TYPE 744: VARIABLE OR CONSTANT SPEED FAN, MASS FLOW RATE INPUT, POWER CALCULATED FROM POWER CURVE POLYNOMIAL

General Description

Type744 models a fan that sets its outlet mass flow rate equal to a user specified inlet mass flow rate. Because mass flow rate is an input (as opposed to a parameter), Type744 can equally well be used to model a constant or a variable speed fan. Unlike most pumps and fans in TRNSYS, Type744 passes the inlet mass flow rate of air through to its output. Type744 sets the downstream flow but does not take a control signal. The fan's power draw is calculated based upon a user specified polynomial. Fan starting and stopping characteristics are not modeled.

Nomenclature

$\dot{m}$	[kg/hr]	Mass flow rate of air passing though the fan.
$\dot{m}_{rated}$	[kg/hr]	Maximum mass flow rate of air that can pass though the fan.
$a_0, a_1, a_2 \ldots$	[-]	Polynomial coefficients in the fan power curve
η_{motor}	[-]	Efficiency of the fan motor
$\dot{Q}_{air}$	[kJ/hr]	Energy transferred from the fan motor to the air stream passing through the fan.
$f_{motorloss}$	[0..1]	Fraction of fan motor inefficiencies that contribute to a temperature rise in the air stream passing through the fan. The remainder of these inefficiencies contribute to an ambient temperature rise.
$\dot{P}$	[kJ/hr]	Power drawn by the fan.
$\dot{Q}_{ambient}$	[kJ/hr]	Energy transferred from the fan motor to the ambient air surrounding the fan.
$h_{air,out}$	[kJ/kg]	Enthalpy of air exiting the fan
$h_{air,in}$	[kJ/kg]	Enthalpy of air entering the fan

Detailed Description

As inputs, Type744 takes air pressure, temperature relative humidity and absolute humidity ratio. Depending upon the mode in which Type744 is operating, the value of either the relative humidity or the humidity ratio input is ignored. The component passes pressure, temperature and either relative humidity or humidity ratio to the TRNSYS PSYCHROMETRICS routine, which returns values of temperature, humidity ratio, relative humidity, and enthalpy. If saturated conditions are passed to the PSYCHROMETRICS routine, PSYCHROMETRICS returns the saturated humidity ratio corresponding to the given temperature. This means that the humidity ratio and relative humidity used in calculations may be slightly different than those passed to the model by the user. If the air condition is saturated at any point in the simulation, the PSYCHROMETRCS routine will print a warning in the TRNSYS list file.

If the fan is determined to be OFF (it's inlet mass flow rate is set to 0), the outlet mass flow rate, power drawn, energy transferred to ambient and energy transferred to the air stream are all set to zero. The temperature of air exiting the fan under the OFF condition is set to the temperature of air at the fan inlet. If, however, the fan is determined to be ON (inlet mass flow rate greater than 0) then the mass flow rate

of air exiting the fan is set to the current inlet mass flow rate specified in the model's input list. The power drawn by the fan when ON is given by equation 744.1.

$$\dot{P} = a_0 + a_1\left(\frac{\dot{m}}{\dot{m}_{rated}}\right) + a_2\left(\frac{\dot{m}}{\dot{m}_{rated}}\right)^2 + a_3\left(\frac{\dot{m}}{\dot{m}_{rated}}\right)^3 + \ldots \quad \text{(Eq. 744.1)}$$

To model a constant speed fan using Type744, the user should insure that the mass flow rate set as an input to the model always has the same value. A variable speed fan is modeled simply by allowing the inlet mass flow rate to vary with time.

Energy transferred from the fan motor to the air stream is calculated as shown in equation 744.2

$$\dot{Q}_{air} = \left(\eta_{motor} + \left(1 - \eta_{motor}\right) f_{motorloss}\right)\dot{P} \quad \text{(Eq. 744.2)}$$

In which η_{motor} is the fan motor efficiency and $f_{motorloss}$ is a value between 0 and 1 that determines whether the fan motor inefficiencies cause a temperature rise in the air stream that passes through the fan or whether they cause a temperature rise in the ambient air surrounding the fan. Through use of the $f_{motorloss}$ fraction, the user can in effect specify whether the fan has an inline motor, in which case all waste heat would impact the air stream temperature and $f_{motorloss}$ would have a value of 1, or whether the fan motor is housed outside of the air stream such that it's waste heat impacts the ambient and $f_{motorloss}$ would have a value of 0.

The energy transferred from the fan motor to the ambient is given by equation 744.3.

$$\dot{Q}_{ambient} = \dot{P} - \dot{Q}_{air} \quad \text{(Eq. 744.3)}$$

The enthalpy of air exiting the fan can now be calculated as shown in equation 744.4.

$$h_{air,out} = h_{fair,in} + \frac{\dot{Q}_{air}}{\dot{m}} \quad \text{(Eq. 744.4)}$$

After applying the user specified fan pressure rise, Type744 obtains the remaining air properties through a final call to the PSYCHROMETRICS routine. The absolute humidity ratio of outlet air is unaffected by the fan ($\omega_{in} = \omega_{out}$). Type744 does not model fan starting and stopping characteristics; as soon as the inlet mass flow rate indicates that the fan should be ON or that the fan should change speeds due to an inlet mass flow rate change, the outlet flow of air jumps to match the inlet flow rate. The time constants with which fans react to input changes are much shorter than the typical time steps used in hydronic simulations.