



IBPSA Project 1

Ice Tank Model

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Basic assumptions

Model based on paper from 2021 Int. Modelica Conference

An Ice Storage Tank Modelica Model: Implementation and Validation

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Governing equations

This model implements an ice tank model whose performance is computed based on performance curves.

The model is based on the implementation of [Guowen et al., 2020](#) and similar to the detailed EnergyPlus ice tank model [ThermalStorage:Ice:Detailed](#).

The governing equations are as follows:

The mass of ice in the storage m_{ice} is calculated as

$$\begin{aligned} d\text{SOC}/dt &= \dot{Q}/(H_f \cdot m_{ice,max}) \\ m_{ice} &= \text{SOC} \cdot m_{ice,max} \end{aligned}$$

where SOC is state of charge, \dot{Q} is the heat transfer rate of the ice tank, positive for charging and negative for discharging, H_f is the fusion of heat of ice and $m_{ice,max}$ is the nominal mass of ice in the storage tank.

The heat transfer rate of the ice tank \dot{Q} is computed using

$$\dot{Q} = Q_{sto,nom} \cdot q^*,$$

where $Q_{sto,nom}$ is the storage capacity and q^* is a normalized heat flow rate. The storage capacity is

$$Q_{sto,nom} = H_f \cdot m_{ice,max},$$

where H_f is the latent heat of fusion of ice and $m_{ice,max}$ is the maximum ice storage capacity.

The normalized heat flow rate is computed using performance curves for charging (freezing) or discharging (melting). For charging, the heat transfer rate q^* between the chilled water and the ice in the thermal storage tank is calculated using

$$q^* \Delta t = C_1 + C_2 x + C_3 x^2 + [C_4 + C_5 x + C_6 x^2] \Delta T_{lmt}^*$$

where Δt is the time step of the data samples used for the curve fitting, C_{1-6} are the curve fit coefficients, x is the fraction of charging, also known as the state-of-charge, and T_{lmt}^* is the normalized LMTD calculated using [Buildings.Fluid.Storage.Ice.BaseClasses.calculateLMTDStar](#). Similarly, for discharging, the heat transfer rate q^* between the chilled water and the ice in the thermal storage tank is

$$-q^* \Delta t = D_1 + D_2(1-x) + D_3(1-x)^2 + [D_4 + D_5(1-x) + D_6(1-x)^2] \Delta T_{lmt}^*$$

where Δt is the time step of the data samples used for the curve fitting, D_{1-6} are the curve fit coefficients.

The normalized LMTD ΔT_{lmt}^* uses a nominal temperature difference of 10 Kelvin. This value must be used when obtaining the curve fit coefficients.

The log mean temperature difference is calculated using

$$\begin{aligned} \Delta T_{lmt}^* &= \Delta T_{lmt} / T_{nom} \\ \Delta T_{lmt} &= (T_{in} - T_{out}) / \ln((T_{in} - T_{fre}) / (T_{out} - T_{fre})) \end{aligned}$$

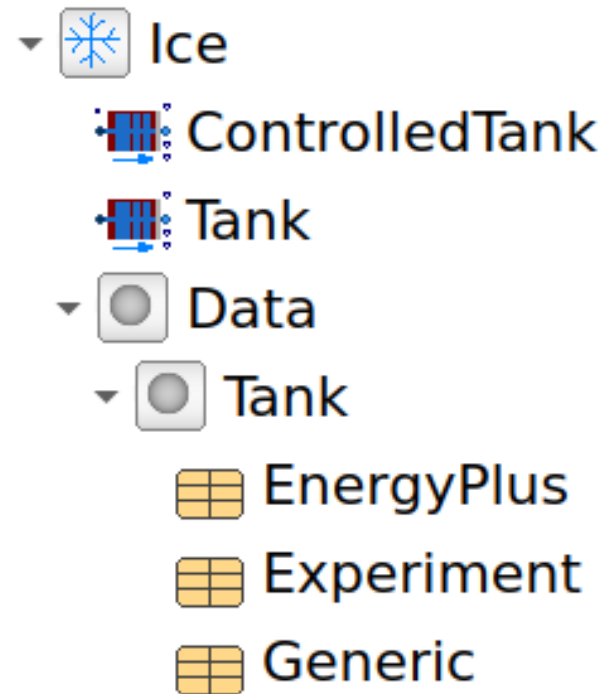
where T_{in} is the inlet temperature, T_{out} is the outlet temperature, T_{fre} is the freezing temperature and T_{nom} is a nominal temperature difference of 10 Kelvin.

Reference

Strand, R.K. 1992. "Indirect Ice Storage System Simulation," M.S. Thesis, Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign.

Guowen Li, Yangyang Fu, Amanda Pertzborn, Jin Wen and Zheng O'Neill. *An Ice Storage Tank Modelica Model: Implementation and Validation*. Modelica Conferences. 2021. [doi: 10.3384/ecp21181177](https://doi.org/10.3384/ecp21181177).

Package structure



Two options:

1. Ideally controlled tank (exact solution, not PI controller as was used in Modelica paper)
2. Tank only (allows for example glycol-water heat exchanger control)

