Simulation of fire concrete drying with Simu-Therm

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Contents

What is drying calculation ?

- A drying simulation is a transient simulation, in which one or more of the wall layers contain free or hydraulically bonded water.
- Like any transient simulation it is based on a steady state calculation and on a transient time schedule usually a heating and drying schedule.
- The water content for some of the layers is entered before the transient simulation is started.
- Result of the simulation are curves of the remaining water content and the water vaporizaton rate over the simulation time period. Both curves are available in diagrams.

In the following example we consider a wall with 2 layers containing water:

- 130 mm dense fire concrete, 6 percent water on dry matter
- 170 mm insulation concrete, 25 percent water

Simulation method

The drying simulation of SIMU-THERM is based on the following assumptions:

Low steam pressure: the water vapor escapes the concrete driven by a pressure close to the ambient air pressure. This is assuming that there are enough free pores and steam exit cavitations.

Vaporization occurs in the temperature range between 100°C and 800°C:
100°C is the boiling temperature of water, concrete is assumed to be dry at 800°C. In that range the pores are opened gradually. So the steam mainly exits towards the hot face.

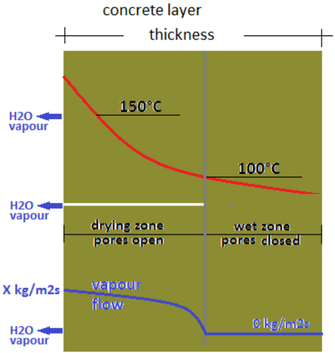


Figure: drying simulation method

Get dialog wall properties

In order to enter the water content of a layer, open the dialog 'wall properties':

1. mark layer 1 (dense fire concrete)
2. click on button *layer properties*.

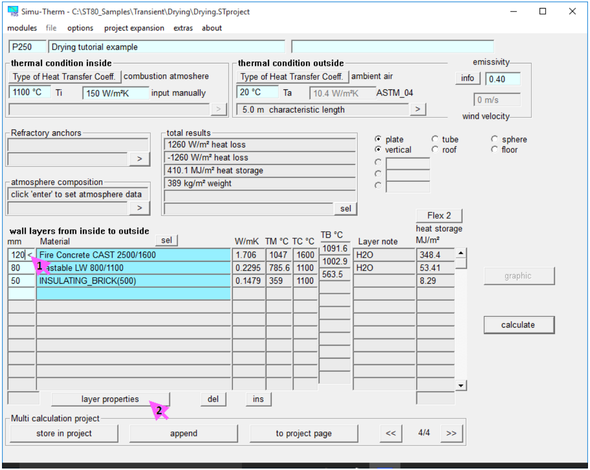


Figure: select layer properties dialog

Enter water content

1. enter water content (P) in percent of dry matter
2. enter water content (M) in $\frac{kg}{m^3}$ or $\frac{lb}{ft^3}$

Example: P $= 7\%$, density $= 2500 \frac{kg}{m^3}$
$\rightarrow M = 175 \frac{kg}{m^3}$

Drying before heating

If water has been removed from the layer by drying in advance, M is lower than calculated like above.

Pre-drying below 100°C cannot be calculated, because it depends on the capillarity of the pores and on the tightness of the concrete skin.

Pre-drying above 100°C: Calculation possible, see section *Pre-drying above 100°C*

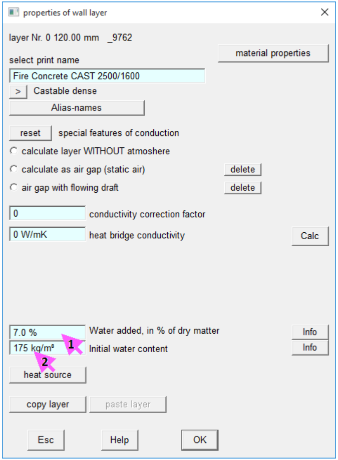


Figure: enter water content of a concrete layer

Switch to transient module

After entering the water contents of concrete layers, you can perform the transient simulation

1. open dropdown menu *modules*
2. select *transient heat transfer*

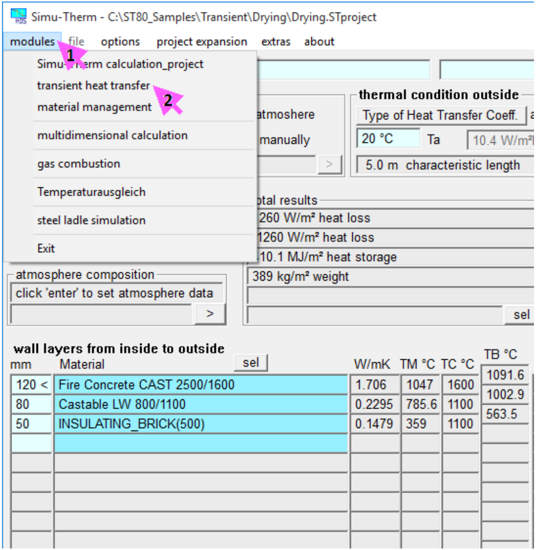


Figure: switch to transient module

Get time schedule

Open or enter a transient time schedule

1. open dropdown menu *files*
2. select *open*
3. search for file type *STtim*
4. select a file, e.g. *DryingSchedule.STtime*

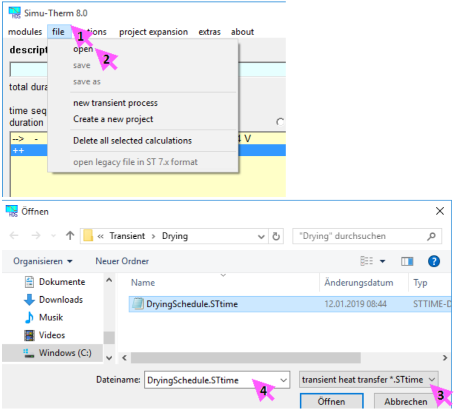


Figure: switch to transient module

Launch simulation

Launch the transient simulation

1. click on button *initial state*
2. select *start simulation in cold state*
3. confirm with *OK*
4. to launch the simulation, click on *calculate new*

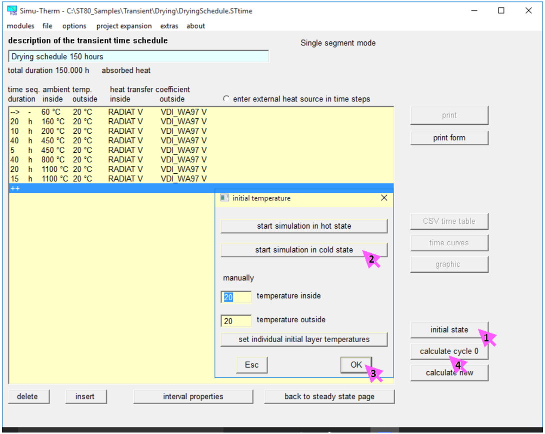


Figure: switch to transient module

Simulation result graph

The simulation graph shows the temperature in the wall at different times. The times are defined by the user in the time schedule

1. initial temperature (start of the simulation)
2. final temperature (end of the simulation, 150 hours)
3. temperature after 70 hours (Line No 4)

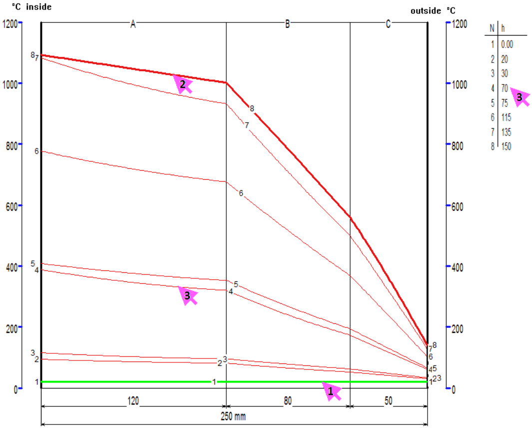


Figure: simulation result graph

Dialog *time curves*

In the dialog *time curves* you can select curves of data recorded during the simulation and display their diagrams.

1. click *OK* to trigger displaying the selected curves (here: inside and outside temperatures, one of the default diagrams)

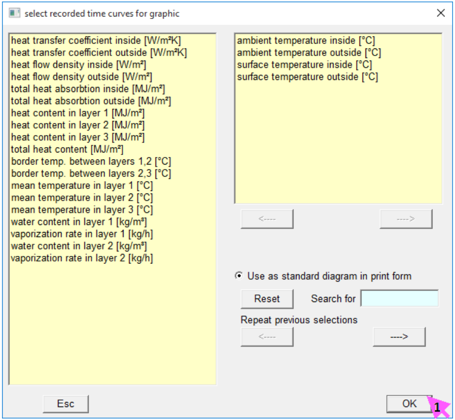
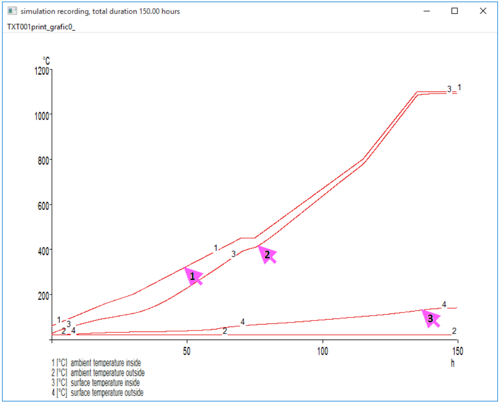


Figure: simulation result graph

Inside and outside temperatures

In the dialog *time curves* you can select curves of data recorded during the simulation and display diagrams of them.

1. ambient temperature inside (= temperaure curve entered in the schedule)
2. surface temperature inside (calculated in the simulation)
3. surface temperature otside (calculated shell temperatue)



Display water content

In order to get a diagram of the water content, move ahead with the right arrow button (1) until the predefined selection (2) appears.

3. confirm with *OK*

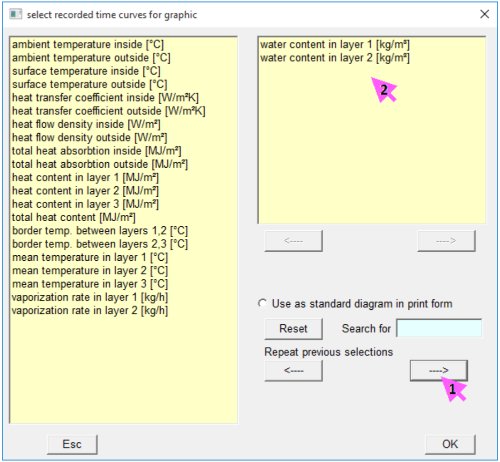


Diagram water content

The diagram shows the remaining water content of the layers over the simulation time in $\frac{kg}{m^3}$

1. ambient temperature inside (= temperaure curve entered in the schedule)
2. surface temperature inside (calculated in the simulation)
3. surface temperature otside (calculated shell temperatue)

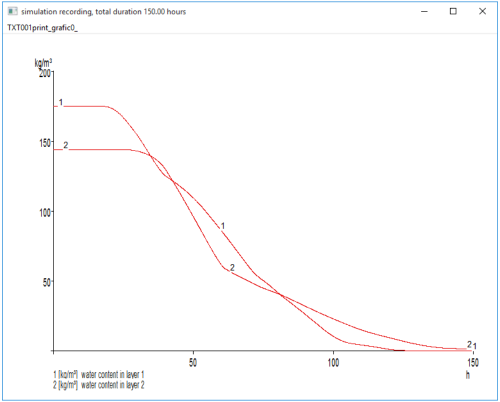


Figure: water content of layers 1,2

Export numbers of the diagram

As in all time diagrams you can export the data of the diagram to a table in CSV format.

1. open drop down menu of the graphic
2. select *export CSV*
3. choose the number of data points (here: 12 points)
4. open CSV file in a spreadsheet software (e.g. Microsoft Excel)

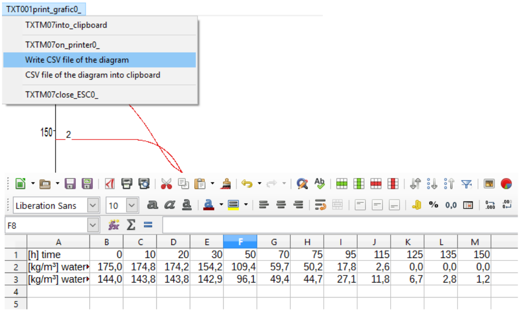


Figure: export CSV files for spreadsheet

Display water vaporization

Move ahead with the right arrow button (1) until the selection *vaporization* (2) appears.

3. confirm with *OK*

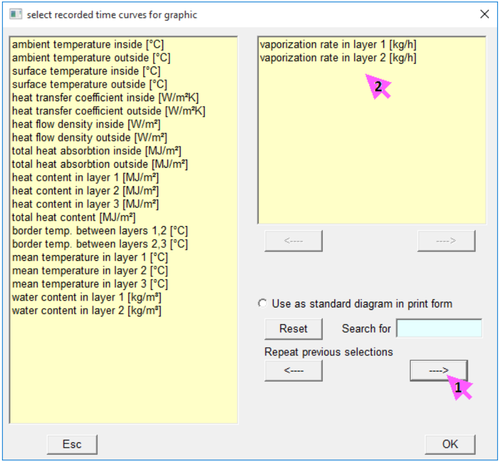


Diagram water vaporization

The diagram shows the water vaporization rates of the layers over the simulation time in $\frac{kg}{s}$

The objective of vaporization curves is to detect peaks of the vaporization rate. The peaks correspond to peaks of steam pressure in the concrete, which should be avoided in order to reduce the risk of damages.

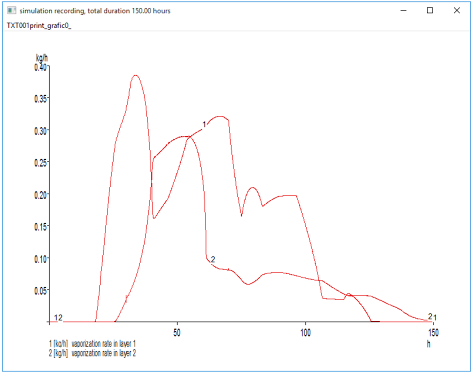


Figure: water content of layers 1,2