation 754.3.

$$\dot{Q}_{tot} = \dot{m}_{air}\left(h_{out} - h_{in}\right) \quad \text{(Eq. 754.3)}$$

Under temperature control, Type754 does not actively humidify the air and thus when sensible energy is added, the latent energy transfer to the air stream is set to zero, as is the flow rate of condensate. Under the situation of adding sensible energy to an air stream there is no way that condensation can occur.

Temperature and Humidity Control

If the user has specified the air outlet humidity set point as a relative humidity Type754 calls the Psychrometrics to determine the equivalent set point humidity ratio. If the user has specified a desired outlet humidity ratio directly, this call to Psychrometrics is skipped since the desired value is already known. Psychrometrics is then called with the outlet pressure, desired outlet temperature and desired outlet humidity ratio. The outlet temperature and enthalpy are returned. The total energy transfer is again given by equation 754.3. To determine the latent energy gain, the TRNSYS Steam Properties routine is called with the outlet air temperature (which is also the temperature of both condensate and water vapor exiting the device) and a quality of 0; the enthalpy of the liquid condensate is returned. The Steam Properties subroutine is called a second time, again with the outlet air temperature but this time with a quality of 1 to determine the enthalpy of the exiting water vapor. The latent heat of vaporization is then

$$HFG = h_{vap} - h_{liq} \quad \text{(Eq. 754.4)}$$

And the latent energy transfer is

$$\dot{Q}_{hum} = \dot{m}_{air}\ HFG\left(\omega_{out} - \omega_{in}\right) \quad \text{(Eq. 754.5)}$$

Humidity Control

In the last control mode, the user specifies only a desired outlet air humidity ratio. Type754 makes a preliminary call to the Psychrometrics routine assuming that the air exits at its inlet temperature and humidity ratio and at the outlet pressure given by 754.1. Again Psychrometrics may reset the outlet humidity ratio if saturation has been achieved due to the pressure drop. If the outlet air is higher in absolute humidity than was desired, the total and humidification energy transfers are set to zero. The temperature of condensate is set to the outlet air temperature and the flow rate of condensate is given by equation 754.2.

If the outlet humidity ratio is lower than the set point, Psychrometrics is again called with the outlet pressure, desired humidity ratio and inlet enthalpy. The only difference in this call is that instead of allowing Psychrometrics to reset the humidity ratio if saturation has occurred, Psychrometrics is asked to reset the outlet air enthalpy to the saturation condition given the desired humidity ratio. The total energy transfer is again given by 754.3 and the humidification energy is given by 754.5 following two calls to the TRNSYS Steam routine once to find the enthalpy of exiting water vapor and once to find the enthalpy of exiting condensate.