TESS HVAC Library Examples - Restaurant with Solar Absorption Cooling

The purpose of this example is to show how to use some of the TESS HVAC library components to simulate a solar absorption chilling system for a small building. This example has also been designed so that all non-HVAC components are standard TRNSYS components. The absorption cooling system is described in five parts: first of all defining the general settings, then implementing the hot, cooling and chilled water loops, and finally the building air loop. This document will guide through each of the five parts.

TESS HVAC components used in this example:

- Closed Circuit Cooling Tower (Type 510)
- Hot Water-Fired Double-Effect Absorption Chiller (Type 677)
- Performance Map Cooling Coil (Type 697)
- Boiler, Efficiencies as Inputs (Type 700)

General Settings and Considerations

First of all, the simulation time step should be small to account for the temperature monitoring of the thermostat. A time step of 5 minutes will be used here. To set the simulation time step, go to *Assembly* → *Control cards* in the top menu. It is important to note that the chosen simulation time step has to be an integer division of the wall time step, which is typically one hour. Therefore, set the time step unit to “string” and type “DELT” for the value, as shown on figure 1.

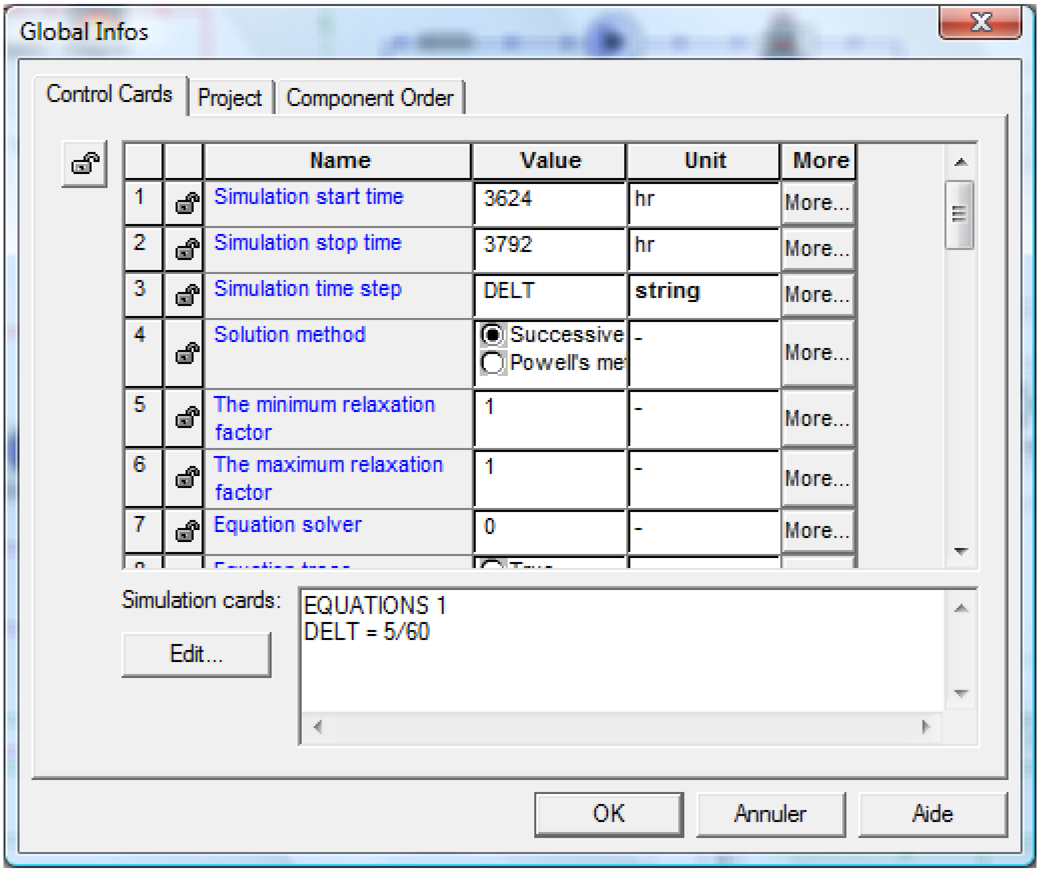

Figure 1: Setting the simulation time step

Then, in the "Simulation cards" text box at the bottom of the window, type "EQUATIONS 1" and define the numerical value of "DELT" to 5/60.

All of the components used, starting with the absorption chiller itself, need to be sized accordingly to the total building cooling load. Once the chiller capacity has been set, every default pump/fan flow rate and HVAC unit capacity has to be scaled in order to meet the chiller requirements. For example, the default rated capacity for the chiller is 5,380,000 kJ/hr, and the default input chilled water flow rate value is 232,000 kg/hr. Since the required chilling capacity is only 100,000 kJ/hr, the chilled water flow rate is to be scaled down to 4,312 kg/hr.

Note: The fluid flow rates in TRNSYS are generally set by the *Hydronics* components (pumps, fans, etc.).

Another important consideration here is to make sure that at least one component in every closed piping loop contains enough capacitance to hold at least one time step worth of fluid, or else convergence problems are likely to occur. This can be achieved by adding pipes (*Hydronics* → *Pipe_Duct*) in the fluid loops, and sizing them by taking into account maximum flow rate and simulation time step. Pipes also make it possible to model environment thermal losses, thus making the simulation more realistic.

The weather data used in this simulation is a TMY2 file for the city of Madison, WI.

Hot Water Loop

The absorption chiller primary energy source is the heat provided by the hot water loop. Whenever possible, water is heated by solar collectors and then stored into a hot storage tank. A differential controller (Type 2b) is used to turn the collector pump on anytime the water out of the solar collectors is hotter than the storage tank water (on the hot side).

The load side (right side) of the hot water loop (see figure 2) features a furnace that provides the fluid the additional heat needed to reach the chiller design hot water inlet temperature. The furnace is controlled by a thermostat that monitors the water temperature at its inlet.

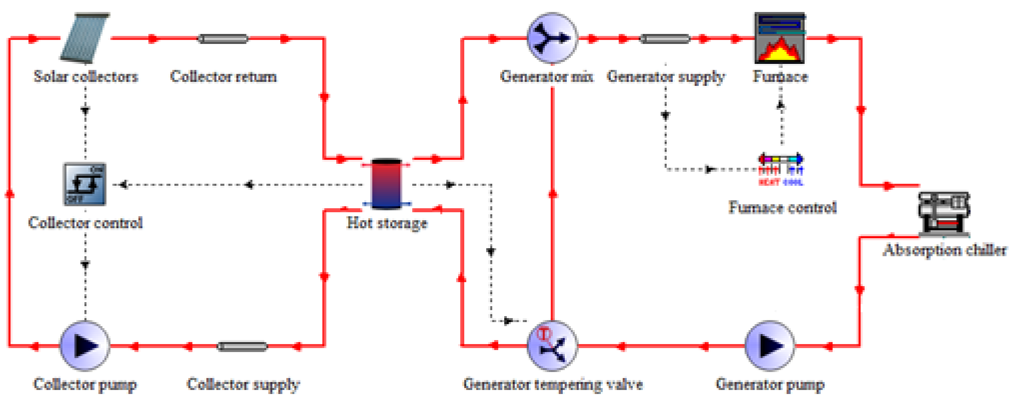

Figure 2: Hot water loop

On the return from the chiller, the water flow is diverted by a tempering valve. If the returning water temperature is greater than the storage hot water temperature, the returning flow bypasses the storage tank and is sent directly back to the furnace. In the opposite case, depending on the tank hot-side temperature, a fraction of the returning flow bypasses the tank and mixes with hot tank water in an attempt to reach the set point temperature (which is the same as the chiller design hot water inlet temperature).

Cooling Water Loop

Cooling water is used in the absorber and condenser parts of the absorption chiller. At the cooling water outlet of the chiller, fluid is pumped to the cooling tower (figure 3). Once again, the fluid flow rate through the loop and the cooling tower capacity need to be scaled accordingly to the cooling load of the chiller.

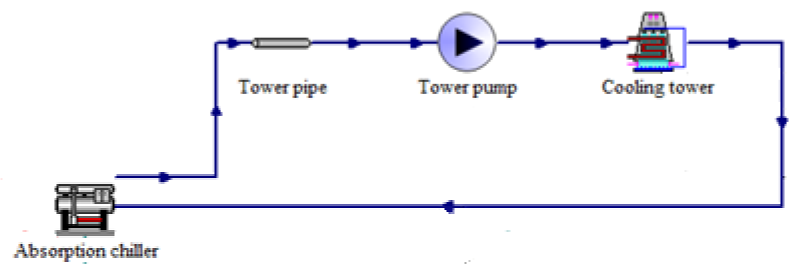

Figure 3: Cooling water loop

Chilled water loop

Chilled water is the useful output of the chiller. At the chiller's outlet, chilled water is pumped to the cooling coil (figure 4). In this device, heat coming from the building air loop is transferred to the chilled water.

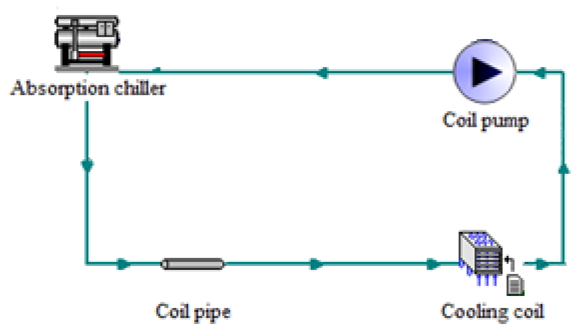

Figure 4: Chilled water loop

Building Air Loop

Chilled air for building cooling is supplied by a fan and the cooling coil. At the coil's outlet, the chilled air main flow is diverted into three flows, each going to a different room. Depending on the current room cooling requirements, which are monitored with thermostats, an equation block calculates the proportion of the main flow rate that is to be sent towards each room. In the case of low building cooling requirements, chilled air is diverted through a channel bypassing the building. Air coming out of the building and the bypass channel is mixed back into one main flow, and then the loop starts again as shown in figure 5. The solid green lines represent air flows.

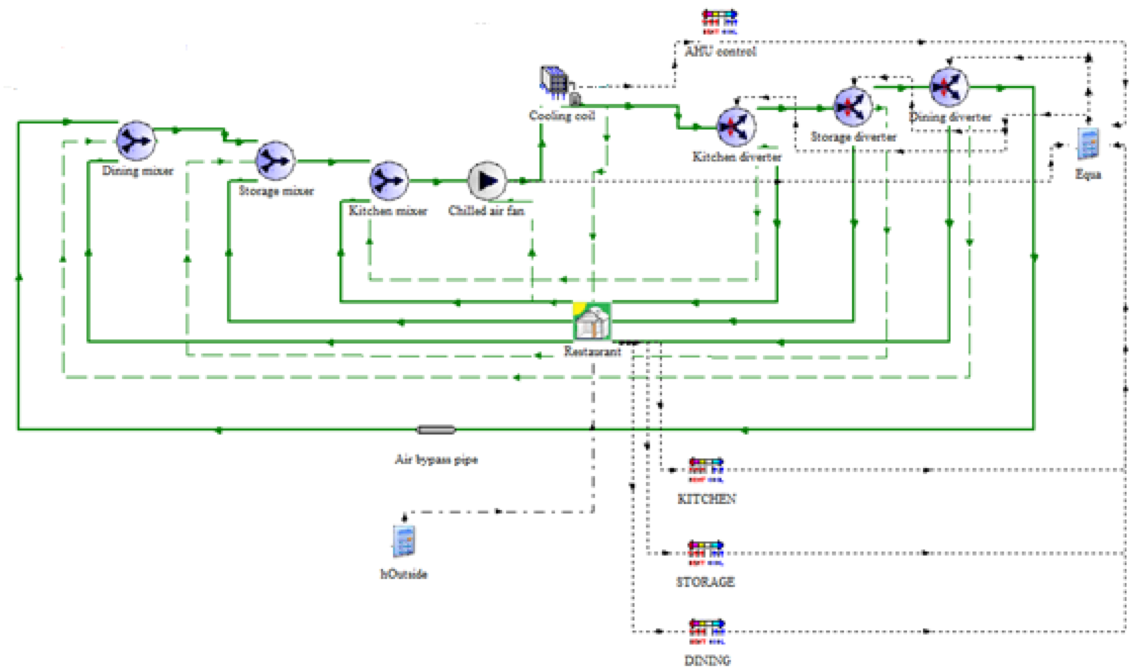

Figure 5: Building air loop

One problem with this control type is that if too much air bypasses the building, it keeps getting colder and colder. This is due to the fact that the cooling coil performs a simple energy balance between the air and water. Thus, air reaches very low and physically insignificant temperatures. To avoid this, a thermostat monitors the cooling coil outlet air temperature. When the chilled air minimum set temperature is reached or the total cooling load is equal to zero, the hot, cooling and chilled water loops pumps are turned off, as well as the absorption chiller and the cooling tower.

Note that there is no output mass flow rate for the air in Type56. As shown in figure 5 by the green dashed line in the Simulation Studio, the output air flow rate from flow diverters is the input into the corresponding flow mixers. Also, there is no input/output relative humidity for flow diverters and mixers. The relative humidity is therefore directly connected from the cooling coil to the building and from the building to the fan.