TYPE 673: TWO PIPE CONSOLE UNIT IN ENERGY RATE CONTROL

General Description

Type673 models a piece of HVAC equipment commonly known as a two pipe console unit. Such devices pass air across a tube bank that contains either hot or cold fluid. Depending upon the temperature of the air and the fluid, the air will exit either hotter or colder than it entered. Type673 models a two pipe console unit in energy rate control mode, meaning that sensible and latent loads are inputs to the model. Type673 includes a "number of identical units" parameter that allows for easy scaling of the system to meet the building load.

Nomenclature

PLR	[0..1]	Fan part load ratio
γ_{fan}	[0..1]	Fan control signal (1: fan is ON, 0: fan is OFF)
P_{fan}	[kJ/h]	Power drawn by the fan
$a_0, a_1, a_2, \ldots$	[-]	Coefficients in the fan power curve
N_{units}	[-]	Number of two pipe console units in simultaneous operation.
P_{rated}	[kJ/hr]	Rated fan power.
$\dot{Q}_{ht,\max}$	[kJ/hr]	Maximum heating rate (includes multiple unit effects and control signal effects)
γ_{ht}	[0..1]	Heating control signal (1: heating is ON, 0: heating is OFF)
Cap_{ht}	[kJ/hr]	Heating capacity of the unit.
$\dot{Q}_{cl,\max}$	[kJ/hr]	Maximum cooling rate (includes multiple unit effects and control signal effects)
γ_{cl}	[0..1]	Cooling control signal (1: cooling is ON, 0: cooling is OFF)
Cap_{cl}	[kJ/hr]	Cooling capacity of the unit.
$\dot{Q}_{met,sens}$	[kJ/hr]	Sensible load met (-ve: heating, +ve: cooling)
$\dot{Q}_{ht,load}$	[kJ/hr]	Sensible heating load (input)
$\dot{Q}_{met,lat}$	[kJ/hr]	Latent load met.
$\dot{Q}_{cl,load}$	[kJ/hr]	Sensible cooling load (input)
$\dot{Q}_{unmet}$	[kJ/hr]	Load unmet (sensible and latent)
$\dot{Q}_{lat,load}$	[kJ/hr]	Latent cooling load (input)
T_{out}	[ºC]	Fluid outlet temperature
T_{in}	[ºC]	Fluid inlet temperature
$\dot{m}$	[kg/hr]	Mass flow rate of fluid flowing through the device.
Cp	[kJ/kg.K]	Specific heat of fluid flowing through the device.

Detailed Description

A two pipe console unit is a device in which air is passed across a bank of tubes that contain a fluid. The device can provide heating or cooling depending upon whether the fluid in the tube bank is hotter or

colder than the air stream. Four pipe console units also exist. In these devices, two separate tube banks are present, allowing the device to heat and cool (dehumidify) at the same time or allowing the device to change between heating and cooling much more rapidly. The cross section of a two pipe console unit is shown schematically in Figure 1.

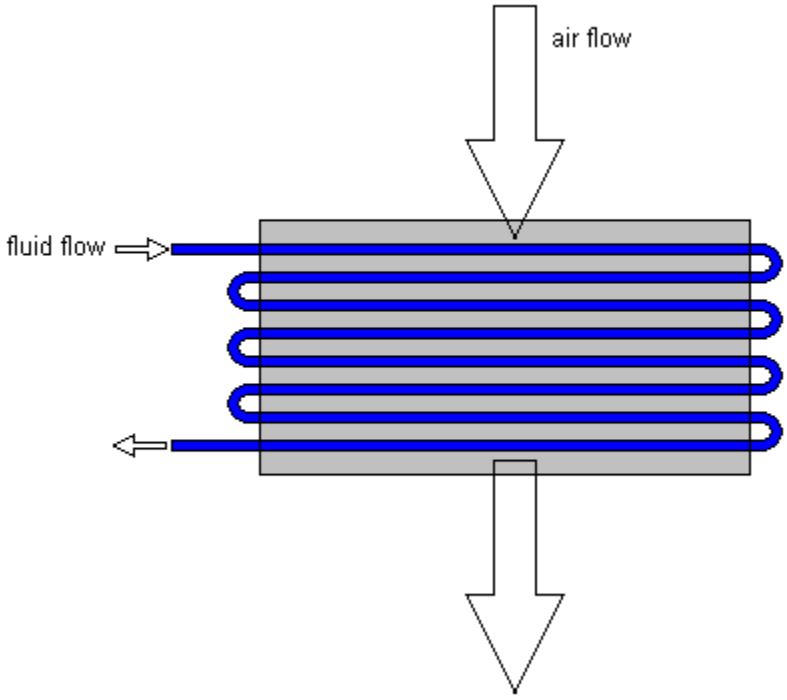


Figure 1: Cross Sectional Schematic of a Two-Pipe Console Unit

Energy Rate versus Temperature Level Control

TRNSYS contains two fundamentally different methods for simulating energy use of buildings and equipment: the "energy rate control" method and the "temperature level control" method. Often when simulating a building, a time step between 15 minutes and one hour is used. This, however, can lead to control problems because a simulation program is able to make a control decision only once per time step. At a given time step, the thermostat in a building might notice that the building temperature is below the set point and would decide to add energy to the space (turn on the heating equipment). The equipment would then stay on for an entire time step (often 15 minutes or an hour), by the end of which, the building is overheated to a point where active cooling might be appropriate. Energy rate control attempts to address this problem by assigning a nearly infinite capacity to the heating (and cooling) systems and to assume nearly perfect control over the system. The building (and equipment) then use only the necessary amount of the available capacity to keep the building exactly at its set point temperature. The control problems of overdriving the system disappear but this is not exactly how a building operates; energy rate control neglects switching dynamics and it neglects the fact that most heating and cooling systems are not infinitely controllable such that they can be configured only to provide or remove the required amount of energy. Energy rate control techniques are useful for generating building loads and for estimating required equipment sizes. They are less useful when trying to simulate buildings and equipment "as built" or when trying to match data. The other option in TRNSYS is to use "temperature level control" in which equipment is assigned a capacity and a control signal. When a thermostat indicates that heating or cooling should be provided then equipment is

switched on and overheating or undercooling may occur if equipment is oversized or if the time step is too large.

Type673 models a two pipe console unit in energy rate control. This means that the user must specify a heating and cooling capacity for the device and provide current load on the device. Type673 will then use the fraction of capacity that it needs in order to meet the load. Of course if load exceeds capacity, the device will be unable to meet the entire load. Type673 reports sensible and latent load met as well as load not met.

Two Pipe Console Unit Performance

When there is no fluid flow through the two pipe console unit, the temperature of fluid exiting the device is set to the temperature of fluid entering the device. The sensible load met, latent load met, and load not met are all set to zero.

Because air may be flowing even if fluid is not flowing through the device, the fan part load ratio and power drawn by the fan are calculated under all circumstances. The fan part load ratio is determined by directly from the fan control signal

$$PLR = \gamma_{fan} \tag{Eq. 673.1}$$

The power drawn by the fan is determined using a fan power curve, the coefficients for which are provided among Type673's parameters.

$$P_{fan} = \left(a_0 + a_1 PLR + a_2 PLR^2 + a_3 PLR^3 + ...\right) N_{units}\ P_{rated} \tag{Eq. 673.2}$$

In which N_{units} is the number of console units being modeled by Type673 and P_{rated} is the maximum power drawn by the fan under its rated conditions.

When fluid is flowing through the console unit, the device attempts to match the user specified sensible and latent loads. The sign convention on sensible load is that a positive value indicates a cooling load while a negative value indicates a heating load. The maximum heating load that can be met by Type673 is given by equation 673.3.

$$\dot{Q}_{ht,\max} = N_{units}\ \gamma_{ht}\ Cap_{ht} \tag{Eq. 673.3}$$

Similarly, the maximum cooling loads that can be met is given by 673.4.

$$\dot{Q}_{cl,\max} = N_{units}\ \gamma_{cl}\ Cap_{cl} \tag{Eq. 673.4}$$

If a heating load on the console unit exists, equations 673.5a through 673.5c give the sensible load met, latent load met and load unmet by the device.

$$\dot{Q}_{met,sens} = -MIN\left(-\dot{Q}_{ht,load}, Cap_{ht}\right) \tag{Eq. 673.5a}$$

$$\dot{Q}_{met,lat} = 0 \tag{Eq. 673.5b}$$

$$\dot{Q}_{unmet} = \dot{Q}_{ht,ld} + \dot{Q}_{met,sens} \quad \text{(Eq. 673.5c)}$$

Equation 673.5c is a bit unintuitive at first but recall that user specified heating loads are assigned a negative value in Type673's sign convention. The load unmet is therefore merely the difference between the user specified heating load and the sensible load that was able to be met given the device capacity. The fan part load ratio is next calculated using equation 673.6.

$$PLR = \frac{-\dot{Q}_{met,sens}}{\dot{Q}_{ht,\max}} \quad \text{(Eq. 673.6)}$$

If a cooling load on the console unit exists, equations 673.7a through 673.7c give the sensible load met, latent load met and load unmet by the device.

$$\dot{Q}_{met,sens} = MIN\left(\dot{Q}_{cl,load}, Cap_{cl}\right) \quad \text{(Eq. 673.7a)}$$

$$\dot{Q}_{met,lat} = MIN\left(\left(\dot{Q}_{cl,\max} - \dot{Q}_{met,sens}\right), \dot{Q}_{lat,load}\right) \quad \text{(Eq. 673.7b)}$$

$$\dot{Q}_{unmet} = \left(\dot{Q}_{cl,load} - \dot{Q}_{met,sens}\right) + \left(\dot{Q}_{lat,load} - \dot{Q}_{met,lat}\right) \quad \text{(Eq. 673.7c)}$$

The sensible cooling load met by the device is the minimum of the user specified sensible load and the device's total cooling capacity. The latent load met by the device is the minimum of the user specified latent load and the capacity remaining after meeting the sensible cooling load. The load unmet is the sum of the user specified sensible cooling load minus sensible cooling load met and the user specified latent cooling load minus latent load met.

The fan part load ratio is next calculated using equation 673.8.

$$PLR = \frac{\dot{Q}_{met,sens} + \dot{Q}_{met,lat}}{\dot{Q}_{cl,\max}} \quad \text{(Eq. 673.8)}$$

With the major energy flows in the two pipe console unit calculated, the fluid outlet temperature may be found using equation 673.9.

$$T_{out} = T_{in} + \frac{\dot{Q}_{sens,met} + \dot{Q}_{lat,met}}{\dot{m}\, Cp} \quad \text{(Eq. 673.8)}$$