TYPE 662: VARIABLE SPEED FAN/BLOWER

General Description

Type662, donated as Type111 to the standard TRNSYS Library with the release of v. 16, models a fan that is able to turn at any speed between 0 (full stop) and its rated speed. While the mass flow rate of air moved by the fan is linearly related to the control signal, the power drawn by the fan at a given flow rate can be any polynomial expression of the control signal. As with most pumps and fans in TRNSYS, Type662 takes mass flow rate as an input but ignores the value except in order to perform mass balance checks. Type662 sets the downstream flow rate based on its rated flow rate parameters and the current value of its control signal inputs.

Nomenclature

$\dot{Q}_{air}$	[kJ/hr]	Energy transferred from the fan motor to the air stream passing through the fan.
η_{motor}	[0..1]	Fan motor efficiency
$f_{motorloss}$	[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 at a given time.
$\dot{P}_{rated}$	[kJ/hr]	Fan power draw when operating at rated conditions.
$a_0, a_1, a_2 \ldots$	[kJ/hr]	Coefficients of the polynomial relating control setting to power draw.
γ	[0..1]	Fan control signal.
$\dot{Q}_{ambient}$	[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
$\dot{m}_{air}$	[kg/hr]	Mass flow rate of air passing though the fan.
$\dot{m}_{rated}$	[kg/hr]	Maximum air flow rate that can pass through the fan.

Detailed Description

During any given time step, Type662 performs a simple set of calculations to determine the conditions of air exiting a fan. As inputs, it takes air pressure, temperature, relative humidity and absolute humidity ratio. Depending upon the mode in which Type662 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 were passed to the PSYCHROMETRICS routine, PSYCHROMETRICS will return the saturated conditions corresponding to the specified 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 due to the control signal being set to 0, the temperature, humidity ratio, relative humidity, and pressure of air exiting the fan are set to the corresponding inlet conditions. Fan

power, energy transferred from the fan motor to the air stream, energy transferred from the fan motor to ambient, and the outlet mass flow rate are all set to zero. If, on the other hand, the fan is ON due to the control signal having a value greater than 0 and less than 1, the power drawn by the fan is calculated by equation 662.1

$$\dot{P} = \dot{P}_{rated}\left(a_0 + a_1\gamma + a_2\gamma^2 + a_3\gamma^3 + a_4\gamma^4 + ...\right) \quad \text{(Eq. 662.1)}$$

With the current power drawn by the fan known the energy transferred to the fan air stream is calculated using equation 662.2.

$$\dot{Q}_{air} = \left(\eta_{motor} + \left(1 - \eta_{motor}\right) f_{motorloss}\right)\dot{P} \quad \text{(Eq. 662.2)}$$

In which η_{motor} is the 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 662.3.

$$\dot{Q}_{ambient} = \dot{P} - \dot{Q}_{air} \quad \text{(Eq. 662.3)}$$

The mass flow rate of air passing through the fan at any given time is linearly related to the control signal as shown in equation 111.4.

$$\dot{m} = \dot{m}_{rated}\gamma \quad \text{(Eq. 662.4)}$$

As with most pump and fan components in TRNSYS the flow rate of air exiting the fan is set by the component without regard to the value of the mass flow rate that is an input to the model. The mass flow rate input is retained to make connections around an air loop more intuitive and to allow for a mass balance check to be made on the fan. Care should be taken in setting up air loops that no more than the fan rated mass flow rate is passed to the model as an input. Type662 prints a warning to the TRNSYS list file at the end of the simulation if the fan mass balance failed during the simulation. Type662 does not generate a simulation stopping error if the mass balance fails.

The enthalpy of air exiting the fan can be calculated as shown in equation 662.5.

$$h_{air,out} = h_{air,in} + \frac{\dot{Q}_{air}}{\dot{m}_{air}} \quad \text{(Eq. 662.5)}$$

Lastly, the pressure rise of the fan is added to the inlet air pressure and the PSYCHROMETRICS routine is called to determine the remaining properties of the exiting air state (temperature, humidity ratio and relative humidity.) The absolute humidity ratio of outlet air is unaffected by the fan ($\omega_{in} = \omega_{out}$).