03.03_PH-SUMMER SCHOOL

PH-CALCULATION – Thermal bridge coefficients with THERM

Composition: Christoph BUXBAUM
Language support: Mark TOLSON
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CONTENT OF THIS PRESENTATION:

03.03.01 Description of the software “Therm”
03.03.02 Working with “Therm” for the generation of thermal bridge coefficients

In the PH-calculation software PHPP, no thermal bridge coefficients are included. They can be taken from thermal bridge coefficient libraries or can be calculated by yourself.

This presentation has been prepared by
Christoph BUXBAUM, Arch. DI. Dr.
Carinthia University of Applied Sciences
A-9800, Spittal / Drau, Villacher Str. 1, Tel +43 05 90500 11
E-mail: c.buxbaum@cuas.at, Web: www.fh-kaernten.at/bph
The THERM heat transfer software

Description

**THERM**
Analysis of two-dimensional heat transfer through building products. Includes a graphical user interface that allows users to draw cross sections of fenestration and other building products, which can then be analyzed by an automatic mesh generator and finite-element heat transfer algorithms. Results are displayed graphically.

**Keywords**
two-D heat transfer, building products, fenestration

**Validation/Testing**
N/A

**Expertise Required**
Understanding of heat flows through building products; knowledge of properties of materials useful.

The THERM heat transfer software

Description

**Users**
Version 5.2 in use by over 1000 users internationally.

**Audience**
Building product developers, designers, analysts determining window ratings (NFRC).

**Input**
Graphic user interface; user enters cross sections of the building products, can read .DXF files and bitmaps.

**Output**
U-factors, isotherms, color-flooded isotherms, heat-flux vector plot, and color-flooded lines of constant flux.

**Computer Platform**
Requires Windows 98, Windows NT, Windows 2000, or Windows XP. Pentium or better. At least 64MB of random access memory (RAM), 128 MB of RAM is preferred for optimum operation. Hard disk drive with at least 15 megabytes of available disk space.

The THERM heat transfer software

Description

**Programming Language**

C, FORTRAN

**Strengths**

State-of-the-art user interface; automatic meshing/re-meshing completely user transparent; advanced radiation and convection models can be incorporated into the finite element analysis algorithms used. The current version is 32-bit, which is faster than previous versions.

**Weaknesses**

...

**Contact**

Company: Lawrence Berkeley National Laboratory
E-mail: THERMHelp@lbl.gov
Website: [http://windows.lbl.gov/software/therm/therm.html](http://windows.lbl.gov/software/therm/therm.html)
Freeware
The THERM heat transfer software

**Description**

THERM is a finite element computer program for the calculation of two dimensional heat fluxes.

**Features**

- Model one and two dimensional heat transfer effects
- Evaluate thermal bridges
- Optimize construction details (joints…)

**Download link:** [http://windows.lbl.gov/software/therm/therm.html](http://windows.lbl.gov/software/therm/therm.html)

**Source:**

INTERNATIONAL PASSIVE HOUSE SUMMER SCHOOL FOR STUDENTS
The THERM heat transfer software

Description / Examples

The thermal behaviour is visible with lines of isotherms or coloured.

Source: http://windows.lbl.gov/software/therm/images/therm2-1.gif
The THERM heat transfer software
Description / Examples

Problems can be shown

Source: http://apps1.eere.energy.gov/buildings/tools_directory/screenshots.cfm/ID=136/pagename_submenu=pagename_menu=pagename=alpha_list
The THERM heat transfer software

Description / Examples

Renovation: most important for passive house windows

Ψ = 0,26 W/(mK)

Ψ = 0,00 W/(mK)

The thermal bridge coefficient can be calculated and the construction can be optimized.
The thermal bridge coefficient can be calculated and the construction can be optimized.

Source:

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We make a calculation model for a structural element consisting out of small elements and we know their thermal quality exactly or nearly exactly.

If you lay a net over the structural element, calculate all junctions, you can conclude the thermal quality of the whole element out of the grid.
The THERM heat transfer software
Description - Finite Element Method
The THERM heat transfer software
Description - Finite Element Method

Example: thermal bridge - constructive

- 20°C
- -10°C

Concrete
Timber
Frame wall
Overhanging balcony slab
Condensation?
Example: thermal bridge - geometric
Working with THERM

Generation of thermal bridge coefficients with “Therm”
Working with THERM

Inputs to THERM

Take a DXF file as underlay
Working with THERM

Inputs to THERM

Start with drawing a contour

Redraw the contour

After the contour is finished,
define the thermal quality of the element
Finite element method
The thermal quality is defined in the material library

Source: Finite element method
The thermal quality is defined in the material library
Define the boundary conditions

You can define all climate data you need
Now its your turn. Let’s call it “a timber frame wall”
Working with THERM

Inputs to THERM

...cover the construction with material

- Material library
- Lambda value
- Emissivity
Working with THERM

Inputs to THERM

...define the boundary conditions

- temperature
- Film coefficient is different inside, outside, up, down....
Working with THERM
Inputs to THERM

...now define the U-factor surface

it is for automatic calculation of measures

Click on the outside line
Working with THERM

Inputs to THERM

...define the boundary conditions

adiabat: without energy going to the surround.

The isotherms are 90 degree to the adiabatic line
Working with THERM
Inputs to THERM

...read the U-value

U-value for total length

“measure of the grill”

maximum error

number of iteration

put in the maximum of error

Source:

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... now we are able to calculate the Psi-value of a corner.

1. define material
2. define boundary conditions
3. simulation
4. read the U-value
Working with THERM
Inputs to THERM

<table>
<thead>
<tr>
<th>Psi value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U-Wert 1-dim</td>
<td>0.103 W/m²K</td>
</tr>
<tr>
<td>U-Wert 2-dim</td>
<td>0.084 W/m²K</td>
</tr>
<tr>
<td>length of construction</td>
<td>2,706 m</td>
</tr>
<tr>
<td>Q 1-dim</td>
<td>0.280 W/mK</td>
</tr>
<tr>
<td>Q 2-dim</td>
<td>0.227 W/mK</td>
</tr>
<tr>
<td>psi</td>
<td>-0.052 W/mK</td>
</tr>
</tbody>
</table>

\[ \Psi = \frac{Q_{2\text{Dim}} - Q_{1\text{Dim}}}{l \times DJ} \]

\[ Q_{1\text{Dim}} = (l_1 \times h \times U_1 + l_2 \times h \times U_2) \times G_t \]

\[ Q_{2\text{Dim}} = (l_1 \times h \times U_1 + l_2 \times h \times U_2 + h \times \Psi) \times G_t \]

\[ l: \text{ length of the thermal bridge} \]

\[ DJ: \text{ difference of temperature inside outside} \]

\[ Q_{2\text{Dim}} : \text{stream of heat 2 dimensional (aus FEM)} \]

\[ Q_{1\text{Dim}} : \text{stream of heat 1 dimensional (at an example out of PHPP)} \]

\[ \Psi: \text{ psi value (linear thermal bridge)} \]
Working with THERM
Inputs to THERM

A window example