TYPE 641: SIMPLE ADIABADIC HUMIDIFER

General Description

This model represents a simple adiabatic humidifier whose outlet air state is determined by an energy balance. Thermal losses from the humidifier are neglected. The model allows for the humidifier not to respond immediately to the control signal but to reach its steady state moisture gain rate exponentially. Furthermore, the model allows the user to determine whether condensate leaves the humidifier at the temperature at which it enters, at the temperature of the air exiting the humidifier or at any point in between.

Nomenclature

$h_{air,in}$	[kJ/kg.K]	Enthalpy of air entering the humidifier.
$h_{air,out}$	[kJ/kg.K]	Enthalpy of air exiting the humidifier
$h_{H_2O,in}$	[kJ/kg.K]	Enthalpy of water entering the humidifier
$h_{H_2O,out}$	[kJ/kg.K]	Enthalpy of condensate (water) exiting the humidifier through the drain
$\dot{m}_{air}$	[kg/hr]	Mass flow rate of air (entering mass flow rate = exiting mass flow rate)
$\dot{m}_{H_2O,in}$	[kg/hr]	Mass flow rate of water entering the humidifier
$\dot{m}_{H_2O,out}$	[kg/hr]	Mass flow rate of condensate (water) exiting the humidifier through the drain
$T_{H_2O,in}$	[C]	Temperature of water being added to the air stream
$T_{H_2O,out}$	[C]	Temperature of condensate
$T_{air,out}$	[C]	Temperature of air exiting the humidifier
f	[0..1]	Fractional variable describing the temperature mixing effects between outlet air and condensate.

Detailed Description

The operation of Type641 is governed by the fairly simple energy balance shown in Figure 1.

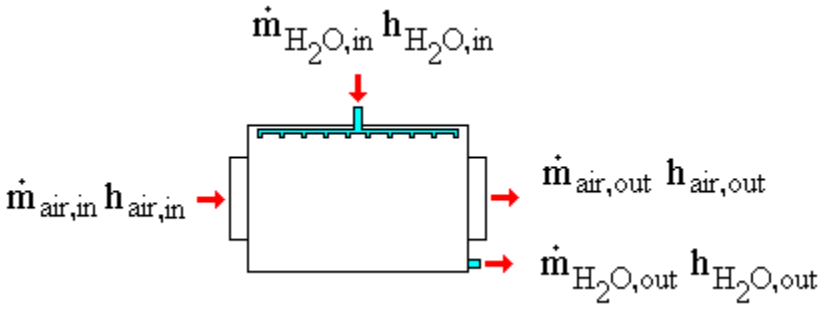


Figure 1: Humidifier Energy Balance

The energy balance on the humidifier is first solved assuming that the flow rate of condensate is zero; in other words, that the air is able to absorb the entire amount of water being added to it by the humidifier. Knowing that the mass flow rate of air exiting the humidifier is the same as the mass flow rate of air entering the humidifier, the first energy balance is written as shown in equation 641.1.

$$h_{air,out} = h_{air,in} + \frac{\dot{m}_{H_2O,in}}{\dot{m}_{air}} h_{H_2O,in} \quad \text{(Eq. 641.1)}$$

The enthalpy of entering water is returned by the TRNSYS STEAM properties based on used specified inlet conditions. Likewise, the enthalpy of inlet air is provided by the PSYCHROMETRICS routine.

The humidity ratio of air exiting the humidifier is computed based on a mass balance. With the conditions of the outlet air now know, Type641 then checks the outlet air for saturation. If it is determined that the outlet air is determined to be past the saturation point, its properties (humidity ratio, relative humidity, enthalpy, etc.) are set to their saturated condition values by the PSYCHROMETRICS routine. Type641 then repeats the energy balance, now including the mass flow of condensate exiting the humidifier using equation 641.2 below.

$$h_{air,out} = h_{air,in} + \frac{\dot{m}_{H_2O,in}}{\dot{m}_{air}} h_{H_2O,in} - \frac{\dot{m}_{H_2O,out}}{\dot{m}_{air}} h_{H_2O,out} \quad \text{(Eq. 641.2)}$$

Depending upon the configuration of the humidifier, a number of different possibilities present themselves for determining a value of the enthalpy of exiting water used in the equation above. Through the use of parameter 5, the user is able to specify whether the condensate exits the humidifier at the same temperature with which it entered the device, at the same temperature as the air exiting the device, or at any temperature there between. The exiting water temperature is determined by equation 641.3 where f is the outlet water temperature factor (parameter 5)

$$T_{H_2O,out} = (1-f)T_{H_2O,in} + fT_{air,out} \quad \text{(Eq. 641.3)}$$

Once the temperature and flow rate of the condensate are determined, Type641 calls the STEAM subroutine again to obtain the exiting water's enthalpy.

Each time a new exiting air enthalpy is calculated, it is compared with the previous value. Iteration continues until these two values match to within a tolerance or until 50 iterations have transpired. The tolerance is, by default set to 0.01 kJ/kg.K. Both the tolerance and the maximum number of iterations may be modified in the Fortran source code.

It is important to note that the mass flow rate of water entering the humidifier is not always the steady state rate set as a parameter to this model. Instead, Type641 is outfitted with a time constant that brings the moisture gain rate from 0 to its steady state value over a specified period of time following an exponential curve as shown in Figure 2.

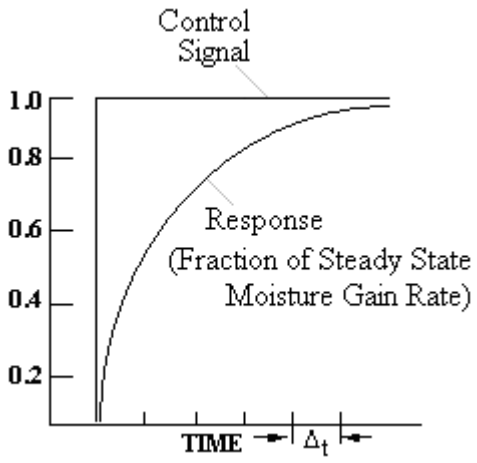


Figure 2: Humidifier Time Constant Behavior

When the control signal drops to zero (the humidifier is turned OFF), the moisture gain rate drops immediately to zero. The time constant does not affect humidifier shut down, only humidifier warm up.