TYPE 700: SIMPLE BOILER WITH EFFICIENCY INPUTS

General Description

Type700 models a simple steam boiler. According to ASHRAE, a boiler is defined by its overall efficiency (output/input) and by its combustion efficiency ((input energy-stack energy)/input energy). In this model, the boiler efficiency and the combustion efficiency are supplied as inputs to the model. A version of this component also exists (Type751) in which boiler and combustion efficiency are read as a function of entering liquid temperature and device part load ratio from an external data file. This component (Type700) assumes that device efficiency is not a function of inlet conditions.

Nomenclature

Cp_{fluid}	[kJ/kg.K]	Specific heat of the liquid stream
$\dot{Q}_{need}$	[kJ/hr]	Energy required to heat the liquid from its entering condition to the set point temperature.
$\dot{Q}_{\max}$	[kJ/hr]	The device capacity. The maximum rate at which energy can be delivered to the liquid.
$\dot{Q}_{fluid}$	[kJ/hr]	The energy delivered to the liquid stream.
$\dot{Q}_{fuel}$	[kJ/hr]	The rate at which fuel energy is consumed.
$\dot{Q}_{loss}$	[kJ/hr]	The rate at which energy is lost from the device due to combustion process inefficiency.
$\dot{Q}_{exhaust}$	[kJ/hr]	The rate at which energy is exhausted from the boiler through the combustion stack or chimney.
$\dot{m}_{fluid}$	[kg/hr]	The mass flow rate of liquid flowing through the boiler.
T_{in}	[ºC]	The temperature of liquid entering the boiler.
T_{out}	[ºC]	The temperature of liquid exiting the boiler.
T_{set}	[ºC]	The boiler set point temperature.
PLR	[0..1]	The boiler part load ratio.
$\eta_{combustion}$	[0..1]	The boiler's combustion efficiency.
η_{boiler}	[0..1]	The boiler's overall efficiency.

Detailed Description

Type700 uses a simple efficiency equation to predict the energy requirement of heating a liquid to its set point temperature. The heater is capacity limited and in these two regards, is quite similar to standard TRNSYS Type6. Where Type700 differs from Type6 is that in addition to the overall device efficiency, Type700 also takes a combustion efficiency input and reports the energy lost during the combustion process and the energy exhausted from the boiler combustion stack.

No Flow Condition

If the flow of liquid through the Type700 boiler is zero, the model sets the output temperature equal to the input temperature and sets the output flow rate to zero. It further sets the energy transferred to the fluid, the energy lost during the combustion process, the energy exhausted through the boiler stack, the amount of fuel consumed and the device part load ratio all equal to zero. The no flow condition supercedes the device control signal meaning that if the input flow rate to the boiler is zero, the model

ignores the value of the control signal. Consequently, the boiler may be ON (control signal set to 1) and yet not be meeting the requested set point temperature.

Boiler OFF Condition

If there is flow of liquid through the Type700 boiler but the boiler control signal is zero (OFF), the model sets the output temperature equal to the input temperature and sets the output flow rate equal to the input flow rate. As with the no flow case, Type700 sets the energy transferred to the fluid, the energy lost during the combustion process, the energy exhausted through the boiler stack, the amount of fuel consumed and the device part load ratio all equal to zero.

Boiler ON Condition

If there is flow of liquid through the Type700 boiler and the boiler control signal is set to 1 (ON), the model first calculates the energy required to elevate the temperature of the liquid from its inlet value to the set point value using equation 700.1

$$\dot{Q}_{need} = \dot{m}_{fluid} Cp_{fluid} \left(T_{set} - T_{in}\right) \qquad \text{(Eq. 700.1)}$$

The required energy input is limited by the device capacity (specified as a parameter) and 0. Thus the device will not calculate a negative value of Q_{need} if the inlet temperature exceeds the set point temperature and the boiler control signal is ON. If Q_{need} does not exceed device capacity, the energy transferred to the liquid stream (Q_{fluid}) is set equal to Q_{need}; the device is assumed to be internally controlled in such a way that it delivers only the required amount of energy to the liquid stream. The outlet temperature is set equal to the set point temperature and the part load ratio (PLR) is set according to equation 700.2

$$PLR = \frac{\dot{Q}_{need}}{\dot{Q}_{\max}} \qquad \text{(Eq. 700.2)}$$

If the boiler is capacity limited because the required energy exceeds device capacity, the energy transferred to the fluid (Q_{fluid}) is set to the device capacity (Q_{max}), the PLR is set to 1 and the outlet fluid temperature is set according to equation 700.3

$$T_{out} = T_{in} + \frac{\dot{Q}_{\max}}{\dot{m}_{fluid} Cp_{fluid}} \qquad \text{(Eq. 700.3)}$$

Once the energy transferred to the fluid is calculated, the amount of fuel consumed by the boiler is calculated by

$$\dot{Q}_{fuel} = \frac{\dot{Q}_{fluid}}{\eta_{boiler}} \qquad \text{(Eq. 700.4)}$$

The energy exhausted from the device is given by

$$\dot{Q}_{exhaust} = \dot{Q}_{fuel}\left(1 - \eta_{combustion}\right) \qquad \text{(Eq. 700.5)}$$

And the energy lost during the combustion process is given by

$$\dot{Q}_{loss} = \dot{Q}_{fuel} - \dot{Q}_{exhaust} \qquad \text{(Eq. 700.6)}$$